Navy Preview SBIR 23.1 Phase I

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N231-068	Cryogenic Solid-State Thermal Energy Storage
N231-069	High-Rate, Reduced Life Cycle Cost Airframe
N231-070	Ultraviolet Solar Blind Sensors for Microsatellites and Small Satellites
N231-071	Compact Aerial Inspection System for Elevated and Small Spaces
N231-072	High Temperature Ceramic Yarn from Discontinuous Silicon Carbide (SiC) Fibers
N231-073	Radiation Hardened FPGAs for Strategic Systems
N231-074	Characterization of the Radiation Environment Capabilities of Exploding Foil Initiators (EFIs)

N231-075	Reduced Integrated Optical Circuits (IOC) Half-wave Voltage (Vpi) for improved Size Weight and Power (SWaP) in Interferometric Fiber-Optic Gyroscopes (IFOG)
N231-076	Electrically Conductive Self-Assembled Monolayer (SAM) Anti-Stiction Coating for Micro-Electromechanical Systems (MEMS)
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N231-001 TITLE: Variable-Angle and Optimal Deployment for Anti-Personnel Obstacle Breaching Systems (APOBS)

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR)

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

OBJECTIVE: Develop a technology to identify and set an optimal launch angle for system deployment and develop an engineering solution to minimize geometric shapes in the line charge deployment.

DESCRIPTION: The current Anti-Personnel Obstacle Breaching System (APOBS) consists of grenades, equally spaced on a fabric reinforced detonating cord over-braided in a polyester support structure. It is a self-contained, two-person portable, one-shot expendable linear demolition charge system used by assault elements. The APOBS kit consists of an aluminum shipping and storage container, a front backpack assembly containing a 25-meter front line charge segment, a rear backpack assembly containing a 20-meter rear line charge segment with rear fuze, a rocket motor front fuze assembly, and a MK19 electric squib inside a sealed foil bag or a non-electric initiator (shock-tube) packed in a fabric reinforced, foam lined container.

Currently the launch rod for the APOBS is installed to the front backpack at a static launch angle. During set-up on uneven or hilly terrain, Marines are trained to improvise backpack supports to adjust the angle of the launch rod. This SBIR topic would identify a lightweight engineering design solution and tool to identify and set an optimal launch angle for APOBS rocket motor deployment to prototype an engineering change to the APOBS system to optimize the deployment of the APOBS to minimize geometric shapes. The optimal deployment of the APOBS' grenades is a straight line. Due to rocket motor thrust, current drogue chute drag or impulse drag of the rear backpack and/or drogue chute, environmental conditions or some unknown factor during deployment results in the grenades deploying with a transverse wave along the detonating cord. This transverse wave can result in arc, u-shape or loops forming along the detonation cord. These non-straight geometric arrangements of the APOBS after deployment may result in unexploded grenades as the grenades detonate from the rear and front fuzes to the center connector.

The technology must meet Threshold requirements = (T)
It is highly desirable that the technology meets Objective requirements = (O)
The system will meet the performance characteristics identified in Reference 1.

Deployment conditions

1. Emplacement Time:

1.1 Shall be capable of being emplaced and fired by a team of no more than two individuals in the delay mode within 120 seconds (T), 30 seconds (O), while wearing the battle dress uniform. The time parameters, though desired, are not required for individuals wearing cold weather and/or Mission Oriented Protective Posture equipment.

2. Weight

2.1 Shall have a maximum system weight (less Shipping & Storage Container) of 130 pounds, where the weight of the Front Backpack by itself and combined weight of the Rear Backpack and Softpack shall each weigh no more than 65 pounds. There shall be one APOBS per Shipping & Storage Container. The weight of one APOBS with one Shipping & Storage Container shall not exceed 230 pounds.

Current Weights:
Current front backpack (59.5 lbs)
Current rear backpack (52.3 lbs)
Current Soft pack (11.0 lbs)

3. Deployment

3.1 Shall have a .95 probability of not exceeding a maximum deviation of plus or minus 15 degrees (T), 10 degrees (O) from the aimed line of fire in a cross wind with a velocity of 15 (T) or 25 (O) miles per hour or less.

3.2 Shall have a minimum mission reliability of 0.90 (T), 0.95 (O). If the line charge crosses during deployment and does not consume all energetic components when detonated it is considered a "fratricide" and is counted as a failure.

3.3 Shall have a design with an effective range of up to 45m (T, current design); 70m (O).

3.4 Shall be effective in clearing terrains up to 40o (T), 60o (O).

3.5 If the terrain slope is greater than 18% slope, a tool should be provided to enable the operator to set the optimal launch conditions of the APOBS (T), variable slope up to 45o (O).

3.6 Able to be used in all soil types to include gravel, sand, clay, grasslands, and ice.

PHASE I: Develop concepts for APOBS technology that meets the requirements in the Description. Demonstrate the feasibility of the concepts in meeting Marine Corps requirements. Establish that the concepts can be developed into a useful product for the Marine Corps. Feasibility will be established by material testing and analytical modeling, as appropriate. Provide a Phase II development plan with performance goals and key technical milestones, and that will address technical risk reduction.

PHASE II: Develop 30 prototype APOBSs, minimum, for evaluation to determine their capability in meeting the performance goals defined in the Description. Demonstrate technology performance through prototype evaluation and modeling over the required range of parameters. Evaluation results will be used to refine the prototype into an initial design that will meet Marine Corps requirements; and for evaluation to determine their effectiveness in an operationally relevant environment approved by the Government. Prepare a Phase III development plan to transition the technology to Marine Corps use.

PHASE III DUAL USE APPLICATIONS: Support the Marine Corps in transitioning the technology for Marine Corps use. Support the Marine Corps for test and validation to certify and qualify the system for Marine Corps use. Potential dual-use applications include path/trail clearance and road clearance.

REFERENCES:

1. APOBS Product description. Nammo. https://www.nammo.com/product/our-products/grenades-warheads-energetics/apobs/
2. "Anti-Personnel Obstacle Breaching System." Ensign-Bickford Aerospace & Defense. https://www.ebad.com/apobs/

KEYWORDS: APOBS, breaching, explosive, line charge, mines, obstacles, demolition

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N231-002 TITLE: Seamless Knitted Mesh, Cold Weather Baselayer Undershirt and Drawer

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR)

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

OBJECTIVE: Develop a seamless undershirt and drawer that could replace the current, conventionally cut and sewn mesh, cold weather baselayer undershirt and drawer.

DESCRIPTION: The Marine Corps recently developed and is fielding a new cold weather, mesh baselayer undershirt (MIL-DTL-MC033) and drawers (MIL-DTL-MC032). The current garments are constructed through conventional cut and sew technology and use three different fabrics: a mesh (MIL-DTL-MC034), jersey (MIL-DTL-MC035), and rib knit (MIL-DTL-MC036). The items are for use next to skin in extreme cold weather. The mesh structure provides standoff between a Marine’s skin and other layers to allow for evaporation of sweat and creation of air pockets, keeping the wearers dry and warm. The technology used to construct the current garments is known as “cut and sew.” Knit fabric manufacturers produce fabrics to specifications and test the fabrics to ensure they meet certain requirements, which includes, but is not limited to, construction, colorfastness, burst strength, launder-ability, and shade matching. The cold weather, mesh baselayer undershirt and drawers are constructed with three fabrics, a mesh, jersey, and rib knit, meaning the three fabrics in the current manufacturing method must be produced separately. Once the fabrics are approved for use, they are shipped to the garment manufacturer to cut the fabrics, based off a pattern, and sew them together to create the undershirt and drawer. The cut and sew process typically uses multiple operators to perform various functions: one operator to cut and multiple operators to stitch the pieces together.

Newer seamless v-bed knitting machines utilize technology that allows for knitting and garment formation such as, but not limited to, T-shirts, leggings, shorts, underwear, compression, and maternity-wear, on one machine. This technology is used extensively in Asia and is slowly becoming more common in the US. There are two main manufacturers of seamless v-bed knitting machines: Shima Seiki and Stoll. These machines specialize in producing engineered panels or tubes with multiple stitches, such as jacquards, ribs, or special textures. This capability requires less labor, less factory space, no sewing thread, and creates less fabric waste. Seamless knitting can customize the placement of yarns to offer varying permeability and knit constructions within a garment without seams. One knitting machine has the capability to knit the entire garment, including adding cuffs, buttonholes or openings, collars, etc. There is little to no waste as the knitting process takes the yarn directly from cone to garment, rather than cone to fabric to cut pattern parts to garment.

A seamless garment would only need to be tested once at the end of production, instead of fabric and garment testing, to verify requirements for quality assurance in areas such as construction, colorfastness, burst strength, launder-ability, and shade matching. The manufacturing supply chain would be shortened, eliminating the cut and sewing operations.

The MIL-DTL- documents listed as reference material are available on the DLA ASSIST site (https://assist.dla.mil/online/start/).

PHASE I: Conduct research on and determine the performance level of a seamless mesh undershirt and drawer, as compared to the existing mesh undershirt and drawer. Develop initial concepts and evaluate their technical feasibility. Compare concepts to traditionally sewn seams using internationally recognized standards and test methods such as those referenced in the American Association of Textile Chemists and Colorists (AATCC) and American Society for Testing and Materials (ASTM) International to determine the most appropriate concept(s) prior to down selection and subsequent assembly of prototype garments. Develop a cost and durability comparison between the current cut and sew base layer and the estimated cost of a seamless mesh baselayer. Develop a Phase II plan for prototype production.

Develop and deliver fabric samples that meet all or most of the three fabric specs and provide fabric level test data comparing the developed samples to the current requirements. Validation/tests should demonstrate where the seamless undershirt and drawer meets and/or does not meet the requirements, as defined in the, Mesh, Cold Weather Baselayer Undershirt and Drawer Detail Specifications [Refs 1 and 2]. Integrate all three types of fabric into one swatch to demonstrate the construction transition. Yarns with fiber content outside of the current specs, (MIL-DTL-MC034), jersey (MIL-DTL-MC035), and rib knit (MIL-DTL-MC036), will be considered if they meet all or most of the fabric specs. Any yarns considered shall meet the No-Melt, No-Drip (NMND) requirement, cannot contain cotton, and must meet most fabric requirements.

Develop the program for a seamless knit mesh base layer and provide a single demonstration model, also referred to as a mockup, of a single seamlessly knit top and bottom. A garment constructed only through seamless knitting is preferred though garments with the finishings linked on, i.e., cuffs or collar, will be considered. Minor garment changes compared to the current baselayer shall be considered if needed to improve manufacturability.

PHASE II: Optimize the proposed concept(s), work with Government entities for initial fit assessment, grade programs to size S-XL, work with government entities for subsequent fit assessments, and produce prototypes for preliminary evaluations. Conduct material and system-level evaluations against all test methods deemed necessary by Textile Technologists for the end use of the garment. Develop prototypes to demonstrate and evaluate the suitability of the technology in a field evaluation.

Design, develop, and test prototype garments utilizing the best candidate seamless knitting technologies selected from Phase I. Provide at least 50 seamless sets (undershirt and drawer) in multiple sizes to the Marine Corps for Marine Corps testing and evaluation.

Conduct a US manufacturing feasibility analysis using mesh undershirt and drawer as a demonstration model for the technologies' viability. Subject prototype garments to comparison between current specification requirements and laboratory durability prediction assessments using multiple launderings, prior to user evaluation. Prototype garments will be considered for a Government user evaluation. Following a user evaluation, the government will evaluate the prototype garments through objective laboratory assessments and by collecting user feedback through focus groups to determine performance, durability, reduction of bulk and weight, operational compatibility, and ease of care.

PHASE III DUAL USE APPLICATIONS: Provide support in transitioning a seamless knitting technology into appropriate Marine Corps garments. Develop a plan to determine the effectiveness of the re-engineered clothing items in operationally relevant environments. Support the Marine Corps with certifying and qualifying the garments for Marine Corps use.

There are a wide range of DoD uniform items that this technology could improve including: physical fitness uniforms, T-shirts, base layers, other undergarments, and accessory items such as gloves. Further research and development on this technology could result in follow-on garments for Marine Corps use. Interest in this technology has been shown by the Joint Service Chem/Bio clothing group for a knit undergarment top and pants to eliminate seam leakage, and by NAVAIR for a seamless base layer system to reduce bulk and chafing. Similarly, the Army has expressed interested in the seamless technology for use in their base layers and the Navy has a current SBIR topic for the seamless manufacturing of the flight deck jersey. The Marine Corps has additional interest in this technology to incorporate padding in knitwear (i.e., elbow pads).

Commercial industries would also benefit from this technology. Sectors such as athletic base layers for cold weather activities, i.e. hiking, climbing, skiing, etc. would be ideal transition partners interested in this technology. Other products that could use this technology could include athletic leggings, winter sweaters, t-shirts, undergarments, gloves, beanie caps, and more.

REFERENCES:

1. MIL-DTL-MC033, DETAIL SPECIFICATION, UNDERSHIRT, MESH, COLD WEATHER BASELAYER. https://assist.dla.mil/online/start/index.cfm – site registration required to access document.
2. MIL-DTL-MC032, DETAIL SPECIFICATION, DRAWER, MESH, COLD WEATHER BASELAYER. https://assist.dla.mil/online/start/index.cfm – site registration required to access document.
3. MIL-DTL-MC034, DETAIL SPECIFICATION CLOTH, MESH KNIT. https://assist.dla.mil/online/start/index.cfm – site registration required to access document.
4. MIL-DTL-MC035, DETAIL SPECIFICATION CLOTH, JERSEY KNIT. https://assist.dla.mil/online/start/index.cfm – site registration required to access document.
5. MIL-DTL-MC036, DETAIL SPECIFICATION CLOTH, RIB KNIT. https://assist.dla.mil/online/start/index.cfm – site registration required to access document.
6. NAVY SBIR Topic N182-124 Seamless Knitting for Military Protective Clothing https://www.navysbir.com/n18_2/N182-124.htm
7. AATCC 8 - Colorfastness to Crocking: AATCC Crock-meter Method; AATCC 15 - Colorfastness to Perspiration; AATCC 16 - Colorfastness to Light; AATCC 61 - Colorfastness to Laundering, Home and Accelerated; AATCC 81 - pH of the Water-Extract from Wet Processed Textiles; AATCC 88B - Smoothness of Seams in Fabrics after Repeated Home Laundering; AATCC 100 - Antibacterial Finishes on Textile Materials, Assessment of; AATCC 135 - Dimensional Changes of Fabrics After Home Laundering AATCC 197 -Vertical Wicking of Textiles; AATCC Evaluation Procedure 1, Gray Scale for Color Change; AATCC Evaluation Procedure 2, Gray Scale for Staining; AATCC Evaluation Procedure 6, Instrumental Color Measurement; AATCC Evaluation Procedure 8, AATCC 9-Step Chromatic Transference Scale; AATCC Evaluation Procedure 9, Visual Assessment of Color Difference of Textiles. American Association of Textile Chemists and Colorists (AATCC). https://www.aatcc.org
8. ASTM D737 - Standard Test Method for Air Permeability of Textile Fabrics; ASTM D3512 - Standard test method for Pilling Resistance and other related Surface Changes of Textile Fabrics: Random Tumble Pilling Tester; ASTM D3776 - Standard Test Method for Mass Per Unit Area (Weight) of Fabric; ASTM D3787 - Standard Test Method for Bursting Strength of Knitted Goods Constant-Rate-of-Traverse (CRT) Ball Burst Test; ASTM D3887 - Standard Specification

for Tolerances for Knitted Fabrics; ASTM D6193 - Standard Practice for Stitches and Seams; ASTM D6797 - Standard Test Method for Bursting Strength of Fabrics Constant- Rate-of-Extension(CRE) Ball Burst Test; ASTM E2149 - Standard test Method for Determining the Antimicrobial Activity of Immobilized Antimicrobial Agents Under Dynamic Contact Conditions; ASTM D6413 - Flame Resistance, Flame, Glow, Char- Before and After Laundering. American Society for Testing and Materials (ASTM) International. https://www.astm.org

KEYWORDS: cold weather clothing; mesh knit; underlayer; base layer

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N231-003 TITLE: Broadband Antenna Solution for Vehicle-Mounted Electronic Warfare Systems

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Microelectronics; Networked C3

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OBJECTIVE: Develop an innovative and operationally suitable consolidated (minimized size and weight) antenna solution for sensing and transmitting broadly across the electromagnetic spectrum with angular resolution sufficient for geo-location and direction finding.

DESCRIPTION: Marine Corps Systems Command (MCSC) provides vehicle-mounted Electronic Warfare Systems (EWS) for geo-locating, direction finding, and countering threats on the ground and in the air. In order for these systems to be maximally effective against the breadth of potential threats, they must be able to accurately sense and defeat a variety of complex threat signals across the electromagnetic spectrum at once.

With the emergence of ultra-wideband photonic receiver technology that can very rapidly process, de-conflict, and identify threats across the entire frequency range of the electromagnetic spectrum, there comes a need for complimentary broadband antenna hardware to sense and locate threats and transmit to defeat them. Current antenna technologies are limited in frequency range and thus multiple antennae are required to cover very broad ranges, especially at the lower end of the frequency range. Current broadband antenna technologies also lack the precision in angle of arrival in azimuth and elevation critical to geo-locating and direction finding.

Requirements for the Broadband Antenna for the Photonic Receiver

- Capable of operating in the frequency range from as near DC as possible to 20GHz (Threshold), 80+GHz (Objective).
- Must be accurate in angle of arrival in order to support geo-location and direction finding. Preference is maximizing angle of arrival precision and accuracy in both azimuth and elevation, achieved with a threshold of no more than 4 antennae, with a preference that multiple antennae occupy the same physical space. Antennae that occupy the same physical space will be considered one antenna, even if they are electromagnetically multiple antennae. No single antenna should exceed a 1ft cube in size.)
- Total weight must not exceed 50 lbs (T), 10 lbs (O).
- Must receive and transmit across the entire frequency range (T), able to receive and transmit simultaneously at the same frequency (O).
- Must have an elevation and azimuth instantaneous beam width of ±45° field of view (T) when mounted on a vehicle platform. A 360° azimuth field of view is preferred but must be able to resolve to 45° sectors (T). Higher resolution is desirable.
- Must have a flat gain response within each octave of less than 1dB gain (T), less than 0.5dB gain (O). Small regions of non-flatness (up to 3dB off the gain) are acceptable so long as they can be

adequately characterized and assumed within the antenna pattern. A preference is provided to solutions with a gain response better than unity (0 dB) over the frequency range.

- Water resistant as the antenna is intended to be used as part of a vehicle mounted expeditionary EWS.
- Capable of functioning on the move.
- Designed to meet MIL STD 810H, but testing of prototypes is not included in the scope of the Phase I or II research.
- Must use standard radio frequency interfaces to easily integrate with PORs and the required frequency interfaces need to be defined in any proposal. A preference is provided to minimizing the number and type of interfaces needed to cover the entire frequency range.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DSS and MCSC in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

PHASE I: Develop concepts for a broadband antenna that can be integrated with a photonic receiver and vehicle-mounted EWS, and that meets the requirements in the Description. Demonstrate the feasibility of the concepts in meeting Marine Corps needs and establish that the concepts can be developed into a useful product for the Marine Corps. Establish feasibility through modeling and simulation. Provide a Phase II development plan with performance goals and key technical milestones, and that will address technical risk reduction and includes specification for a prototype.

The Phase I effort will not require access to classified information.

PHASE II: Develop a scaled prototype integrated with representative receiver(s) that cover the frequency range for evaluation purposes in an actual or simulated electromagnetic environment representative of the breadth, volume, and complexity of an operational electromagnetic environment. Evaluate the prototype to determine its capability in meeting the performance goals defined in the Phase II development plan and the Marine Corps requirements for integration with an EWS as the front-end antenna. Demonstrate system performance through prototyping. Use evaluation results to refine the prototype into an initial design that will meet Marine Corps requirements. Prepare a Phase III development plan to transition the technology to Marine Corps use.

The Phase II effort will likely require secure access, and the contractor will need to be prepared for personnel and facility certification for secure access (see note in Description section).

PHASE III DUAL USE APPLICATIONS: Support the Marine Corps in transitioning the technology for Marine Corps use. Develop the broadband antenna solution for evaluation to determine its effectiveness in an operationally relevant environment. Support the Marine Corps for testing and validation to certify and qualify the system for Marine Corps use.

As the communications industry grows and advances in capability exponentially, antenna technology remains an important enabler to maximize performance while minimizing cost and footprint. The developer of this broadband antenna could potentially market the solutions or products derived lessons learned to the communications industry.

REFERENCES:

1. "2018 U.S. Marine Corps Science & Technology Strategic Plan." https://www.microwaves101.com/uploads/2018-USMC-S-and-T-Strategic-Plan.pdf
2. "Marine Corps Reference Publication 3-32D.1, Electronic Warfare." United States Marine Corps. Publication Control Number144 000246 00. 02 May 2016. https://www.marines.mil/Portals/1/Publications/MCRP%203-32D.1%20(Formerly%20MCWP%203-40.5).pdf?ver=2016-08-04-062544-020
3. "MCSC Modernizing Communication Gear to Enhance Electronic Warfare." The Official Website of the United States Marine Corps. https://www.marines.mil/News/News-Display/Article/2635688/mcsc-modernizing-communication-gear-to-enhance-electronic-warfare/

KEYWORDS: Electronic Warfare; Broadband; Antenna; Geo-location; Direction Finding; Flat Gain Response

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N231-004 TITLE: Technologies for Marine Corps Radars and Telecommunications Industry S-Band Spectrum Sharing

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): 5G; Artificial Intelligence (AI)/Machine Learning (ML)

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

OBJECTIVE: Develop automated real-time/near real-time spectrum management tools, radio-frequency sensing equipment, algorithms, and/or other technologies that aid Marine radar operators and spectrum planners in spectrum sharing management; and in de-confliction and optimizing radar coverage for United States Marine Corps (USMC) S-band radars operating within congested and contested EM environments.

DESCRIPTION: The S-Band portion of spectrum has unique properties that make it desirable for both military radars and telecommunications industry use, such as 5G. In the Continental United States, the telecommunications industry and Congress are increasingly exerting pressure on the Department of Defense (DoD) to either vacate or share significant portions of S-Band. America’s Mid-Band Initiative for Telecommunications auctioned 3450MHz to 3550MHz to the telecommunications industry. The Emerging Mid-Band Radar Spectrum Sharing initiative directs DoD to study the ability to vacate or share 3100MHz to 3450MHz. Having to share or vacate this spectrum could severely compress the operating space for USMC radars that operate in S-Band. Automated tools and planning aids can help de-conflict spectrum either through deliberate planning or through dynamic spectrum sharing.

Solution requirements include:

- Must take into account geographic and electromagnetic (EM) environments and have the ability to identify conflicts between radar systems and other emitters in the environment.
- An environmental sensing capability shall be automated but also support manual identification and placement of emitters in the environment.
- Display the radar system and other known emitters on a heat map.
- Identify possible conflicts and make recommendations to the user, such as utilizing frequency de-confliction in the planning phase and/or EM Interference (EMI) mitigation opportunities in the operational phase.
- Work standalone as a planning tool or used in conjunction with a radar system to automate changes to the operating parameters of the radar system to support dynamic spectrum sharing and de-confliction efforts in real-time/near real-time.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DSS and MCSC in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

PHASE I: Develop concepts and determine feasibility for planning aids, sensing equipment, software algorithms, or other methods to assist radar operators and spectrum planners. International Telecommunications Union provides recommendations ITU P.528 A Propagation Prediction Method for Aeronautical Mobile and Radionavigation Services using the VHF, UHF and SHF bands and ITU P.452 Prediction Procedure for the Evaluation of Interference Between Stations on the Surface of the Earth at Frequencies Above About 0.1 GHz provide a baseline for developing the models. Demonstrate the feasibility of military radars and commercial telecommunications systems co-existing in the same spectrum space. Establish that the concepts can be developed into a useful product for the Marine Corps. Material testing and/or analytical modeling, as appropriate will establish feasibility. Provide a Phase II development plan with performance goals and key technical milestones that addresses technical risk reduction.

PHASE II: Develop a full-scale prototype for evaluation. Evaluate the prototype through bench or lab testing to determine its capability in meeting the performance goals defined in the Phase II development plan and the Marine Corps requirements for S-Band spectrum sensing and de-confliction. System performance shall be demonstrated through prototype evaluation and modeling or analytical methods. Conduct system testing in a relevant environment. Evaluate and compare the results to the defined requirements. Prepare a Phase III development plan to transition the technology for Marine Corps use. It is probable that the work under this effort will be classified under Phase II (see Description section for details).

PHASE III DUAL USE APPLICATIONS: Clearly identify and describe the expected transition of the product/process/service within the Government. Possible dual use applications include, civilian air traffic control applications or weather radars.

REFERENCES:

1. International Telecommunication Union P.528 A Propagation Prediction Method for Aeronautical Mobile and Radionavigation Services using the VHF, UHF and SHF bands https://www.itu.int/rec/R-REC-P.452/en
2. ITU P.452 Prediction Procedure for the Evaluation of Interference Between Stations on the Surface of the Earth at Frequencies Above About 0.1 GHz provide a baseline for developing the models https://www.itu.int/rec/R-REC-P.528/en

KEYWORDS: Spectrum Mapping; Spectrum Management; Spectrum Sharing; Radar; Radio Frequency; Electromagnetic Compatibility; 5G; S-Band Radar

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N231-005 TITLE: One Way Luminescent (OWL) Tracer Technology for 40mm Ammunition

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR)

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

OBJECTIVE: Develop one-way luminescence (OWL) tracer technology that provides warfighters the capability to see the path of projectiles without exposing their positions, so that fire can be immediately adjusted instead of waiting for impact signatures.

DESCRIPTION: The intent of this SBIR topic is to develop OWL technology for 40mm ammunition. This includes low, medium, and high velocity cartridges. Additionally, high explosive and practice cartridges are to be included.

The technology must meet Threshold requirements = (T)
It is highly desirable that the technology meets Objective requirements = (O)

1) Under Night and Low-Light conditions:
    a) Cartridge signature must be luminescent. (T=O)
    b) Cartridge signature must be non-incendiary and non-fire producing (T=O)
    c) Degree of visibility (DOV) from the gunner position must be less than 30° (T); less than 25° (O)
    d) Night Vision Goggles (NVG): Visible to the gunner for a range of 900 m (T); 1500 m (O)
    e) Eyesight/Optics: Visible to the gunner for a range of 900 m (O)
2) Under Day conditions, visible to the gunner for a range of 900 m (T); 1500 m (O). With or without optics.
3) Does not degrade precision or reliability in all weather / climatic conditions in which Marines operate. (T=O)
4) Does not increase cost per cartridge by more than 5% (T); by more than 1% (O)
5) Storage without degradation of compounds:
    a) Duration: 10 years (T); 15 years (O)
    b) Temperature: - 25°C to 60°C (T); -46°C to 70°C (O)
6) Range is equal to or greater than currently fielded cartridges (T=O)
7) Muzzle velocity is equal to or greater than currently fielded cartridges (T=O)

Current tracer technology has limitations in performance that this topic will address. This includes:

- DOV: 30°. Current technology has a DOV = 30° which may risk exposure of the gunner's position.
- Degradation: The luminescent technology currently available degrades after extended periods of time in storage. The decrease in effectiveness of the OWL technology diminishes lethality.

PHASE I: Develop concepts for OWL technology that meets the requirements defined in the Description above. Demonstrate the feasibility of the concepts in meeting the Marine Corps requirements. Establish that the concepts can be developed into a useful product for the Marine Corps. Feasibility will be established by material testing and analytical modeling, as appropriate. Provide a Phase II development plan with performance goals and key technical milestones, and that will address technical risk reduction.

PHASE II: Develop prototype 40mm cartridges for evaluation to determine their capability in meeting the performance goals defined in the Description above. Demonstrate technology performance through prototype evaluation and modeling over the required range of parameters. Evaluation results will be used to refine the prototype into an initial design that will meet Marine Corps requirements; and for evaluation to determine its effectiveness in an operationally relevant environment approved by the Government. Prepare a Phase III development plan to transition the technology to Marine Corps use.

PHASE III DUAL USE APPLICATIONS: Support the Marine Corps in transitioning the technology for Marine Corps use. Support the Marine Corps for test and validation to certify and qualify the system for Marine Corps use.

Commercial applications may include, but not be limited to, law enforcement.

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4. MIL-DTL-50863F w / Amendment 5. 22 November 2021. https://standards.globalspec.com/std/14495426/MIL-DTL-50863F%20(5)%20CONT.%20DIST

KEYWORDS: Ammunition; tracer; luminescence; luminescent; OWL; 40mm; one-way

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N231-006 TITLE: Next Generation Toolsets for Weapons Separation Evaluations to Enable Enhanced Strike Capabilities

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR); Hypersonics

OBJECTIVE: Develop a next generation software package to simulate and assess multiple weapons' trajectories after release from tactical aircraft to ensure safe and effective separation.

DESCRIPTION: As adversary aircraft detection and surface-to-air strike capabilities increase, the need for long-distance, over-the-horizon strike capabilities intensifies. The difficulty in simulating accurate pre-flight trajectories increases drastically as more conventional air-to-ground strike capabilities like Small Diameter Bomb Increment IIs (SDB-IIs) continue to become smaller and lighter, allowing aircraft to deploy more assets. Air-launched weapon systems are highly stressed during aircraft separation and terminal phases. Common design traits of effective long-range weapons, such as high maneuverability, low observability, and aerodynamic efficiency, often exacerbate this problem. During separation, modern air-to-ground stores can dissipate more than 10% of their energy arresting forces and moments imparted by the aircraft environment. This level of energy loss can have profound impacts on the maximum range of the weapon. For smaller and lighter stores, the influence of the aircraft during the separation phases produces large body rates on the store, often in excess of 1000 degrees per second, which affects the ability of the assets to complete their mission.

The current Six-Degree-of-Freedom (6DOF) trajectory solver, NAVSEP, is a FORTRAN-based toolset, which originated in the 1970s. Unfortunately, the use of FORTRAN makes it difficult to maintain or increase NAVSEP's abilities to better predict and understand the relationship between the aircraft and the multiple assets during separation phases. As a result, NAVSEP lacks modern data analytics methods such as data handling and interpolation methods, workflow automation approaches, and the ability to handle complex autopilots featured in many modern weapon systems. These deficiencies can significantly increase analysis time required to assess weapon separation performance, especially between test flights. Late identification of store separation and controllability issues during flight test can result in reduced flight envelopes or asset redesign causing significant fielding delays.

A novel toolset with a core 6DOF equation-of-motion solver, an integrated visualization tool/workflow, and an efficient miss distance calculator for generating proximity data between the aircraft and store is sought. The core 6DOF solver will synthesize freestream aerodynamic information, aircraft influence data, and other external forces such as rocket motor thrust, bomb rack ejection forces, and so forth to produce store trajectories across given employment or jettison envelopes. The core 6DOF solver will report diagnostic data for trouble shooting purposes. The computed store trajectories are paramount to understanding separation dynamics to assess safety and weapon system controllability which are critical to system performance.

This integrated visualization tool will use computer-aided design (CAD) geometries of representative aircraft and stores to produce animations of body trajectories output by the core 6DOF solver. Visualizations will quickly assess potential areas of concern during release.

An integrated miss distance calculator will provide the means for quantitatively assessing the safety of a given separation using trajectory data from the core 6DOF solver and CAD geometries from the visualization tool. Minimum miss distance is the most direct measurement of safety that exists, but it comes at a high-computational cost, which limits its utility. An efficient calculator that identifies the

location of this key metric will enable expanded utilization and ultimately enhance Naval Air Warfare Center Aircraft Division's (NAWCAD) organic separation assessment capability.
The resulting flexible software package will be able to handle aerodynamic input data from legacy and modern wind tunnel testing methods, along with Computational Fluid Dynamics simulation data, to generate high-confidence weapons' trajectories near the tactical aircraft. This capability is necessary to ensure stores separate safely from the aircraft before their design is finalized. In addition, the novel software tool will assess separation dynamics, which are critical to weapon controllability and performance.

PHASE I: Develop workflow, explaining a novel approach for simulating store trajectories using Next Generation 6DOF equation-of-motion solver. Approach must include interpolation schemes and be compatible with Windows 10. The preferred solution is Operating System independent. For example, the proposed tools/process could use webapps, function in platform-independent environments (such as python scripts), or be compiled to run on modern versions of Windows (version 10), Mac OS (version 12), and RedHat Linux (version 8) operating systems with no special environments or libraries. Concept software designs for integrated visualization tool and miss distance calculator will be generated with performance estimations or simple demonstrations of capabilities showing time to compute. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Produce prototype toolset based on the Phase I results. Develop and refine toolset workflow assuring accurate and efficient calculation and user interaction with computed data. Validate core 6DOF calculations with relevant inputs simulating known trajectories. Demonstrate entire workflow and applicability with Navy Information Technology (IT) systems.

PHASE III DUAL USE APPLICATIONS: Complete validation and verification of Next Generation toolsets. Speed of code performance, as well as accuracy of calculation comparisons to existing tools (where applicable), workflow and compatibility with Naval Air Systems Command (NAVAIR) systems will be evaluated.

The resulting 6DOF computational modeling capability can be utilized for optimization and evaluation of airdrop separation from commercial aircraft, ensuring safe separation and delivery of packages for commercial and humanitarian relief applications. Because the core dynamic equations are derived from general equations of motion, coupled with integration algorithms to yield a trajectory, the product is able to calculate the dynamics of several types of vehicles in motion, such as general aircraft, orbital launch vehicles, and so forth [Ref 2].

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KEYWORDS: Store Separation; Six-Degree-of-Freedom; 6DOF; analysis toolset; trajectory; calculation; visualization

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N231-007 TITLE: DIGITAL ENGINEERING - Digital Modelling and Simulation of Maneuvering Hypersonic Weapons

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

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

OBJECTIVE: Develop and advance computational simulation tools for modeling of weapon maneuvers in the hypersonic flight regime.

DESCRIPTION: The maneuverability of hypersonic vehicles offers a significant tactical advantage as maneuvering can increase both weapon survivability and lethality, especially in the endgame scenario. However, it is important to understand the design tradeoffs between maneuverability and effectiveness (e.g., range, impact velocity, etc.) to ensure a high probability of mission success. Simulating the vehicle environment and response over the entire trajectory with high-fidelity modeling tools is often intractable due to the high computational cost. In practice, low-fidelity physics models (i.e., zeroth to first-order models) are used to simulate the environment and response of the vehicle across its intended trajectory. These low-fidelity models often neglect a large degree of the complex physics encountered in the hypersonic regime. To ensure vehicle performance and mission effectiveness, it is critical that computational tools are able to accurately (90 – 95% accurate) and efficiently predict the vehicle trajectory and its ability to maneuver during the glide phase and at endgame. New computational tools and methods are desired, which leverage high-performance computing and surrogate/reduced-order modeling without degrading model fidelity while utilizing reduced computational resources for full-trajectory and mission-effectiveness simulations. 90 - 95% accuracy is a reasonable goal. The modeling approach will consist of a rocket boosted hypersonic glide body. The simulation shall begin after rocket separation. The glide body should glide along a predetermined powered trajectory and perform maneuvers along the ingress to the target. Final selection of the study vehicle and associated propulsion system will be made in Phase I with government agreement. The study vehicle should focus on phenomena in the Mach 5 – 10 range. The end simulation shall be capable of sustained (minutes) in this regime.

Proposed solutions should include any relevant expertise and experience in predicting high-Mach aerodynamics and development of associated simulation models. Demonstrated experience in low-order modeling of high-fidelity physics is a factor. Consideration could be given to interface definition for compatibility with other high-fidelity codes, model attributes of relevant physics in the regime, computational cost, and potential for integration into existing simulation tools like CREATE AV. Company codes are acceptable but any new methods must be adaptable to government codes like CREATE AV. Consideration should be given to the appropriate balance of computational cost, code complexity, and accuracy of prediction. Uncertainty quantification of the tool is strongly encouraged.

PHASE I: Review the accuracy and cost of current industry standard existing computational tools/methods at simulating the trajectory (including boost, ballistic, cruise, and terminal phases), accuracy, and computational cost of hypersonic maneuvering vehicles. Assessments of computational tools should address the adequacy and fidelity of physical models, including, but not limited to, aerodynamic models and flight trajectory models. Identify the gaps/limitations of existing tools/methods at accurately predicting vehicle performance over the full trajectory. For methods that are deemed inadequate, describe how the method can be updated to make it suitable for hypersonic applications. Any description of method development should capture the work required and associated risks. A canonical vehicle geometry and associated source data (e.g., flight test data, ground test data, etc.) should be identified to support and validate any proposed method development to occur in Phase II. Availability of validation data is a consideration.

Availability of new or existing approaches to reduce the computational burden associated with running high-fidelity prediction tools should be evaluated. The Phase I product should focus on any existing methods that could significantly reduce computational cost (e.g., CPU count, CPU hours, memory allocation, etc.), while not substantially impacting simulation accuracy. The Phase I report should provide a detailed plan for Phase II including schedules, important milestones, specific tasking, and availability of computational resources. If use of DoD High Performance Computing resources is required, resource requirements should be identified in detail. Maximum use of in-house resources is encouraged. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop the computational tools/methods necessary to accurately predict vehicle response over the vehicle's trajectory at reduced cost (50 – 75% computational cost reduction target). Any computational tools developed should execute quickly on modest hardware such that trajectory analyses can be performed with minimal turnaround time. The desired level of model fidelity and complexity should be considered above that which is typically used in conceptual design tools. Multiple analyses per day on multiple (< 10) computing platforms is a reasonable target. Incorporate newly developed tools/methods (e.g., ROM for aerodynamics) into existing DOD toolsets (e.g., CREATE-AV products or others). Exercise updated toolsets using a generic hypersonic vehicle geometry and evaluate predictive capability against available test data. Determine metrics for quantifying uncertainty in simulation predictions. Establish confidence intervals using uncertainty quantification toolsets/methods.

PHASE III DUAL USE APPLICATIONS: Verify and validate (V&V) the new methods based on available test data. Methods should be updated based on the V&V effort. Additional analyses should be performed on a Navy relevant configuration.

With the push for commercial aircraft operating at hypersonic speeds now part of the national discussion, the tools and methods developed under this SBIR topic will have utility to the design and development of future commercial hypersonic platforms.

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KEYWORDS: Hypersonics; Maneuver Prediction; Computational Aerodynamics; Aircraft Performance; Digital Engineering; Weapons

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N231-008 TITLE: DIGITAL ENGINEERING - Broadband Real-time Data Bus

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Networked C3

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

OBJECTIVE: Develop an open protocol, software and hardware to support the use of IP devices (e.g., an Ethernet-enabled sensor with an Ethernet-enabled mission computer system) over a STANAG-7221 link without interfering with a MIL-STD-1553 connection being used concurrently.

DESCRIPTION: Many currently fielded Navy platforms use the serial bus standard MIL-STD-1553. The standard features multiple redundant balanced line physical layers, a (differential) network interface, time division multiplexing (TDM), half-duplex command/response protocol, and can handle up to 30 devices. Typically, this ensures that platforms have twin-axial (co-axial) cabling installed throughout the asset, even including weapons interfaces, which connect to external mounted weapons or information pods. The data rate exhibited by MIL-STD-1553 (around 1 Mbps) is insufficient for many platform data requirements,; for example, full motion video surveillance, software defined radio interfaces, and raw radar data transfer. In 2016, STANAG 7221 was introduced, which described the Broadband, Real-Time Data Bus (BRTDB) Standard which supports up to 200 Mbps data transfer over the same twin-axial cabling currently in the platforms without interfering with the existing MIL-STD-1553 data transfer. Essentially STANAG 7221 utilizes a Digital Service Link (DSL)-like frequency division multiplexed (FDM) architecture. Digital Service Link is defined as the following: transport service delivered via the internet or other electronic network, which is automated and requires little to no human intervention to operate. For this SBIR topic, implementing STANAG 7221 implies the higher data rate (and higher frequency) STANAG 7221 signals can co-exist with the standard MIL-STD-1553 signals (at lower frequency). Co-existence of these signals on a single bus is by this definition, “high data rate” and using spread spectrum (signals at high and low frequencies) in an FDM architecture constitutes “Broadband.” This feature is extremely powerful considering the difficulty involved with changing cable configurations on aircraft (impacting the Operational Flight Plan) and changing cable configurations on Navy ships (impacting the certified ship configuration).

With most sensors and computing devices supporting IP over Ethernet, in a typical environment these items can easily be added, removed, or moved in a platform network with a simple configuration change and the movement of some standard connectors, often RJ-45 or MIL-DTL-38999. In contrast, the use of STANAG 7221 requires some significant development effort to adapt a device specific proprietary interface to the 7221 data physical layer at both source and destination.

The proposed solution should support Standard Network Management Protocol v3 (SNMP) for management and statistics, or an equivalently acceptable standard. The design should consider warfighter ease of use to create a data bus that is legacy compatible and does not impact the standard 1553 bus configuration, effectively “plug and play,” to enable STANAG 7221 speeds for IP-based traffic simultaneously. Warfighter input as a key design input is recommended. This solution should be prototyped and tested against programmatic requirements and not require a Depot maintenance cycle to implement (i.e., be installed either at the Operational or Intermediate level of maintenance, i.e., "drop in" or "Plug and Play" without any required user configuration once installed.)

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. owned and operated with no foreign influence as defined by DoD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence and Security Agency (DCSA) formerly Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances. This will allow contractor personnel to perform on advanced phases of this project as set forth by DCSA and NAVAIR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advanced phases of this contract.

PHASE I: Create and demonstrate the feasibility of a real-time broad band data bus capable of supporting legacy MIL-STD-1553. and also demonstrate transmission of data at a higher data rate, higher bandwidth traffic on a common data bus. Methods for bridging data and providing link status should be investigated. Issues associated with using STANAG 7221 should be investigated and mitigated. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop a prototype hardware solution with integrated software, which is able to drop in and provide IP connectivity at STANAG 7221 speeds over MIL-STD-1553 bus with no manual configuration required.

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

PHASE III DUAL USE APPLICATIONS: Further develop, transition, and integrate a production level device, which can be installed on platforms and used to transport IP data at 7221 data rates over 1553 buses.

The commercial sector has mostly adopted higher data rate standards than MIL-STD-1553. However, the use of Time-Differential and Frequency-Differential modulation on the same channel has industry application and can be ported to analogous systems. This also serves as a precursor for Fiber Channel communications and Free Space Optics, which are used currently in industry and will later be adopted by Military armed forces once affordable, and coincident with a program that can leverage industry's investments.

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KEYWORDS: Broadband; High Data Rate; FDM; TDMA; STANAG; Twin-Axial; Co-Axial

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N231-009 TITLE: DIGITAL ENGINEERING - High-Speed Data Return for Tactical Environments

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Artificial Intelligence (AI)/Machine Learning (ML); General Warfighting Requirements (GWR)

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

OBJECTIVE: Develop a solution to utilize data that would otherwise be wasted, and use it to determine near real-time solutions for ongoing and soon to be executed missions.

DESCRIPTION: U.S. Navy aviation platforms continue to add sensors and storage for data/intelligence collection. While some of that data informs battlespace management teams, often subtle, useful data returns with the platforms after a mission, without being analyzed and exploited.

There is no current process to cull and analyze such data for timely (real-time/near real-time) and useful information (not already identified and designated in the real-time battlespace management arena) capable of informing mission planning and tactics development teams for near-future exploitation. Hand analysis alone by individuals is unlikely to meet this need. Therefore, the Navy requires high-speed data returns for tactical environments. Today there exists a need to create/enhance the ability to download, aggregate, and analyze seemingly innocuous or inconclusive data gathered by tactical and strategic sensors and provide possible tactically relevant conclusions for timely (hours/days) exploitation to mission planners. Within the Department of Defense and similar agencies, there could certainly be vast opportunities for technology transfer and adaptation. The analysis and use of meta-data within law enforcement and similar agencies is a useful guide. Adaptations outside the armed forces could also be numerous, depending on adaptability of any software and/or algorithms involved (biomedical, etc.).

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. owned and operated with no foreign influence as defined by DoD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence and Security Agency (DCSA) formerly Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances. This will allow contractor personnel to perform on advanced phases of this project as set forth by DCSA and NAVAIR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advanced phases of this contract.

PHASE I: Design, develop, and demonstrate feasibility of data aggregation, analysis, and exploitation construct that meets tactically relevant mission planning timelines (minutes/hours) between various sea, air, space, and cyber mission planning tools. The Phase I effort will include prototype plans to be developed in Phase II.

PHASE II: Finalize, test, and demonstrate a prototype that can locally aggregate, analyze, and exploit tactically relevant information – not exploited/exploitable during real-time battle management –gathered by disparate naval aviation platforms for follow-on mission planning.

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

PHASE III DUAL USE APPLICATIONS: This is an issue that transcends naval air platforms as it addresses the efficient utilization of data in a virtual environment where there is an overabundance of data being collected and stored, but not always utilized. Massive amounts of data being collected and then stored without being utilized for its near real-time value is not limited to armed forces, it is an issue that can be alleviated within private sectors supporting critical infrastructure.

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KEYWORDS: Tactical intelligence; data management; mission planning; air platform; data exploitation; data analysis

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N231-010 TITLE: Active Low-Voltage Thin-Film Lithium Niobate Electro-Optic Modulator

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

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

OBJECTIVE: Develop an electro-optical device that can practically, and reliably, enable the direct connection between an antenna and a photonic link on a tactical platform.

DESCRIPTION: Radio frequency (RF) photonic systems offer wide bandwidths and unique signal processing that can advance the capabilities of microwave, and millimeter-wave, receivers [Refs 1, 2]. With the addition of the direct antenna to photonic link, proposed in this SBIR topic, RF photonic systems can also increase the sensitivity, dynamic range, and flexibility of microwave, and millimeter-wave, receivers.

With the addition of wavelength division multiplexing (WDM), multiple RF over fiber (RFoF) links can be matched with an antenna array to independently return all the RF signals from an antenna array over a single fiber. Such a system could increase the sensitivity and dynamic range of the array and mitigate the coaxial cabling weight and loss. On one tactical platform, the switch from RF cabling to RFoF would result in an estimated 200 lbs. of weight reduction. With a direct antenna to photonic link, the temperature sensitive elements of the photonic system can be contained in a protected environment within the tactical platform where size, weight, and power (SWaP) and environmental constraints are relaxed.
RF photonic system designs have traditionally been hampered by poor Spurious Free Dynamic Range (SFDR) and high noise figures (NF) due to the performance of the electro-optic modulator that converts RF to RFoF.

The high noise figure is primarily caused by the large half-wave voltage (Vpi) of the electro-optic modulator and low optical power levels [Ref 3]. The high noise figure is typically overcome by the addition of a traditional low noise amplifier (LNA) being placed in front of the modulator. The LNA can lower the noise figure, but it is vulnerable to electromagnetic interference (EMI), and it limits both the bandwidth and the SFDR of the overall system, so that the full capabilities of the RF photonic system cannot be realized.

The dynamic range in an RFoF system is dependent largely on the optical power level. High optical power levels can melt or burn fiber connections due to impurities in the epoxy used to glue fiber pigtails or dirt in the connectors. These challenges typically make high optical power difficult, or even impossible, to use in tactical systems due to concerns of manufacturability, reliability, and maintainability.

An electro-optical device that can directly connect between an antenna and a photonic link without an LNA will need to overcome the high half-wave voltage (Vpi) of the modulator and the high optical power necessary to achieve the required noise figure and SFDR.

Recent advances in thin film Lithium Niobate (LiNbO3) modulators have demonstrated that a Vpi of < 1 V is achievable with low insertion loss within an Integrated Photonic Circuit [Refs 4–6].

An active thin film LiNbO3 modulator is a device that combines a high power optical amplifier with a thin film LiNbO3 modulator on a single photonic integrated circuit. This device achieves both the RF performance and system reliability by isolating the high-power optical elements to within a single photonic integrated circuit.

This device will accept an optical power input from a fiber pigtail in the range of 10 dBm to 20 dBm between 1530–1565 nm. The optical signal will be amplified to 30dBm with a constant output amplifier that is integrated on a photonic integrated circuit to directly feed a thin film LiNbO3 modulator in a Mach-Zehnder configuration. The device will provide a 50 ohm RF input with an RF Vpi = 0.5V @20GHz and a 3dB bandwidth at > 30 GHz. The device will provide a dual fiber pigtail output to enable balanced detection [Ref 7]. The thin film LiNbO3 modulator will have a < 3dB optical insertion loss to be demonstrated by a measured optical power level of 27 dBm out of one of the output fibers in a null or peak bias configuration. The expected RFoF link performance using the device is a Noise Figure of 3db and an SFDR of 116dB/Hz at 20GHz, and a total link bandwidth of 0.1-30Ghz

The SWaP-C of the device must be < 50cm^3 to enable mounting at the antenna on a tactical platform. The device should demonstrate an amplifier efficiency of 10% or greater with plans to achieve an operating case temperature of -60 °C – +80 °C. Monitoring and control circuitry for the amplifier and modulator should be self-contained within the device requiring only DC power to the device [Refs 8–10].

PHASE I: Develop a chip-level layout and packaging concept for an active thin film-based LiNbO3 modulator with a clear path to meeting the specifications detailed in the Description. Identify key risk areas to realizing the desired modulator performance and packaging constraints, and mitigate these risks using die-level demonstrations and packaging process development. Demonstrate that a modulator can achieve the desired RF performance specifications with a proof-of-principal benchtop experiment. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Optimize the Phase I design. Create, and test a functioning active thin film-based LiNbO3 modulator, and package the modulator. Demonstrate a packaged, fiber-pigtailed prototype for direct insertion into a photonic link. Demonstrate the Vpi, optical power levels, and amplifier efficiency. Demonstrate prototype operation in an RF photonic link showing compliance with the objective noise figure, SFDR, and frequency range. Characterize the temperature sensitivity of the packaged device and develop a packaging concept to meet the full environmental requirements. Show a path to manufacturability up to 5000 devices/year.

PHASE III DUAL USE APPLICATIONS: Support the DoD in transitioning the proposed modulator. This will include working with a program office to develop a final packaging design that meets the platform SWaP and environmental requirements and developing systems specifications for the associated analog photonic links.

Development of these modulators has widespread commercial applications from 5G/6G signal routing to low-power digital telecommunications and data center routing.

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KEYWORDS: Radio-frequency over fiber; microwave photonics; half wave voltage; noise figure; spur free dynamic range; thin film lithium niobate; fiber optic; electro-optic modulator

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N231-011 TITLE: Optical Additive Manufacturing in Mid-Wave and Long-Wave Infrared Bands

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

OBJECTIVE: Demonstrate the capabilities and benefits of applying state-of-the-art additive manufacturing (AM) for Mid-Wave (MWIR) and Long-Wave infrared (LWIR) refractive lenses, and optically transparent windows, by developing novel AM methods and processes using toxic precursor materials.

DESCRIPTION: For the last few decades, the military has used LWIR (8–12 µm wavelength range) and MWIR (3–5 µm wavelength range) sensors and cameras for reconnaissance and surveillance of targets of interest by thermal emissions.

These MWIR and LWIR sensors and cameras use hazardous materials, mercury (Me), cadmium (Cd), and tellurium (Te) as precursor materials in their optics manufacturing. Indium phosphide (InP) and zinc sulfide (ZnS) have emerged as a presumably less hazardous alternative to cadmium-based optics, yet little is known about their toxicological effects.

Currently, no commercial AM system can be used to repair MWIR and LWIR imaging quality optical glass with sufficient dimensional accuracy and surface finish. A robust MWIR and LWIR AM process to perform net deposition of MWIR and LWIR optical materials on existing glass substrate, which can provide MWIR and LWIR optical imaging surface quality, is needed. This MWIR and LWIR AM process should be able to deposit hazardous MWIR and LWIR optical materials within the desired transmission band, and provide a smooth optical surface quality, so that minimum post-processing is needed. With homogeneous glasses, AM has the potential to rapidly repair existing MWIR and LWIR optical systems with no or minimal post processing (e.g., least amount of time for a final polish to achieve a desired surface flatness, such as lambda/10.) This will dramatically enhance the logistics and maintenance of the Navy's optical systems.

In January 2007, President George W. Bush signed Executive Order (EO) 13423 (2007) Strengthening Federal Environmental, Energy, and Transportation Management, requiring government agencies to reduce the quantity of toxic and hazardous chemicals and materials that are acquired, used, or disposed. Cadmium is among the chemicals to be reduced by the DoD. As a result of this regulation, the use of cadmium significantly raises the maintenance costs throughout the life of MWIR and LWIR sensors and cameras.

Due to these increasing costs, regulatory pressure, and risk to personnel performing, a robust MWIR and LWIR AM process to repair MWIR and LWIR optical sensors and cameras with good optical properties and surface quality is needed. This MWIR and LWIR AM process should be able to deposit MWIR and LWIR optical precursor materials within the desired transmission band and provide a smooth optical surface quality so that minimum post-processing is needed.

The Navy desires to understand how to implement and use a novel MWIR and LWIR AM process with respect to:
(a) optical materials deposition within the desired transmission band, thus providing optics with an optical surface quality of lambda/10 flatness with minimum post-processing; and
(b) how and when MWIR and LWIR AM will be financially beneficial to support field optical repairs.

Emphasis should be placed on MWIR and LWIR AM systems with respect to minimizing hazards, risks, accidents, and near misses, cost reduction (both production and Non-Recurring Engineering (NRE) for tooling), sustainability (waste reduction, reduced need for large dedicated tools, etc.), and AM manufacturing process improvements. The proposer should consider this effort as the innovative advancement of developing a novel MWIR and LWIR AM systems for MWIR and LWIR optical components repairs that meets the following performance objectives:

1. Prove by demonstration the state-of-the-art novel MWIR and LWIR AM methods to produce an optical surface with a flatness having the following characteristics: (a) a net surface flatness of lambda/10, Centration = 3 arc minutes, Clear Aperture > 90% of Diameter; (b) with a transmission window from 3—5 µm and a second transmission window 8—12 µm; (c) Clear aperture must be 3 in. in diameter; and (d) a thermalized design that must work from -54° to 90°C.
2. Provide a cost analysis of MWIR and LWIR AM for MWIR and LWIR optical components versus machining or tooling, which should include the cost of time to acquire the parts (impact on enabling a rapid prototype turnaround), as well as material and any associated labor costs.
3. Based on research, develop a timeline of events for when the developed MWIR and LWIR AM technology may be extended to high-rate production of optical components.
4. Develop a plan and process for using the developed AM technology for the manufacturing of MWIR and LWIR optical components, and ultimately implemented to develop and manufacture selected MWIR and LWIR optical components.

PHASE I: Analyze the current state-of-the-art MWIR and LWIR AM technology. Identify the technological, innovative, and reliability challenges to determine the feasibility of using MWIR and LWIR AM for the refurbishment of MWIR and LWIR optical components (the required optical properties, full densification, and smooth surface finish, as provided in the Description), and propose a plan for how these will be addressed. Perform a preliminary identification of hazards and cost comparisons for MWIR and LWIR AM of MWIR and LWIR optical components.

Demonstrate the feasibility of the concept in meeting topic description, and establish that the concept can be minimally toxic, feasible, and affordably produced. Feasibility will be established by some combination of initial prototype testing, analysis, or modeling. Affordability will be established by analysis of the proposed materials and processes, and by comparison to existing and established semiconductor, additive, and automated manufacturing techniques. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype using MWIR and LWIR AM. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Design and fabricate, using MWIR AM, a MWIR window with an 8° or 0° face angle for imaging in the MWIR (3-5 µm) with a surface flatness of lambda/10. Perform optical testing on the components and compare to current production components. Integrate the prototype components into a U.S. Government-provided unmanned air vehicle (UAV) turret assembly, and perform a series of evaluation tests to validate feasibility. Government provided UAV specification documentation that includes metrics and testing methods will be provided prior to Phase II. Develop an initial process that will be further refined in Phase III as part of Government depots using the MWIR and LWIR optical component MWIR and LWIR AM capability, including a timeline of events envisioned.

Determine optimized processing conditions, cost model, and report commercial viability of MWIR and LWIR AM process.

PHASE III DUAL USE APPLICATIONS: Provide representative prototype samples using the developed AM process to a U.S. Government laboratory and a Government depot. Evaluate, by conventional metrology, the innovative optical surface with the flatness, as stated in the Description, to ensure the AM process is on par with an optical flatness produced by common practice. Transition the AM process to a U.S. Government laboratory and a Government depot. Perform testing and make improvements to the AM process based upon the Government's evaluations and results. Begin producing optical MWIR and LWIR AM components for field testing and use in military systems.

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

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KEYWORDS: additive manufacturing (AM); lens; window; toxic; repair; optical

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N231-012 TITLE: Compact, High-Performance Metamaterial Acoustic filter with Monolithic Integrated Signal Processor

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR);Microelectronics

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

OBJECTIVE: Develop passive acoustic metamaterials that can be combined/supplemented with the Navy's existing acoustic sensor to perform analog signal processing, with the following simultaneous and substantial performance improvement objectives:

(a) 10X improvement in the signal to noise ratio;

(b) 1000X reduction in the amount of post-reception signals requiring Analog to Digital (A/D) & D/A conversions, digital processing, and sensor-to-aerial platform transmission, thereby significantly and commensurately improving the overall system speed and reducing the sensor power consumption.

DESCRIPTION: Naval underwater acoustic sensors operate in an underwater environment that is inundated with noises from multiple natural and man-made sources such as breaking waves, marine lives, and ship traffic. Reducing the noise level in an acoustic sensor's received signals is critical to increasing the sensitivity in detecting acoustic signatures of modern underwater ever quieter naval targets. Since naval underwater acoustic sensors are deployed in water as expendable sensors, they also are constrained by limited on-board power supply, as well as the latency in system communication and information processing with the aerial platform. Acoustic metamaterials have recently demonstrated the full control of acoustic waves' amplitudes and phases [Refs 1–4], and therefore create the unparalleled potential to be used as an integrated analog signal processor within a sensor. This unique characteristic of the metamaterials is revolutionary, as the conventional acoustic sensors alone cannot possess any sensed signal or information [Refs 5–7]. A passive acoustic metamaterial layer mounted on the front end of an acoustic sensor can process the incoming acoustic signals, extract, and identify the acoustic signatures before acoustic-to-electrical transduction, A/D conversion, and sensor-to-aerial platform transmission. Such analog signal processing components will lead to significantly increased signal-to-noise ratio, reduced power consumption, and improved sensing speed compared to the existing legacy systems that directly capture and relay all the received digital signals to the aerial platform for back-end digital processing.

One pragmatic approach for implementing this multifunctional metamaterial filter/processor for improving the signal-to-noise ratio is to implement acoustic frequency and spatial filters into the metamaterial filter layer to remove the noises from various sources. Those filters can be created with arrays of subwavelength resonance structures. For instance, if the center frequency and direction for the acoustic signal reception are f_0 and a_0, respectively, only the signals within a narrow frequency band (e.g., f_0 ± 0.1f_0) and direction range (e.g., a_0 ± 10°) will be able to pass through the metamaterial layer and reach the underlying sensor. Noise outside the designated frequency and direction ranges will be rejected. In addition to metamaterial's noise reduction capability via frequency/direction filtering, the metamaterial layer is multifunctional and also possesses the aforementioned unique, game-changing feature of extracting and identifying relevant underwater acoustic target signatures without the traditional back-end post-reception digital computational processing. Only those extracted features will be converted to electrical signals, digitalized, and transmitted to the aerial platform. As a result, there would be a 1000X reduction in the post-reception and post-detection information signals that require A/D & D/A conversions, digital processing, and sensor-to-aerial platform transmission, thereby significantly and commensurately improving the overall system speed. Last, but not the least, as the acoustic metamaterial layer is a completely passive structure that has no power consumption, the associated electronics of the acoustic sensor will consume less power and have lower complexity proportionally compared to that of existing legacy sensor system.

It is therefore the goal of this SBIR topic to develop passive acoustic metamaterials that can be combined/supplemented with the Navy's existing acoustic sensor to perform analog signal processing, with the following simultaneous and substantial performance improvement objectives:

(a) 10X improvement in the signal to noise ratio;

(b) 1000X reduction in the amount of post-reception signals requiring A/D & D/A conversions, digital processing, and sensor-to-aerial platform transmission, thereby significantly and commensurately improving the overall system speed and reducing the sensor power consumption.

PHASE I: Determine feasibility of suitable acoustic metamaterials and the design procedure for a passive signal processing layer that extracts underwater target signatures from acoustic echo signals. Develop a detailed concept design that shows 10X improvement in the signal-to-noise ratio and 1000X reduction in the amount of post-reception and post-detection information requiring A/D & D/A conversions, digital processing, and sensor-to-aerial platform transmission. Modeling and simulation, or other rigorous and scientifically sound methods, should be used to demonstrate the metamaterial's performance in accordance with the stated metrics of interest. Begin development of a prototype manufacturing plan for Phase II. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop, demonstrate, and validate a well-defined deliverable prototype, which meets topic requirements. Test and evaluate the acoustic filtering and signature detection performances of the prototype in a laboratory setting and then in a relevant simulated operating environment compatible with intended naval applications. Deliver a prototype, including recommendations for large-scale manufacturing.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology for DoD use. Since the design and prototypes are generic, assist in applying the design for specific system applications such as active or passive underwater target detection and identification.

The industrial and medical sectors can also benefit from this crucial, game-changing technology development in the areas of acoustic detection and identification for industrial equipment and noninvasive health monitoring and sensing with unprecedented signal-to-noise improvements.

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KEYWORDS: Metamaterials; Acoustic Filter; Monolithic; Signal Processor; Acoustic Sensor; Aerial Platform

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N231-013 TITLE: Tip-Off Optical Reconnaissance-Sensor for Counter Hypersonics (TORCH)

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Artificial Intelligence (AI)/Machine Learning (ML);Hypersonics;Space

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

OBJECTIVE: Develop and demonstrate critical elements of advanced optical system design for the detection, identification, and tracking of hypersonic cruise missiles to provide early cueing of fixed-site and ship self-defense systems in a tiered fixed and mobile network utilizing both unmanned and manned platform concepts.

DESCRIPTION: Due to the rapidly escalating threat that hypersonic vehicles present to Armed Forces of the United States, it is desirable to have reliable early warning system for "tip off" alert to incoming hypersonic vehicles. This SBIR topic is looking to augment a stationary and mobile tiered capability with a unique optical sensor capable of addressing this threat type. This capability is also measurement and signature intelligence (MASINT).

Hypersonic weapons represent a new and disruptive threat to Armed Forces worldwide. The operational attributes of this class of vehicle present a unique detection and defense problem. There is a need for advanced sensing to support initial detection ("tipoff"), as well as targeting and guidance for defensive systems. A unique attribute of hypersonic weapons is the ability to maneuver and approach a target area from many potential directions, which vastly complicates the sensing problem by increasing the required search volume and requiring increased sensing resources. To be useful, a cost-effective, distributed, early-warning sensing architecture is required to provide "tipoff" to alert Armed Forces of incoming hypersonic threats.

The attributes of such an architecture include, but are not limited to:

(a) a passive sensor with target classification capability,
(b) capability to relay communications through multiple pathways, and
(c) a cost-effective and covert platform.

Sensor Chip Array (SCA) target metric characteristics include, but are not limited to:

(a) Format 1024 x 1024
(b) Pixel Pitch 20 μm x 20 μm
(c) Wave Band Optimized Mid-Wave Infrared (MWIR)
(d) Quantum Efficiency 80%
(e) Operating Temperature 150 K (goal)
(f) Frame Rate 2.5 kHz (full frame), 10-50 kHz (windowed)
(g) Read Noise (input referred RMS) 350 e-
(h) Well Depth 250 k e-
(i) Single Sensor FOV 34°
(j) NEI (measured) 2E11 photon/cm^2s

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. owned and operated with no foreign influence as defined by DoD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence and Security Agency (DCSA) formerly Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances. This will allow contractor personnel to perform on advanced phases of this project as set forth by DCSA and NAVAIR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advanced phases of this contract.

PHASE I: Define sensor carrying requirements in terms of power, volume, weight, noise limitations, motion limitations, and so forth. Identify specific configuration(s) to be included, and develop the strategy and design of integration and scale of the autonomous platform. Define the prototype system to include the requirements of observation behaviors, software, and communications to allow cooperative sensor array technology. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop a prototype that can perceive, identify, and track a hypersonic vehicle in an idealized Navy data collection. Further develop a prototype and demonstrate it on a manned or unmanned system. Perform ground- or sea-based trials data collection of individual vehicles in terms of feature identification performance, operational agility, and accuracy. Perform limited sea trial test data analysis of airborne objects.

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

PHASE III DUAL USE APPLICATIONS: Complete final testing and perform necessary integration and transition for use in counter-hypersonic surveillance and monitoring operations with appropriate current platforms and agencies and future combat systems under development.

Commercially, this product could be used to enable remote airborne environmental and satellite monitoring.

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KEYWORDS: Hypersonic; counter-hypersonic; electro-optic; surveillance; classification; remote sensing; AI/ML

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N231-014 TITLE: Multistatic Radar Network Distributed Time, Frequency, and Phase Synchronization System

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Cybersecurity; General Warfighting Requirements (GWR); Networked C3

OBJECTIVE: Develop and demonstrate an adaptive distributed time, frequency, and phase synchronization system having a clock capable of achieving a stability less than 1E-15/sqrt(tau) with flicker floor less than 1E-17 with a 1E-16 long-term stability for a multistatic radar network.

DESCRIPTION: There is a Synthetic Aperture Radar (SAR) network requirement for a precise space-time synchronization system. The stringency of this synchronization requirement tightens with increasing bandwidths and carrier frequencies. Moreover, time errors translate to range errors, and phase and frequency errors negatively affect the Doppler processing and phase coherence. Simple one-way, or standard two-way, time transfer between flying clocks will completely break down because of the time-of-flight variations and Doppler shifts associated with the strongly time-varying link distances. These problems are often approached monolithically and from a monostatic point of view. However, much could be gained by designing these subsystems from a multistatic system's perspective.

In cases where exploiting bistatic SAR using transmitters of opportunity locating objects of interest in operational theaters without drawing the attention of hostile forces, the limits on time and frequency synchronization may well be set by the radar hardware rather than the method of time transfer. Moreover, the propagation delay from antenna feed to frequency sampling often changes depending on the selected radio frequency (RF) pathway, attenuation or gain, and frequency band. Depending on the RF architecture, this delay may vary by many nanoseconds. Additionally, this delay may drift over the lifetime of the hardware, or due to temperature and internal platform power line variations. Thus, this RF path delay requires continuous calibration to achieve sub-nanosecond timing. Further, the local oscillator carrier is often digitally synthesized, which sets the lower phase noise and spurious limits along with the smallest possible frequency increment. The radar transmission trigger and pulse repetition frequency (PRF) control lines are generally digitally driven (e.g., field-programmable gate array (FPGA)). Such FPGA switching circuitry may have a peak-to-peak jitter as high as 150 ps. Digital devices may also have propagation delays on the order of nanoseconds with the gate-to-gate, and more so, part-to-part, skews of several nanoseconds. Finally, cable lengths of 1 cm amounts to about 51 ps in a RG-58 coax cable. Thus, careful calibration of the RF and digital pathways is required to achieve sub-nanosecond timing. Timing, better than approximately 100 ps, will require an ultra-precise clock operating in femtoseconds. Allowing for 50 ps breakdown in time-of-flight reciprocity, the radar network timescales must be synchronized to less than 1E-15 seconds in time deviation.

Ship defense depends on Doppler radars that detect and track sea-skimming missiles in the ocean clutter. Since the Doppler shift of a fast missile would be far larger than the Doppler shift of known maritime sources of radar clutter, the background noise floor is provided by the phase noise of the local oscillator. Since the radar cross section of an anti-ship missile is very small, detection is difficult. Measurement noise floor analyses revealed excess laser noise to be the dominant performance limitation. Thus, reducing the noise floor is worthwhile in terms of detecting targets with smaller radar cross section at greater ranges. The current instability of microwave stable local oscillators (STLOs) is about 1E-13. Using all-optical clock (1E-16 to 1E-18 inverse square root of the integration time) techniques, a stability improvement of about a factor of 100 should be possible. This should significantly lower the noise background against which sea-skimming missiles need to be detected, and thus improve radar effectiveness in terms of probability of detection and range.

Hence, there is a need for an affordable timing synchronization system with a tactical atomic clock (threshold), and to be later upgraded with a chip-scale photonic integrated clock (Objective). The chip-scale photonic integrated clock for large-scale radar network shall have a stability less than 1E-15/sqrt(tau) with flicker floor less than 1E-17, and with a 1E-16 long-term stability for a multistatic radar network. The tactical atomic clock and the chip-scale photonic integrated clock should be robust, universal, and transfer medium independent. Moreover, either clock should be easy to interface to a wide range of synchronization systems and sensors to suit a variety of networked radar applications. A two-way time transfer scheme is required to null the propagation delay. A holdover capability is highly desirable in case the transfer medium becomes temporarily unavailable. It is further required to have the capability to synchronize using the transmitted radar emissions in absence of a dedicated time transfer medium. Finally, the time and frequency accuracy should match or exceed the limits set by cognitive radar systems used in radar communication networks performing multiple activities and tasks simultaneously.

The timing synchronization system with a tactical atomic clock (threshold), and to be later upgraded with a chip-scale photonic integrated clock (Objective), must be able to operate in the following environments:

(a) Operational Temperature: -40°C–70 °C,
(b) Storage Temperature: -51 °C–85 °C,
(c) Operational Altitude: 0–65,000 ft (0–19,812 m) above sea level,
(d) Mechanical Shock: 40 g, 11 ms, each axis,
(e) Vibration: Tracked and Wheeled Vehicle, Fixed- and Rotary-Wing Aircraft, Unmanned Air vehicles, Gunfire;
(f) Fluid Contaminations: Diesel, Hydraulic, Oil, Bleach;
(g) Relative Humidity: 10–95%
(h) EMI/EMC: MIL-STD-461F, RE102, CE102, CS101, CS114, CS115, CS116, RS103;
(i) Power: MIL-STD-1275E, MIL-STD-704F.

PHASE I: Provide a concept of employment for a timing synchronization system to be an integral part of the radar network using a tactical atomic clock.

Provide a trade-off analysis for a timing synchronization system identifying (1) a tactical atomic clock and a chip-scale photonic integrated clock providing extremely stable timing signals, (2) a radar network signal that needs to be synchronized, (3) a detector that can measure the timing difference between radars, and (4) a control box to lock the timing of all radars to that of the reference. If radars are far away from each other, a timing link is also necessary to deliver the timing signal from each radar in the radar network.

Demonstrate the feasibility of the tactical atomic clock and a chip-scale photonic integrated clock in a synchronization system through modeling and simulation for a bistatic and multistatic radar network. Include the processing blocks that provide the critical functions and include a baseline set of quantitative implementation requirements that will form the basis for further development in Phase II. Provide prototype plans to be developed under Phase II.

PHASE II: Based on the Phase I effort, develop and demonstrate a prototype synchronization system determined to be the most feasible synchronization system for radar networks using a chip-scale photonic integrated clock as specified in the above Description.

Move the synchronization system for radar networks from concept to physical implementation using IEEE 1588v2 Precision Time Protocol where applicable, Network Time Protocol Version 4: Protocol and Algorithms Specification where applicable and 1139-1999 - IEEE Standard Definitions of Physical Quantities for Fundamental Frequency and Time Metrology-Random Instabilities where applicable. The prototype synchronization system will be tested for performance and environmental stability at a government testing facility during a Rapid Prototype Experimental Demonstration (RPED) to be determined at a future date in Phase II option period, if exercised.

PHASE III DUAL USE APPLICATIONS: Test the adaptive distributed time, frequency, and phase synchronization system having a chip-scale photonic integrated clock, and integrate it into SAR military applications, legacy systems, and other platforms that will benefit from this system. Demonstrate time synchronization capability applications running on a local Area Network (LAN) without external time references. Transition the adaptive distributed time, frequency, and phase synchronization system having a chip-scale photonic integrated clock to a Program of Record.

Military applications for an adaptive distributed time, frequency, and phase synchronization system having a clock include unmanned air systems (UAS), micro-air-vehicles (MAVS), miniature precision-guided weapons, compact high-performance missile- and air-launched interceptors, and advanced laser beam pointing/steering systems in need of: (a) frequency-hopped communications; (b) synchronization and/or syntonization; (c) ranging from precision metrology; and/or (d) Position Navigation Timing (PNT) in Global Positioning System (GPS)-denied environments. Other applications include DoD ground and flight test facilities, data acquisition systems, data fusion, internal aircraft or weapon system networks. Commercial applications for an adaptive distributed time, frequency, and phase synchronization system having a clock include guidance of airplanes under GPS-denied conditions and navigation in uncharted terrains. Other commercial applications include: all data acquisition systems, LANs, Wide Area Networks, cloud computing, wireless home phone networks using frequency hopping (UWB), and distributed processing applications.

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KEYWORDS: Time; clock; synchronization; multistatic; picosecond; radar

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N231-015 TITLE: Back End Data Lake and Microservices (BEDLAM) Strategy for Battle Management Aid (BMA) Development

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Artificial Intelligence (AI)/Machine Learning (ML)

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

OBJECTIVE: Develop a prototype integrated multiple Battle Management Aid (BMA) data lake, and expose the data available to developers for reuse while maintaining proper security boundaries for the software applications to protect intellectual property rights of all developers.

DESCRIPTION: The U.S. Government is in need of a method to standardize and add desired data and microservices into a common repository for use and reuse. Data sources are often common between applications but the data is delivered to the application as needed, such that a common data source and common data delivery occurs asynchronously and takes up available bandwidth for intra-application sharing multiple times. Similarly, developers often develop BMA in nongovernment-controlled repositories, which, despite inherent common microservices, may not use the same sources for those microservices (e.g., time servers, network protocols, etc.). As developers deliver code into the U.S. Government's environment, re-development is often required to integrate a replacement set of microservices over the original baseline to adhere to the environment's available source requiring rework to recode to use the U.S. Government source.

In addition, current-state microservices are typically limited to basic data such as time or position. As increasingly complex BMAs are developed, the potential for reuse, and therefore optimization, of shared data across BMAs is limited without a unified data strategy for development/security/operations (DevSecOps) environments. This SBIR topic seeks to take advantage of a subset of known data requirements across current BMAs, to include more complex data available as an output from a multitude of existing applications and leverage the current-state DevSecOps environment to provide that data as one of the available microservices for development. As the U.S. Government seeks to require developers not only to deliver, but actually develop in the U.S. Government's DevSecOps environment, a more flexible back end data lake to enable sharing of data across BMAs in the same environment is desired. An added benefit is that as this government purpose rights data lake is rendered, it should facilitate application porting between environments without imposing an overhead cost, because all used commercial DevSecOps environments may adopt and expand it.

This SBIR topic seeks to enable management of big data by standardizing the mechanism for delivering data repeatedly to multiple applications on a shared network, using data fields common between differing applications. This is also an enabler for network-aware applications to be developed, because one of the common data fields will natively become the required information to interface with a routing stack, and to build the request for data into a common mechanism across the same network. As capabilities like Communications-as-a-Service (CaaS), which is a Program of Record requiring compliant applications to proliferate, are fielded, the same applications may be useful across different platforms with minimal Non-Recurring Engineering to integrate them, and this data lake could become a commoditized government furnished software product to all developers in the future.

The desired solution should be flexible and adaptable. As a given developer requests data and access to data sources, the back end data lake will optimize the computational, storage, and communications bottlenecks inherent in a large monolithic traditional development where feasible, to enable the same data to be accessible to multiple developers, whether contractor or government. The goal is to avoid duplicative storage of data— – and therefore the design might include data translation capabilities as infrastructure the data lake will host. The data lake should also provide an adequate mechanism for the U.S. Government to write BMA requirements into contractual efforts to leverage it, such as an application programmable interface (API) such as RESTful. Note, REST is an Architecture, not a Standard, but rather, it's an architectural style that provides constraints that guide API design. Many APIs do not conform to every element of REST, which has caused some to use the term RESTful to describe the most common types of APIs.

As an example task, many applications exist that enable specific physical layer control over a tactical radio, but these are typically developed by the radio manufacturer, necessitating a license cost for any network controller leveraging that particular application. For next-generation Naval Tactical Grid (NTG) applications, the Department of Navy (DON) must optimize the backend data lake supporting the front end graphical user interface for control and management of many network applications, including, but not limited to, the physical layer devices, crypto, and legacy interfaces using the available standardized interfaces that are becoming required, such as Secure Network Management Protocol (SNMP) for Common Data Link (CDL) systems (Bandwidth Efficient CDL Rev B specification is classified, this is the protocol required), Dynamic Link Enhancement Protocol (DLEP) for Tactical radios, and so forth; for translating to legacy interfaces at the data layer before delivering the requested data to the user interface layer.

Developing a single data lake that can be a repository for relevant data coming from all hosted applications, cognitively recognize when duplicative data is being requested via a services-oriented architecture, such as Communications-as-a-Service (CaaS).

The proposed solution should minimize the bandwidth of duplicate data traversing the network backbone, support all BMA developers in providing a unified data management strategy during development in a DevSecOps environment by enabling a common data lake to then provide microservices (e.g., map data, timing, navigation signals, own-ship position, etc.) across applications, rather than uniquely requesting that data across. This is often a bandwidth constrained communications backbone during wartime operations.

Proposed solutions should support standardized network management protocols such as simple network management protocol (SNMP) and adhere to government-defined data models such as the YANG data model. Proposed solutions should support Containers-as-a-Service (CaaS) development, to provide a solution for an initial data lake that could be supported in a DevSecOps environment such as Overmatch Software Armory (OSA) to support all BMA developers toward the end state of a common microservices architecture and data lake. Design should consider acquisition constraints for current-state processes for fielding new systems and applications to a shipboard environment in the strategy for implementation.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. owned and operated with no foreign influence as defined by DoD 5220.22-M, National Industrial Security

Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence and Security Agency (DCSA) formerly Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances. This will allow contractor personnel to perform on advanced phases of this project as set forth by DCSA and NAVAIR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advanced phases of this contract.

PHASE I: Develop and demonstrate feasibility of a design citing industry standard methods for merging together the superset of data inputs and outputs from a sample set of existing applications and rendering that into a backend data lake with an accessible API for use in development of new applications. Methods for manipulating data into multiple requested formats from the raw repository state, providing micro services requests to and from applications, methods of enabling parallel processing, and methods of data management to minimize redundancy and optimize network performance for multiple data requests of the same time to different endpoints, are all in scope of this effort. A proposed implementation plan, including a mechanism for publishing new data sources, formats, and micro services coded to specific applications that can be tailored, should be included. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop a prototype data lake solution and reference implementation of BMA developer resource requests and automated delivery of requested data. An example using existing BMAs is not required, but would provide a meaningful deliverable. Implement into U.S. Government DevSecOps environment (specified by the topic's Technical Point of Contact) and support BMA development in response to a validated fleet requirement specified by the government at kickoff with the microservices and data lake on the back end as prototype.

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

PHASE III DUAL USE APPLICATIONS: Integrate government-specified third-party developers in refactoring, new development, or interfacing of at least two government-specified, third-party-developed BMAs to prove out the concept and continue to refine the application from Phase II to at least two service-level platform systems across the joint community in response to a validated fleet requirement. Private sector has an equal, if not greater, requirement for big data analytics and real-time performance (e.g., analysis of market trends driving a decision to invest or divest in a given stock, fund, or sector).

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KEYWORDS: Data Management; Data Strategy; Big Data; Optimization; Software Development; Battle Management Aid

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N231-016 TITLE: Emissive Image Display for Flight Simulators Wide-angle Collimated Displays

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR)

OBJECTIVE: Develop an emissive image surface (EIS) for flight simulator wide-angle collimated display applications that significantly increases the American National Standards Institute (ANSI) contrast performance without degrading other performance.

DESCRIPTION: Collimated cross-cockpit displays are common in fixed- and rotary-wing aircraft flight simulators and/or flight training devices (FTD). This type of wide-angle collimated display provides two pilots, seated side by side, the same out-the-window (OTW) imagery (i.e., cross cockpit) without angular errors or distortions. A large spherical mirror is used that subtends the OTW field of view (FOV), and has a center of curvature located near the center-point between the eye boxes of the two pilots [Ref 1]. Current wide-angle collimated display technology uses multiple display projectors to illuminate a smaller toroidal-like screen called the back-projection screen (BPS), which is typically located above the cockpit and approximately half the radius of the large spherical mirror. While not as common, wide-angle collimated displays may also use front-projected screens (FPS). In the FPS configuration the projectors are in front of the toroidal screen. Together, the large spherical mirror and BPS/FPS create a virtual or collimated image, which appears to be at a fixed distance away from the eye point. For example, a collimated display with an 11 ft (3.35 m) radius is used to make a virtual image that appears to be 10 m away when, in reality, the pilot is sitting only 3 m away.

A display with a low contrast ratio makes an image look washed out. Although collimated cross-cockpit display projectors typically have a sequential contrast ratio (e.g., full on/full off) on the order of 2,000:1, the effective ANSI contrast ratio can be on the average 10:1. The ANSI contrast ratio is a more representative metric of contrast because it considers realistic operating conditions. It has been documented that ANSI contrast exhibits a better correlation with the perceived contrast by a pilot in an FTD.

Attempts to increase ANSI contrast in the FTD industry have only generated marginal increases in contrast from 8:1 to 15:1, with an average of 10:1 over the last 20 years. The low ANSI contrast is due to scattering from transmission through the BPS, back-reflection from the lower portions of the main collimated mirror, reflections from the cockpit windshield, secondary scattering off the BPS, cross reflections inside the BPS, and other unwanted reflection. Scattering not only affects luminance and contrast but the perceived resolution as well.

High-density, emissive display technology has greatly advanced over the past several decades and is approaching a point where it may be able to replace the BPS/FPS and projectors in modern flight simulators. However, challenges remain in the construction of such EIS, integration of the collimated display optical components, and integration with existing image generators (IG). This SBIR topic seeks to develop next-generation EIS for use in FTD/FTD -wide-angle FOV collimated display systems.

Requirements for collimated cross-cockpit displays with EIS performance:

* Support dual pilot cross-cockpit views for flight simulation applications separated at least 48 in. (1.22 m) apart.
* Viewing volume sphere 12 in. (30 cm) in diameter at pilot view point.
* Threshold horizontal FOV no less than 180° with an objective of 220°.
* Threshold vertical FOV no less than 60° with an objective of 80°.
* Threshold ANSI contrast greater than 15:1 with an objective of 25:1.

* Threshold static spatial resolution less than 5 arc min/OLP with objective 2 arc min/OLP.
* Threshold display average luminance of 10 ft (3.05 m) lamberts (fL) with objective of 20 fL.
* Threshold display average black level 0.001 fL with objective of 0.0001 fL.
* Support the use of multiple image generator rendering channels.
* Objective is to support night vision goggles (NVG) stimulation.
* Threshold 100% of the sRGB color space with objective of Rec. 2020 (UHDTV) color space.
* Support for auto-alignment.

The main challenges include development of a emissive image surface, high-contrast and high-luminance display, limited vertical FOV, NVG stimulation, calibration, maintenance, and use in motion platforms. These challenges must be addressed in the proposal.

Development of an emissive toroidal-like curved surface presents a significant challenge. If tiled subpanels are used, discontinuities and distortions at the boundaries need to be carefully considered. Vertical FOV in wide-angle collimated display today is limited to 60°. The limitation in vertical FOV is a limitation of the current optical design. Increasing the vertical FOV is possible by increasing the diameter of the display but that increases the FTD footprint. Larger vertical FOV is a desirable feature for helicopter FTD.

Traditional RGB emissive displays may not provide enough energy in the near-infrared to stimulate NVG. The ability to provide a simultaneous near infrared light source component to the emissive display, which can be driven by a separate image generation channel, is desirable objective.

Distortions at display boundaries must be adjusted or calibrated and maintained over time. Furthermore, the use of wide-angle collimated displays in motion platforms is also a desired feature. Replacement of the complete display due to subcomponent failure is not economically or functionally practical. The display should allow for the replacement of sub display components (e.g., emissive tiles) and the fast calibration to achieve a seamless display. Motion platforms generate stress and forces that require a ruggedized design and therefore need to be accounted for in the design.

In addition to addressing emissive displays for wide-angle collimated displays, the proposal should include an assessment of how the proposed collimated concepts and technology can be extended to being used in real image dome type display training devices.

PHASE I: Design, demonstrate, and prototype a collimated display that includes novel EIS technology to meet or exceed the required collimated display performance thresholds. Determine technical feasibility through analysis, prototyping, and testing. The Phase I effort will include a scale down prototype, metrics and measured of performance. Demonstrate that the scaled down prototype performance will scale to meet or exceed the required performance thresholds on a full-scale collimated display. Determine if the novel EIS can be used as a replacement for current BPS/FPS. Identify, address, and document benefits (e.g., cost and performance), deficiencies, main challenges, and areas for improvement. The Phase I effort will include prototype plans to be developed under Phase II.

Address how this EIS technology can be modified to be used in real image dome type display systems. Identify, address, and document benefits (e.g. cost and performance), deficiencies, main challenges and areas for improvement.

PHASE II: Develop, prototype, and demonstrate that a full-scale functional prototype of the novel EIS display will meet or exceed the required performance thresholds and capabilities for a collimated display system. The Phase II effort will include a large-scale prototype based on Phase I prototype, and measured performance. Demonstrate that this large-scale prototype performance will scale to meet or exceed the required performance thresholds/objectives. Determine if the novel EIS can be used as a replacement for current BPS/FPS systems. Identify, address, and document benefits (e.g. cost and performance), deficiencies, main challenges and areas for improvement.

Determine how the EIS technology/design can be used in real image dome type display systems. Identify, address, and document benefits (e.g. cost and performance), deficiencies, main challenges and areas for improvement.

PHASE III DUAL USE APPLICATIONS: Develop full-scale collimated display that uses the EIS technology or integrate the full-scale EIS technology into an existing flight training device collimated display that meets or exceeds the required performance thresholds. Measure performance and document lessons learned. Perform pilot evaluations of the display's performance and capabilities. Compare the new display's performance to current collimated display systems. Determine if the novel EIS can be used as a replacement for current BPS/FPS. Identify, address, and document benefits (e.g., cost and performance), deficiencies, main challenges, and areas for improvement.

Federal Aviation Administration (FAA) uses collimated displays for flight training devices at level D [Ref 3]. Advances in EIS and collimated displays can be applicable to the commercial pilot training industry.

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KEYWORDS: flight training devices; FTD;; collimated displays; back projection screens; emissive displays; emissive image surface; EIS

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N231-017 TITLE: Enabling Technologies to Support Individual Blade Control for Rotorcraft

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR)

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

OBJECTIVE: To enable Individual Blade Control (IBC) on future fielded rotorcraft through development and demonstration of novel/robust supporting technologies that address practical implementation issues for safety critical rotor control.

DESCRIPTION: There is a sizeable body of research establishing the benefits of IBC on rotorcraft including increased performance, improved handling qualities, extended component life, improved ride quality, reduced noise, and more. Reference 1 outlines a series of full-scale wind-tunnel tests of IBC technology on a modern, hingeless rotor design. The authors showed a reduction in power required in forward flight conditions of up to 7% (benefits increase further with speed). They also found up to 80% simultaneous suppression of the in-plane hub forces and moments, and up to 99% suppression of the vertical shear forces at the primary, per-blade frequency. This directly translates to longer component life and a smoother ride. Further, they observed up to a 12 dB (85%) reduction in noise generated by blade-vortex interaction (a major source of rotorcraft noise). References 2-6 provide additional examples of IBC's benefits. Successful implementation of IBC in a safety critical application represents the next big leap in rotorcraft capabilities.

To realize this leap, flight control systems must be able to move each blade on a rotor-system independently of one another at frequencies up to an order of magnitude higher than the primary (1P) rotor frequency. At this time, IBC technology has flown only in limited fashion on demonstration aircraft [Refs 7-9]. IBC technology has not progressed past limited flight tests; primarily because it is very challenging for a flight control system to provide the kind of actuation needed in the rotating rotor frame while addressing all of the practical concerns of production rotorcraft. All of the flight tests referenced relied on classical swashplate controls in addition to the IBC system to ensure airworthiness with respect to failure immunity and adequate system performance.

In order to make IBC realistic for production rotorcraft, the challenges of practical implementation must be addressed. Practical implementation issues include, but are not limited to, reliability, redundancy, failure modes, system performance, packaging, production, cost, and maintainability. This SBIR topic seeks technologies that would enable application of IBC technology in future production rotorcraft by addressing the aforementioned implementation issues. The primary technical challenge is that the blades to be controlled reside in the rotational environment (rotor head) while the rest of the aircraft is in the stationary frame. Proposed technological solutions will be expected to address this challenge through allocation and design of control components in the stationary and rotating frames, as well as the transmission of power, mechanical motion, information, and so forth, across the frames.

The proposed technology is not required to represent a complete, tip-to-tail solution to IBC, but complete solutions are of interest. This SBIR topic is also interested in foundationally enabling technology that could be employed in a number of full IBC solutions (e.g., redundant, high-bandwidth, high-throw actuators that are robust to the rotational environment; improvements/alternatives to hydraulic or electronic sliprings; fail-op/fail-safe redundancy management strategies). Whether the proposed technology is an enabling solution or a full IBC concept, it is expected to be able to support a complete, IBC rotor-control system without the need for traditional rotorcraft control systems as a back-up in order to realize benefits in total aircraft cost, complexity, and weight.

Proposed full IBC solutions should include, but not be limited to:

Performance:

1. Have the ability to completely replace existing rotor-control systems by demonstrating +/- 15° (Threshold)/ +/- 20° (Objective) of blade pitch authority at 1P.
2. 2. Have the ability to support Higher Harmonic Control (HHC) modalities by demonstrating +/- 2° (Threshold) / +/- 5° (Objective) of blade pitch authority at 2P and +/- 1° (Threshold) / +/- 2° (Objective) of blade pitch authority at 7P.

Safety/Reliability:

1) In support of demonstrating the ability to completely replace existing rotor-control systems, show architecture and analyses to demonstrate a Probability—Loss of Control (PLOC) of the rotor head of 1 E-8 or less per flight hour.
2) Plan/approach for meeting environmental requirements of MIL-STD-810.

If the technology is not a full IBC solution, then its ability to support technical measures above should be demonstrated through a combination of test, simulation, and analysis.

Although not required, it is highly recommended that the proposer work in coordination with the original equipment manufacturer (OEM) to ensure proper design and to facilitate transition of the final technology.

PHASE I: Determine the technical feasibility of the proposed, IBC-enabling technologies. If a full IBC solution is proposed, the ability of the technology to completely replace existing rotor-control systems and support all published IBC/HHC modalities will be assessed. If the proposed technology is a supporting technology, the technical description of the types of IBC mechanizations that it would support, and the details of the specific implementation, should be established. In both cases, the proposed technology should be assessed for impact on practical implementation issues such as reliability, redundancy, failure modes, system performance, packaging, production, cost, and maintainability. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop a prototype of the technology proposed in Phase I. The prototype will be tested and demonstrated in a relevant environment to validate the feasibility of the concept as well as to uncover and mitigate any unforeseen technological challenges.

For full IBC solutions, the prototype may be sub-scale or partial systems where appropriate. A full-scale prototype with a bench-test level of fidelity is acceptable for component solutions though specifics may be tailored for the given technology.

For all technologies, practical implementation issues such as weight, power demand, thermal management, reliability, redundancy, failure modes, packaging, production, cost, and maintainability will be assessed in detail through analysis, simulation, test, or a combination of methods.

Provide a final report covering design, analysis, simulation, testing, results, and discussion of findings. Potential analysis may include Fault Tree Analyses (FTA's)/Reliability Block Diagrams (RBD's), Failure Modes and Effects Analysis (FMEA), summary of fault detection/accommodation for the proposed architecture, and so forth. A copy of any software or simulation models developed for Phase II should be delivered. Any hardware (full prototype or component) developed for Phase II should be delivered.

PHASE III DUAL USE APPLICATIONS: Further mature the technology developed in Phase II by addressing any substantive technical issues uncovered and either demonstrating the technology in flight on a sub-scale aircraft, or on full scale on whirl stand/ground test rig. Perform engineering design to incorporate the technology in a potential future rotorcraft.

All of the benefits of IBC listed above translate directly to the commercial rotorcraft market. The link to more traditional rotorcraft is clear; however, the recent push towards urban mobility and the electric Vertical Take-Off and Landing (eVTOL) market could see IBC technology being adopted commercially before military applications. Urban mobility implies an emphasis on noise reduction while operating in cities/suburbs, a desire for reduced vibration for passenger comfort, and the need for very low PLOC. While closely related, eVTOL demands increase efficiency to offset current limitations in battery technology.

This technology also has potential to apply to other, nonrotorcraft markets that could utilize IBC such as ship/submarine propellers and the wind-turbine industry.

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KEYWORDS: Individual Blade Control; Higher Harmonic Control; Future Vertical Lift; Swashplate; Fault Tolerant Flight Control; Rotorcraft

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N231-018 TITLE: Superconducting Thermal Spreader Enabled MWIR Band-IVb Quantum Cascade Laser with 65 W Average Output Power

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR); Microelectronics; Quantum Science

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

OBJECTIVE: Develop a high-performance, superconducting heat spreader to reduce the junction temperature of a BandIVb, almost beam diffraction-limited high-power quantum cascade laser that outputs average output power > 65 W with wall-plug efficiency (WPE) > 35% during high-repetition rate, pulsed-mode operation.

DESCRIPTION: High performance Midwave Infrared Quantum Cascade Lasers (MWIR QCLs) relevant for various naval applications, such as directed infrared countermeasures (DIRCM), stand-off detection, or atmospheric optical communications, rely on QCLs' ability not only to generate light in midwave infrared atmospheric transmission windows, but to deliver a high degree of intensity focused to a small angular profile at a distance [Refs 1–3]. This requirement emphasizes a high brightness beam over pure power scaling. High continuous wave (CW) output power in QCLs is generally achieved with increases in wall-plug efficiency (WPE) utilizing a narrow-ridge waveguide. Such approaches have led to CW powers of ~5 W [Ref 4]. Also, power scaling of a single QCL device has been demonstrated as a new promising route to further increase in power through the geometry of the QCL core by reducing the number of superlattice periods while simultaneously expanding the breadth of the device [Refs 5–7]. These so-called broad-area devices manage the inherent thermal constraints of CW operation by manipulating the heat flow out of the laser core with the changing geometry. Manipulation of the laser core geometry has been shown to ensure brightness for these devices by adjusting mode competition in favor of the fundamental transverse mode in a way compatible with CW power scaling. > 7 W of CW optical power in a high-quality beam have been demonstrated from a single broad-area QCL emitter, and model projections show that up to 15 W can be achieved from a fully optimized device.

For many defense applications, a signal modulated at MHz frequencies with high-duty cycle (over 40% or higher) is a compatible replacement for CW operation due to the laser modulation frequency exceeding the required sampling frequency of the sensor/detector. The operating space between a negligibly small duty cycle and CW, shows promise as an excellent avenue for the significant enhancement of average power by regulating the transient temperature of the laser with a large duty cycle, quasi-CW (QCW) operation. This can optimize the tradeoff between laser pulse uptime and a cooling cycle to reduce temperature buildup that degrades laser performance. In addition, average power may be increased by a substantial amount, while simultaneously reducing the need for input power by driving the device in a pulsed mode with high-repetition rate. The cooling cycle that occurs when the laser is not being driven, reduces the temperature of the laser, enhancing peak power to a degree where average power achieved is higher than that of CW conditions. The enhancement to WPE is significant in this pulsed operation because the increased average power is achieved by reducing the average energy input from CW conditions. However, the legacy MWIR QCL devices optimized for CW operation will not show much significant improvement in average power when operated in quasi-continuous wave (QCW) mode as average power for such devices peak at 100% duty cycle, that is, in CW mode of operation. Therefore, the entire laser structure, including the active region stage and waveguide designs, have to be optimized for QCW operation.

In addition to the advances in the QCL physics and designs, many recent advances in thermal management can be leveraged, such as vapor chambers, Ag-diamond alloys for CTE-matched submounts, novel phase change materials for efficient active heat extraction, and so forth [Refs 8 & 9], to push the aggregate performance envelope of QCLs. It is the also the goal of this SBIR topic to develop active cooling superconducting heat spreaders, of which the thermal conductivity should exceed the commonly used AlN, Cu, or CuW substrates (140-180 W cm-1 K-1) by at least a factor of 10. The final packaging solutions should enable efficient extraction of at least 200 W of dissipated power. The proposed laser and heat spreader solutions need to assure reliable operation in a variety of environmental conditions, which includes operation under high g-forces [Ref 6]. Combining a superconducting heat spreader with a high-performance QCL operating at QCW mode, can elevate the device performance with average output power and WPE to an unprecedented level. Finally, this paradigm-shifting approach of agglomerating active superconducting heat spreader with a high-performance QCL in QCW mode, will enable the elimination of the use of an active water cooling system, resulting in up to a factor of five in size and weight of the overall laser cooling system configuration.

PHASE I: Demonstrate feasibility of modelling and simulation on thermal management and packaging solutions that would allow for efficient extraction of at least 200 W of dissipated power. Design the thermal management packaging solution that should include active cooling heat spreader with—at a minimum—over 10X improvement over conventional submount heat spreader. The solutions should include an overall QCL cooling subsystem that does not include any active water cooling, and has lower size and weight compared to the current conventional cooling solution. The active cooling solution design should enable the demonstration and delivery of QCL with WPE of 35% operating at QCW mode with the required duty cycle and with 65 W average output power at 30 C for at least ten minutes. Technological risks, reliability concerns of the proposed solution, and future transfer to manufacturing process should be discussed in depth. Also, demonstrate a 4.6 µm QCW QCLs delivering over 10 W of average power. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Optimize the QCL and superconducting substrate design. Fabricate, demonstrate, and deliver a packaged prototype of a 4.6 µ QCL system delivering over 65 W of average power operating in QCW mode with the required duty cycle and with beam quality of M2 < 1.5 for an aggregate ON cycle exceeding ten minutes.

PHASE III DUAL USE APPLICATIONS: Transition the technology for DoD use. Assist in applying the design for specific system applications such as countermeasures. This is expected to entail selection of device performance parameters, and adjustment of corresponding process parameters, in order to produce the required quasi-continuous output power at the optimum Phase IVb wavelength. The final product will be a high-performance laser device of which the output power can be scaled, if necessary, via beam combining for current and future generation DIRCMs, LIDARs, and chemicals/explosives sensing.

The commercial sector can also benefit from this crucial, game-changing technology development in the areas of detection of toxic gas environmental monitoring, non-invasive health monitoring and sensing, and laser spectroscopy.

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KEYWORDS: Superconducting Thermal Spreader; High-Brightness; High-Efficiency; Mid-Wave Infrared; Band-IVb; Quantum Cascade Laser; Quasi-Continuous Wave Operation

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N231-019 TITLE: Big Data Analytics (BDA): Real-Time Data Mining and Track Fusion of National and Tactical Data

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Artificial Intelligence (AI)/Machine Learning (ML); Autonomy

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

OBJECTIVE: Develop advanced real-time, and near real-time, data mining and fusion algorithms to exploit all relevant multi-intelligence data sources and rapidly create fused sensor tracks of “maritime surface vessels” to improve classification confidence.

DESCRIPTION: Multiple services utilize the Minotaur Family of Services (MFoS) solution set to aggregate and correlate multi-intelligence sensor data on board aircraft. Modern Artificial Intelligence (AI), Machine Learning (ML), and data analytic techniques can provide an enhanced Maritime ISR Common Operating Picture (COP) needed for higher fidelity track quality to correlate and fuse tracks from multiple data sources to support operations blue water and littoral environments.

This SBIR topic focuses on data mining and sensor fusion of data derived from aircraft organic sensors and multi-intelligence (multi-INT) sources, including near real-time data streams and archived data sources, to rapidly provide reliable, valuable, and accurate decision support for maritime surface vessel classification. The technique needs to take into consideration the combined power of AI, ML, and BDA to exploit a priori information of the surface vessel and environmental background. See references 1, 2, & 3 for additional information. The a priori knowledge is critical in the detecting, tracking, and rapid classification (or re-establish the identification) of the surface vessels with respect to tactics used in non-cooperative situations. The ability to fuse data across multiple systems, high precision-low persistence (tactical data) with low precision-high persistence (national data) should be used to support the classification of unknown surface vessels; “dark” surface vessels; surface vessels with large gaps in track data; and surface vessels “spoofing” to mask their identity. See reference 6 for additional information. The database and fusion techniques need to take into consideration latency and pedigree of the data, creation of false tracks attributed to “data ringing” (i.e., duplicate tracks) and “data looping” (i.e., reporting of same source track to different locations), and prior fusion techniques of data. Understanding the root cause and documentation of the mitigation steps in addressing “data looping” and “data ringing” is required. Data-driven algorithms that can aggregate and fuse data from various sources, and identify the appropriate data and interface standards (e.g., style guides, ontology, ICDs, metadata, etc.) are required to generate interoperable data models. Data aggregation can include, and is not limited to, data collection; data processing; data cleansing; and data analysis. The database and fusion techniques are to leverage all data sources such as (but not limited to) Radar; Electronic Intelligence (ELINT); Communication Intelligence (COMINT); Automatic Identification Systems (AIS); and Imagery to accurately identify and fuse useful multi-INT, multisource data. The resultant solution will feed the MFoS, the Maritime ISR Common Operating Picture (COP) used by the U.S. Government.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. owned and operated with no foreign influence as defined by DoD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence and Security Agency (DCSA) formerly Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances. This will allow contractor personnel to perform on advanced phases of this project as set forth by DCSA and NAVAIR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advanced phases of this contract.

PHASE I: Develop advanced real-time, and near real-time, data mining and fusion algorithms to exploit all relevant multi-INT data sources and rapidly create fused sensor tracks of “maritime surface vessels” to improve classification confidence. The study should include the ingestion of data and normalization to ensure consistent data models needed to accurately correlate, and temporally and spatially fuse the different data sources. Publicly accessible data can be used for the Phase I approach. The final report shall include a conceptual design and the prototype design plan for Phase II. Phase I analysis results from modeling and simulation should be included in the final report.

PHASE II: Continue to mature algorithms developed in Phase I to accept data sources from the U.S. Navy MFoS, in addition to data from near real-time sources and data lakes from other services and national data. Sensor sources will include maritime surface vessel track or location information, and will be supplied by the U.S. Government in the beginning of Phase II activities. Perform a study of the interface standards (e.g., style guides, ontology, ICDs, metadata, etc.) required for correlation and fusion of the track information and dissemination of data within MFoS. The algorithms will maintain or improve track accuracy and classification of the maritime surface vessels, and not degrade any uncertainties during the fusion process. The algorithms should maintain the interface standards required for the MFoS operating environment. Demonstrate the algorithms with the objective of showing a high level of confidence for fused tracks. Data looping and data ringing will be documented during Phase II, and the final report should include a summary of the studies, root cause, and mitigation steps in addressing data looping and data ringing. The final report will include the algorithms and data models required to interface with MFoS sensor data and sensor data from other sources (including national data sources and data lakes).
Work in Phase II may become classified. Please see note in Description paragraph.

PHASE III DUAL USE APPLICATIONS: Refine the design, test, and integrate the architecture and algorithms into MFoS. The final design will also focus on the sustainment of the algorithms. Phase III deliverables should include but not be limited to a Pre-Design Review (PDR) and Critical Design Review (CDR), performance requirement generation, associated testing and analysis of the software, ICDs, instructions, and manuals.

Big data mining and analytics will benefit both DoD and agencies using MFoS, while also providing commercial application ranging from exploring trends from sensors, devices, video, audio, web, and social media.

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KEYWORDS: Artificial Intelligence; AI; Machine Learning; ML; Big Data; Big Data Analytics; Analytics; Data Lakes; Fusion; Track Fusion; Classification; Maritime Classification; Maritime Situational Awareness; Minotaur; MFoS

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N231-020 TITLE: Detection and Tracking of Hypersonic Missiles from Glide-to-Terminal Phase Using Electro-Optic Infrared Sensors

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR);Hypersonics;Microelectronics

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

OBJECTIVE: Develop and demonstrate novel early-warning detection and tracking methodology of hypersonic missiles transitioning from glide-to-terminal phases, using airborne electro-optical Infrared (EO/IR) sensor suite.

DESCRIPTION: Hypersonic missiles [Ref 1] are emerging threats that are likely to penetrate current anti-missile shield systems. Within the last few years, U.S. adversaries [Refs 1-3] have fielded early versions of hypersonic weapons that can travel faster than five times the speed of sound and potentially put U.S. naval assets at great risk.

Therefore, earlier detection and tracking of the incoming hypersonic missiles—especially in their final and terminal phases—is very crucial to an overall and effective hypersonic missiles countermeasure strategy. However, radar detection is not a viable and effective surveillance and reconnaissance tool for detection and tracking [Refs 2 & 3]. When an aerial vehicle is traveling at hypersonic speed through the atmosphere, a plasma sheath envelops the aerial vehicle because of the ionization and dissociation of the atmosphere surrounding the vehicle. The plasma sheath absorbs radio waves and thereby rendering the vehicle practically invisible to active radar systems.

There have been recent technological advances in EO/IR sensors with improved materials, manufacturability, greater wavelength capabilities, and improved spectral responsiveness in all spectral bands. From ultraviolet to long wavelength IR sensors with extremely low background noise performance, an EO/IR sensor suite with multiple spectral bands are excellent surveillance and reconnaissance candidates as augmentation sensors to existing hypersonic missile defense detection and tracking systems and/or existing airborne EO/IR sensors [Ref 4]. For instance, when a hypersonic aerial vehicle is travelling through the atmosphere at speeds of Mach 5 or higher, it encounters intense friction with the surrounding air. The nose cone and the leading edges of the flight vehicle will experience extremely high temperatures up to 3000–5000 °F (1648.89–2760 °C). The extreme temperatures of a vehicle’s leading edges and the exhaust plumes of the missile engine provide a very strong IR heat signature in stark contrast against its colder background, dramatically enhancing its detectible and identifiable signatures [Ref 5].

Therefore, similar to the methodology of large aircraft infrared countermeasure (LAIRCM) platform, of which the electro-optical missile-warning sensor is, designed to provide missile-warning capability to protect large military aircraft from IR-guided heat-seeking missiles. This SBIR topic seeks an EO/IR sensor suite solution on manned or unmanned aerial platforms to detect, identify, and track hypersonic missiles during their transition from glide phase to terminal phase. The expected capabilities can include sensor fusion of multiple spectral bands, and high-speed multisensor data processing aided by artificial intelligence and machine learning. The proposed physical EO/IR sensor suite should be compatible with, and integrated with, the existing EO/IR sensors on board naval aerial platforms.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. owned and operated with no foreign influence as defined by DoD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence and Security Agency (DCSA) formerly Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances. This will allow contractor personnel to perform on advanced phases of this project as set forth by DCSA and NAVAIR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advanced phases of this contract.

PHASE I: Design and demonstrate the feasibility of a multispectral EO/IR signature model for hypersonic missile systems to define the requirements for airborne EO/IR sensor suites, sensor fusion, and multisensor data processing. Use hypersonic aerial platform flight profiles, plasma sheath distribution surrounding a hypersonic missile, and expected EO/IR signatures available in the public domain literatures for the design. Develop the conceptual EO/IR sensor suite system concepts. Identify strengths/weaknesses associated with the proposed solutions, methods, and concepts. Define the most viable approaches that can maximize the probability and minimize the false alarm rates of detection and tracking of hypersonic missiles. Include prototype plans to be developed under Phase II.

PHASE II: Continue development and refinement of the airborne sensor suite system concept with detection and tracking algorithms using the Navy-provided aerial platform and hypersonic missile information. Characterize the EO/IR sensor suite and algorithm in a relevant operating environment, and improve and upgrade the system design based on the required system performance in terms of accuracy and false alarm rates of detection and tracking. Deliver the finalized system design and the associated detection and tracking algorithm at the end of Phase II.

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

PHASE III DUAL USE APPLICATIONS: Complete development, perform final testing, and integrate and transition the final solution to naval EO/IR sensors systems.

The algorithmic approaches based on the selected EO sensors could be utilized by a very wide variety of airborne and space-based EO sensor systems for the detection and tracking of very high-speed aerial vehicles.

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KEYWORDS: Detection; Tracking; Hypersonic Missiles; Glide Phase; Terminal Phase; EO Sensors; electro-optical; infrared; EO/IR

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N231-021 TITLE: Enhanced Aircraft Non-Cooperative Target Recognition

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR)

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

OBJECTIVE: Develop Doppler-polarimetric-based Non-Cooperative Target Recognition (NCTR) techniques as a complementary enhancement to legacy NCTR techniques.

DESCRIPTION: The ability to generate and exploit information from multiple polarizations generally has not been possible with our fielded airborne maritime surveillance and air-to-air radar systems due to their single polarization capability. Some of the newest generation of air-to-air and airborne early warning radar system are fully polarimetric, so there is no physical reason not to pursue this new source of information if meaningful performance improvements can be realized. Long ago, polarimetric radar was shown to be valuable in civilian applications including: (a) agriculture, for crop-type identification, crop condition monitoring, soil moisture measurement, and soil tillage and crop residue identification; (b) forestry, for clear-cuts and linear features mapping, biomass estimation, species identification and fire scar mapping; (c) geology, for geological mapping; (d) hydrology, for monitoring wetlands and snow cover; (e) oceanography, for sea ice identification, coastal wind field measurement, and wave slope measurement; and (f) coastal zone, for shoreline detection, substrate mapping, slick detection and general vegetation mapping. Many of these uses are also of value to the military. However, there are other potentially valuable benefits of polarimetry. These include improved performance in the presence of rain, using polarization selectivity/diversity to counter effects from jammers, and improved non-cooperative target recognition (NCTR) capability, particularly when used to enhance with traditional techniques such s High Range Resolution(HRR), Inverse Synthetic Aperture Radar (ISAR), micro-Doppler and Jet Engine Modulation (JEM). While the information content in polarimetric variables may be limited, it will be available under the constraints on time, carrier frequency, and bandwidth, as long as the system allows for multiple polarizations. This makes polarimetric features especially interesting for target classification.
Of particular interest in this SBIR topic is the utility of polarimetry in the characterization or classification of electrically-large, nonstable targets. The question of whether polarimetric data can enhance target classification has been touched on to some degree in the open literature. We know that polarization scattering properties are, in general, invariant for targets of interest, but they may vary widely and rapidly for only small aspect changes. Even for the simple extended targets, no well-defined optimum polarization exists. These targets are large in comparison to the wavelength, and have unresolved scattering centers. Because of the internal movements of the scattering centers, or due to changes of the aspect angle with the radar, the relative distances between scattering centers changes and thus the scattering properties of targets. It is shown that compound objects can be represented as a set of deterministic scatterers by using Doppler polarimetric formalism. In some respects, Doppler polarimetry can be considered as a decomposition of a random target into deterministic ones. The Doppler polarimetric decomposition is based on the spectral properties of targets and the result is more physical than for the decomposition theorems, which are based on only polarimetric targets properties. A variety of target recognition approaches are possible. Consider a polarimetric ISAR target image. It could be broken

down into a set of scattering centers. Each of these centers identified as a scattering primitive. This is achieved by matching each scattering center from the target image set to a simulated image of a primitive. By utilizing multiple target images (ranging in frequency, orientation, and polarization) a prediction of primitive characteristics is achieved. In principle with sufficient angular realizations the scattering primitives can be placed in three-dimensional space. Leveraging synergistic machine/deep learning target recognition techniques under development, including their real and synthetic training data, a Doppler-polarimetric-based NCTR technique could be a powerful enhancement to other complementary NCTR techniques.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. owned and operated with no foreign influence as defined by DoD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence and Security Agency (DCSA) formerly Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances. This will allow contractor personnel to perform on advanced phases of this project as set forth by DCSA and NAVAIR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advanced phases of this contract.

PHASE I: Utilizing computational electromagnetics modeling applications, generate aspect-dependent polarimetric scattering matrices of multiple aircraft, and investigate the use of Doppler polarimetric decomposition as an NCTR technique. Assess whether this information provides a robust discriminate between similar aircraft types. Consider the impact of model fidelity in the stability of Doppler polarimetric features. Assess the relative enhancement of NCTR performance when used in conjunction with legacy techniques. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop and demonstrate a Doppler polarimetric NCTR exploitation signal processing approach using collected field data supplied by the Navy sponsor. Assess the performance as a function of dwell time and illumination geometry. Develop mode design and tactical utilization recommendations for radar systems identified by the Navy sponsor.

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

PHASE III DUAL USE APPLICATIONS: Complete development, perform final testing, integrate, and transition the final solution to naval airborne NCTR system. Doppler polarimetric radar techniques have the potential to provide additional insights into remote sensing of weather and other environmental effects.

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KEYWORDS: Polarimetric; Radar; Non-Cooperative Target Recognition; Electromagnetic Scattering; Inverse Synthetic Aperture Radar; Doppler

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N231-022 TITLE: Accelerated High-Power Blue Laser Design Cycle Enabled by Deep Neural Networks

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Artificial Intelligence (AI)/Machine Learning (ML); General Warfighting Requirements (GWR); Microelectronics

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

OBJECTIVE: Develop an automated high-peak-power blue laser with high-repetition-rate design process via using neural networks and machine learning (ML) algorithms that will result in up to 50 times reduction in design cycle time compared to the conventional "manual" laser design process.

DESCRIPTION: The Navy requires a high-peak-power blue laser system solution to be operated in pulsed mode with high-repetition rate for standoff oceanographic sensing applications from an aircraft at an altitude of under 1000 ft (304.8 m). It should be ruggedized and sufficiently small in size, weight, and power consumption (SWaP), to be used in naval fixed- and rotary-wing platforms. The current state of the art, which includes Optical Para-Metric Oscillators (OPOs), wavelength doubling of titanium-sapphire (TiSa) based lasers, doubling and tripling of other laser hosts, and blue laser diodes, do not adequately support the naval-demanding performance, size, and weight objectives. Many commercially available lasers and near-term developmental lasers meet a few of the required characteristics, but none can meet every performance criteria. It is paramount that the blue laser solution meets or exceeds the design objectives in order to be effective for standoff oceanographic sensing.

The performance specification of this laser solution include, but are not limited to:

(a) high-repetition rate (Threshold: 250 Hz),
(b) high-peak-power (> 20 MJ per pulse with pulse width no more than 25 ns),
(c) blue wavelength at 47X nm,
(d) Spectral line width of less than or equal to 0.1 nm,
(e) wall-plug efficiency of greater than 5%,
(f) laser beam quality m^2 - 3,
(g) lightweight. (Total weight including the laser head, cooling system, power supply, and control system) < 50 lb (22.68 kg),
(h) small volume. (Total volume for the cooling system, power supply, control system and laser head) < 2 ft^3 (.057 m^3),
(i) ability to be ruggedized and packaged to withstand the shock, vibration, pressure, temperature, humidity, electrical power conditions, and so forth, encountered in a system built for airborne use,
(j) reliability: Mean time between equipment failure—300 operating hr.

Whether the laser design is based on a multistage OPO architecture or frequency conversion of diode-pumped solid-state laser, the laser performance metrics (such as emission wavelength, threshold-current density, pulse width, repetition rate, slope efficiency, and their temperature dependence) are closely linked to the intricate interrelationship among the brightness of the pump laser. Suppression of the unintended parasitic solid-state laser emission, temperature control of the solid-state crystal, and the nonlinear properties of the nonlinear crystal, and so forth. The complexity of the architecture generally requires a time-consuming iterative process between experiment and design optimization to achieve the highest device performance, which adds substantial cost to laser manufacturing. Automated optimization algorithms similar to the one used in References 1 and 2 could both greatly reduce the time (and cost) required to develop new high peak power blue laser systems with specified performance characteristics and potentially lead to new insights into blue laser design.

The current blue laser design process generally involves a human in the loop—even for a single iteration. The function performed by the human is to identify specific features in the design and determine whether a certain performance metric can be achieved. Emerging data-driven automated optimization algorithms could potentially address the difficulties facing this laser design.

As the blue laser requirements grow and progress, the design processes become more challenging. With conventional design approaches based on computational optimization, one typically starts with a prior design and computes the performance, compared to the target response. The parameters in each of the active components in the multistage architecture are calculated and applied to the design. This process, performed repetitiously, often takes many iterations before a design is found that meets the design criteria. As an alternative, the data-driven approach [Refs 1 and 2] is rapidly emerging where deep neural networks are used for inverse device design. A large data set of existing designs and corresponding performances can be used to train artificial neural networks [Ref 3] so that the networks can develop intuitive connections between the laser system designs and their performances. After training, the neural network can accomplish a design goal in hours instead of weeks as compared to the conventional approach. Such an approach has been used previously in photonic structures [Ref 2], where neural networks successfully model the wave dynamics in the Maxwell's equations and the quantum mechanics in the laser architectures.

This SBIR topic seeks the development of a power scalable blue laser system solution that will meet the aforementioned size, weight, performance, and reliability requirements via a multiphysics-based, deep neural network, ML process. It is also the objective of this topic to accelerate the development cycle time of the laser aided by the ML compared to the conventional "manual" design process by at least a factor of 50.

PHASE I: Develop a methodology for implementing the training plan for neural network-based blue laser design optimization without human intervention. Develop feasibility of a ML process, which is suitable for advancing the performance of the blue laser with respect to the performance specifications stated in the Description. The ML process should address all design parameters of the multistage laser architecture. Develop the design verification plan for the ML algorithm for accelerating the blue laser prototype development. The Phase I effort will include prototype plans to be developed in Phase II.

PHASE II: Demonstrate the fully automated blue laser design algorithms using machine learning methodology. Perform experimental verification of the generated designs by demonstrating that the blue laser performance metrics are met with less than +/- 5% variations from the target performance specifications. Develop a prototype blue laser system based on the ML process that meets the required laser system specifications. Deliver the fully automated blue laser design algorithms with complete and detailed user manual and documentations. Benchmark the design cycle time using the algorithm aided by ML against the conventional method without using ML, and verify the cycle time reduction.

PHASE III DUAL USE APPLICATIONS: Transition the technology for DoD use. Test and finalize the technology based on the design and simulation results developed during Phase II. Transition the design algorithm for DoD applications in the areas of standoff oceanographic sensing applications.

Commercialize the design algorithm enabled by deep neutral networks from this effort for law enforcement, marine navigation, medical applications, and industrial manufacturing processing.

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KEYWORDS: Accelerated; High Power; Blue Laser; Design Cycle Time Reduction; Deep Neural Networks; Machine Learning

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N231-023 TITLE: Assured Positioning, Navigation, and Timing Using Nontraditional Means

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR)

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

OBJECTIVE: Develop alternative Positioning, Navigation, and Timing (APNT) technologies and determine a feasible hybrid solution of APNT sensors for aiding an Embedded Global Positioning System (GPS)/Inertial Navigation System (INS) (EGI) utilizing a Positioning, Navigation, and Timing (PNT) modular open system approach (MOSA) for use in a GPS degraded or denied airborne, maritime environment.

DESCRIPTION: GPS is utilized worldwide in military and commercial systems to provide precise PNT. However, GPS signals may not be available or reliable in a degraded/Anti-Access/Area Denial (A2/AD) environments. Inertial navigation systems (INS) and precision clocks may extend the PNT solution for short periods, but both are subject to drift errors. An alternative real-time PNT solution—utilizing complimentary PNT sensor data and networks—is required to maintain an accurate and reliable navigation solution by bounding the drift errors without GPS dependency.

Current DoD efforts with PNT MOSAs are in development such as the Embedded Global Positioning System/Inertial Navigation System-Modernization (EGI-M) and Resilient- Global Positioning System/Inertial Navigation System-Modernization (R-EGI), in addition to PNT MOSA compliant alternatives [Refs 3, 6, 7, & 8]. PNT MOSAs will enable integration of complimentary PNT (or APNT) sensor hardware, data, and algorithms through modular, open system architectures. An aircraft's existing EGI may be able to be augmented through novel APNT sensors. The EGI-M, R-EGI, or PNT MOSA compliant alternative could be used with the insertion of a new APNT sensor suite (e.g., processor card, antenna, or sensors) to supply the aircraft or missions systems with complimentary PNT data required to bound drift errors. For example, lines of bearings from active signal of opportunity sources (SOOP) can assist in bounding inertial drift of the INS [Ref 4], or the local measurements of the Earth's magnetic variation could supply course geo-positioning [Ref 5].

This SBIR topic does not seek optical line-of-sight algorithms (e.g., visual positioning systems [or camera-based positioning solutions], star trackers, or other sextant-based solutions). Optical line-of-sight algorithms can be utilized to assist in bounding the solution from other APNT sensor solutions. The APNT sensor solution should be an "all-weather solution" not dependent upon cloud cover that prevents optical line-of-sight solutions.

The proposed solution set should:

a) allow for a common reference for aircraft operating together in a Tactical Navigation (TACNAV) or Relative Navigation (RELNAV) solution, where RELNAV accuracy can be enhanced using precise timing from a designated platform with the use of tactical Networks and Communication Systems,

b) utilize existing altimeters (e.g., laser, radar, barometric altimeters) to continue to aid in damping/resolving the vertical solution,
c) accommodate desires for minimizing parasitic drag effects on the aircraft (e.g., small projections from the aircraft into the airstream),
d) consider impacts to the aircraft's outer mold-line to minimize drag,
e) Size, Weight, Power, and Cooling (SWAPC) form factor
o brass-board, proof-of-concept design to be within a ¼ ATR
o ICD for EGI-M, R-EGI, or PNT MOSA to be supplied during Phase II
f) take into consideration use in a military operating environment.

The APNT solution is targeted for an airborne platform. The APNT solution should have a positional performance of 100 m or less (Threshold), 35 m (Objective). The APNT solution should perform in an A2/AD environment without GPS dependency.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. owned and operated with no foreign influence as defined by DoD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence and Security Agency (DCSA) formerly Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances. This will allow contractor personnel to perform on advanced phases of this project as set forth by DCSA and NAVAIR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advanced phases of this contract.

PHASE I: Perform a study focusing on the most feasible technical APNT solutions for airborne platforms in maritime environments including an assessment of the ability of the technology solution (hardware and processing resources) to meet SWAPC form factor for an APNT design as referenced in the Description above. Solutions that leverage networks for enhanced timing techniques utilizing existing tactical data links should be provided in the trade space. A conceptual architecture is required as a product of the Phase I effort. The Phase I Option, if exercised, should demonstrate the ability of the proposed architecture solution to resist jamming while still meeting operational performance requirements through a robust modelling and simulation (M&S) environment. The model should demonstrate the ability of the APNT solution to provide navigation updates that are tightly coupled with an EGI-M, R-EGI, or PNT MOSA compliant alternative. The final report should include the M&S plan and the results of the M&S performed.

PHASE II: Develop and demonstrate a prototype software APNT solution, or EDM, that builds upon the proposed solution and architecture developed in Phase I with brass-board, proof-of-concept design. A Design Review should be conducted early in the development phase. The effort should include a lab demonstration, and optionally, a moving ground-based demonstration. The final report should include the lab demonstration plan and results, and a transition plan for Phase III focusing on an integration into an EGI-M, R-EGI, or PNT MOSA compliant alternative that includes an affordability plan for transition, including further technical maturation and manufacturability of the resulting prototype for an airborne military environment.

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

PHASE III DUAL USE APPLICATIONS: Refine the design, and lab (or ground) test, and integrate the APNT solution within an EGI-M, R-EGI, or PNT MOSA compliant alternative and flight test in a surrogate aircraft. A later option will be to flight test in a Navy RDT&E aircraft. The Phase III design will also focus on the manufacturability, production, and sustainment of sensors, cards, antennas, and components for compliance with the military operating environment (military standards and handbooks such as 810, 704, 461, 464 should be used as reference until exact specifications are supplied). Phase III deliverables will include an additional Preliminary Design Review (PDR) and Critical Design Review (CDR), associated Qualification Testing and analysis to support Flight Testing, performance requirements, associated ICDs, and manuals.

APNT augmentation to GPS-based systems is applicable to all aircraft using GPS.

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KEYWORDS: GPS; PNT; Position, Navigation, Timing; Assured PNT; Alternate PNT; APNT; EGI-M; Signals of Opportunity; Network Assisted PNT

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N231-024 TITLE: Minotaur Alternate Radio Command and Control Operations Using Ultrahigh Frequency Data Mode

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR); Networked C3

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

OBJECTIVE: Develop an architecture that can disseminate Line-of-Sight (LOS) and Beyond (LOS) Internet Protocol (IP)-Based Tracks via existing ARC-210 Gen5/6 Radios via the Ultrahigh Frequency (UHF) Transport Layer.

DESCRIPTION: The Navy requires common, Ultrahigh Frequency (UHF) communications dissemination and sharing capability that will allow extended range data sharing and dissemination of Minotaur Family of Services (MFoS) data products at the forward edge/operating area of our Multi-Agency Platforms. This SBIR topic seeks to enable Distributed Maritime Operations (DMO) to achieve Joint All-Domain Command and Control (JADC2) across multi-services/Agency/Domain (USN, USMC, USCG, and CBP), enabling Level of Interoperability (LOI) 3 Command and Control of other Platform's Sensors.

1. The Open Systems Interconnection (OSI) Model will be used for the conceptual framework to describe the functions of the Minotaur Alternate Radio C2 Operations (MARCO) networking system. The effort needs to support the following use cases to achieve Joint interoperability across multiple platforms:
Node-to-Node Mode: MFoS data products need to be shared between MFoS equipped Platforms via UHF Frequency data channels enabling Full Kill-Chain Execution from Sensor to Shooter.
2. Communications Relay Mode (LOS): Establish Line-of-Sight (LOS) communications relay across multiple nodes to allow for Over-the-Horizon data dissemination using existing ARC-210 radios to distribute MFoS data.
3. SATCOM Mode (BLOS): Establish Beyond Line-of-Sight (BLOS) communications to accommodate both data providers and consumer roles using existing ARC-210 radios to distribute MFoS data as well as other data sources.

Proposed solutions should enable Distributed Maritime Operations (DMO) to achieve Joint All Domain Command & Control (JADC2) across multi-services/Agency/Domain (USN, USMC, USCG, and CBP). Additionally, this will enable Level of Interoperability (LOI) 3 Command and Control of other Platform's sensors.

Technical considerations should include, but not be limited to:
1. Data Rate – Measure how much/little data can flow from node to node. Minotaur has a Quality of Service (QoS) data throttling capability that we will leverage to show how much Minotaur data

we can share between nodes for Kill Chain execution. Threshold = > 9 kbps, Objective = > 115 kbps
2. Data Latency – Measure time it takes for data dissemination from point A to point B. Threshold = < 2 Seconds, Objective = < 1 Second from Minotaur Platform to Minotaur Platform (Using Minotaur Remote over UHF)
3. Data Integrity – Measure Packet loss between nodes. Threshold = > 95%, Objective = > 99% for 6 minutes in a permissive environment.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. owned and operated with no foreign influence as defined by DoD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence and Security Agency (DCSA) formerly Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances. This will allow contractor personnel to perform on advanced phases of this project as set forth by DCSA and NAVAIR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advanced phases of this contract.

PHASE I: Develop and demonstrate the feasibility of a conceptual design/architecture that will support dedicated UHF C2 communications between two or more aircraft platforms through both LOS and BLOS Physical Layers. Leveraging modeling and simulation simulate Radio Frequency (RF) connections and data message transfer of Minotaur messages to include, but are not limited to, (Based on Bandwidth) track position, classification, speed, altitude, and track quality. An additional objective is to show external control of Minotaur platform sensors using UHF Data mode. The technology should be in compliance with Quality Management and Software Design standards, such as ISO 9001, and DEVSECOPS are desired to ensure future interoperability with the Navy's Naval Operational Architecture (NOA). The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: A lab based demonstration will show aircraft node-to-aircraft node Minotaur Data transfer (both directions), sensor control of an Electro-Optical camera using the Minotaur Interface Control Document (ICD), and exchange of MFoS data (both directions) between a ground node and an aircraft node. The AIS data exchange should be demonstrated over the UHF data network. Laptops installed with MFoS software will be provided as Government Furnished Equipment (GFE) for aircraft and ground nodes.

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

PHASE III DUAL USE APPLICATIONS: Continue the development of the MARCO Software Product to include LOS and BLOS Physical Layers while supporting both classified and unclassified data transport, and address defects from Phase II.

The demonstration will include three or modes simultaneously, two aircraft and one ground, ensuring stability of the aircraft-to-aircraft Minotaur Data transfer (both directions) and exchange of MFoS data (both directions) between a ground node and an aircraft node. The sensor control of an Electro-Optical camera using the Minotaur Interface Control Document (ICD) and AIS data exchange should be demonstrated over the UHF data network is required.

All Minotaur equipped platforms will be able to leverage MARCO's capabilities for data dissemination and sharing. Multi-Agency Platforms will leverage MARCO's capabilities.

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KEYWORDS: Dissemination; Interoperability; Network; UHF; Communications; Transport Layer

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N231-025 TITLE: Autonomous Voice Coordination between Air Traffic Control and Foreign Object Debris Removal Systems

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Artificial Intelligence (AI)/Machine Learning (ML); Autonomy

OBJECTIVE: Develop and demonstrate a software module to allow autonomous Foreign Object Debris (FOD) removal systems to properly coordinate—via voice—with Air Traffic Control (ATC) while operating on airfields.

DESCRIPTION: The U.S. Navy is developing a modern FOD system-of-systems solution to reduce the cost associated with engine damage due to FOD ingestion by 75%. Current FOD reduction approaches are split between base operations and squadrons. The base is responsible for runways, taxiways, and aprons. They use FOD sweeper trucks to clean high-priority areas on a regular schedule. These trucks take about one week to fully clean an airfield. The squadrons address the flight lines by requiring the entire squadron to walk up and down the flight line looking for and removing any FOD. These approaches take significant time away from other duties and still allow $150 million in engine damage each year. This cost will only increase as more advanced aircraft are developed. To address this, part of the FOD system-of-systems solution will develop an autonomous vehicle to replace the sweeper trucks and manual FOD walks. Additionally, this vehicle will be able to perform ad-hoc FOD removal operations as FOD is detected. This reduces overall maintenance costs and personnel workload requirements.

To enable autonomous ad-hoc FOD removal, the system must communicate with ATC over radio to ensure safe runway operations. This SBIR topic is requesting the development of a software module that provides this communication capability. This module will allow the automated system to communicate with ATC via voice over radio to negotiate permission on runways in need of FOD removal, respond to emergencies, and other standard operations. The goal is to enable integration of autonomous systems on airfields without requiring separate ATC procedures for autonomous versus human-crewed systems. Current state-of-the-art autonomous systems typically incorporate an expertly trained human-in-the-loop approach. In this approach, the expert human supervises the autonomous systems and communicates with other humans on the automated system's behalf. This results in additional, specifically trained, personnel on duty during all airfield operations, which adds to the overall operating costs.

This solution should follow proper ATC communication procedures, as outlined in Reference 1. References 2 and 3 also provide background on ATC and airfield operations. The current focus is on land-based airfields, but future operations may extend to carrier-based environments. The solution should also feature open interfaces to allow integration into various future FOD platforms. It will use these interfaces to allow the robot to request permission or information from ATC. These will then be translated into voice to send over standard radio channels. The solution must also provide the reverse to receive information from ATC. The actual radio, transmission, and receiving of the voice data does not have to be part of this solution. The system should understand a range of accents and enunciations from various ATC personnel. The system must also handle light background noise. This background noise is equivalent to talking to a person in the middle of a busy office. Additionally, this solution must run locally on the robot without any off-robot processing (such as cloud-based servers).

Note: NAVAIR will provide Phase I performers with the appropriate guidance required for human research protocols so that they have the information to use while preparing their Phase II Initial Proposal. Institutional Review Board (IRB) determination as well as processing, submission, and review of all paperwork required for human subject use can be a lengthy process. As such, no human research will be allowed until Phase II and work will not be authorized until approval has been obtained, typically as an option to be exercised during Phase II.

PHASE I: Develop a tentative framework for the software module highlighting how the module will address ATC communication protocols. Efforts will also show simple proof of concepts in constructing and interpreting voice responses. The Phase I effort will include prototype plans to be developed under Phase II.

Note: Please refer to the statement included in the Description above regarding human research protocol for Phase II.

PHASE II: Expand the efforts of Phase I by further developing, and fully implementing, the software and adapting the framework as needed. The effort should implement all communication protocols in a robust manner such as handling different accents and enunciations. Validation should occur with a variety of voice data to prove this robustness. This can occur in realistic lab settings or a live environment.) Deliverables include a prototype; the open interface specification; software design documents; the uncompiled, human-readable source code; associated comments and documentation; and any tuned parameters and weights.

Note: Please refer to the statement included in the Description above regarding human research protocol for Phase II.

PHASE III DUAL USE APPLICATIONS: Phase III will incorporate the solution into any existing autonomous FOD platform designs. Efforts will focus on adapting the system to integrate with greater system and improving robustness.

This application directly benefits private and commercial airfields, in addition to military ones. All airfields have their own FOD mitigation plans. At least one commercial airport has indicated that they are exploring automated equipment for use throughout the airfield, as shown in Reference 4. This ATC voice-integration module will benefit those applications.

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KEYWORDS: Autonomy; Natural Language Processing; Air Traffic Control; Open Interfaces; Foreign Object Debris; Voice Integration

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N231-026 TITLE: Friction Drilling Fasteners for Composite Structures

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR)

OBJECTIVE: Develop an innovative friction drilling process that can effectively and precisely fasten together composite structures while preventing induced damage.

DESCRIPTION: This SBIR topic seeks development of an innovative process to fasten composite materials without destroying the integrity of the material. A process such as friction drilling has the potential both to fasten and bond carbon fiber- or glass-based composite material with polymer reinforcement. The Navy uses fiber reinforced polymer (FRP) composites in many military aircraft. Composite materials are in primary load-bearing structures and secondary nonload-bearing structures and skins. The size and complexity of composite components are constantly increasing as the desire for reduced weight drives the replacement of metallic components with low-density FRP. Fatigue and overload conditions require thorough tests and analyses to qualify connections to composite parts for airworthiness. Additionally, nondestructive inspections (NDI) are a crucial requirement for using these connections.

There may be several dozen fastener locations on a single aircraft component requiring a robust and rapid connection process for composites. Hole drilling techniques for FRP material originated from traditional metalworking; however, the unique material properties of FRPs present difficulties in the drilling of a simple fastener hole. Additionally, fastener holes often require precision countersinks. The highly abrasive nature of carbon, glass, and aramid fibers reduces the tool life of traditional tungsten carbide drill bits. This problem necessitates their frequent changing and affects the hole diameter as the material abrades the drill bit. The frictional heat generated by the drill bit can cause severe damage to the polymer matrix, resulting in a loss of strength that can be extremely difficult to detect. Lastly, FRP materials are prone to delamination in several situations due to improper drilling techniques. A friction drilling process may produce a more robust connection.

An alternative method to secure composite parts to other parts involves the use of adhesives. The adhesives require high levels of cleanliness, fixturing tools, curing/wait times, and multiple personnel for assembling non-rigid, large parts. Production must wait for the adhesive to cure and for the removal of the fixturing tools. The shear, and out-of-plane, loads that adhesives transfer from component to component are complex. Adhesives are generally much weaker than fasteners. A process such as friction drilling appears to offer an alternative to adhesives in many applications.

The Navy has a need to address the following technical challenges to qualify a process such as friction drilling:

(a) precision fastener locking with robust bushing collars,
(b) no breakout plies on the exit side,
(c) no delamination from edge of hole or into the part,
(d) no splintering allowed at entrance/exit of hole,
(e) no fatigue or ultimate strength damage from pilot holes,
(f) applied or induced heat must not damage the composite material,
(g) automate the process for bushing collar formation consistency and resilience,
(h) modeling and simulation of the process including temperature profile,
(i) modeling and simulation of the progressive damage for fatigue and overload analyses,
(j) demonstration of equivalent or better fatigue properties than the current processes,
(k) demonstration of ultimate load capabilities equivalent or better than the current processes.

PHASE I: Develop an innovative approach for a friction drilling fastener of relevant diameter and depth in either a carbon fiber- or glass-based composite material with polymer reinforcement representative of those materials used in military aircraft today. Demonstrate feasibility of the developed approach for producing bonded composite materials. The Phase I effort will include the development of prototype plans for Phase II.

PHASE II: Show that the strength quality can be at least equal to what is currently achievable with traditional drilling or adhesive bonding with similarly produced composite materials. Validate the associated material strength properties around the friction drill bonded region through fatigue and overload testing. Fully develop a prototype friction machining tool, demonstrate the precision fastener capability developed in Phase I, and expand the capability for rapid assembly.

PHASE III DUAL USE APPLICATIONS: Demonstrate fatigue properties and ultimate load capabilities equal to or better than the current processes to transition this technology to applicable platforms.
This SBIR topic will greatly assist the recreational marine industry, the aerospace industry, the wind turbine industry, and any other industry that uses composite materials.

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KEYWORDS: Friction drilling; flow drilling; composites; thermoset; thermoplastic; fatigue

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N231-027 TITLE: Low-cost, Low-SWaP, and High-Performance Uncooled Infrared Imager

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR)

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

OBJECTIVE: Develop low-cost, high-performance, uncooled infrared (IR) focal plane array (FPA) sensors using innovative novel materials; based on photon detection combined with silicon readout integrated circuits (ROICs), in the mid-wave IR (MWIR) and/or long-wave (LWIR), spectral bands.

DESCRIPTION: IR imaging technologies play a critical role in a variety of military applications including night vision, forward-looking IR cameras, and missile tracking. In these applications, size, weight, and power (SWaP) are often constrained, especially in aerial platforms such as small and mini UAVs, and in man-wearable configurations for situation awareness. These applications would greatly benefit from low-cost, uncooled, low-SWaP, and high-performance IR detector technologies that are suitable for SWaP-constrained imaging missions. Currently, microbolometer technology provides uncooled IR thermal detection, but microbolometer performance is generally limited by low sensitivity, high noise, slow video speed, lack of spectral content, and incompatibility with complementary metal oxide semiconductors (CMOS). While CMOS-compatible microbolometer IR FPAs have been developed recently, the performance and overall SWaP and cost still need to be improved [Ref 1] for increasingly demanding naval applications with smaller platforms and lighter payload capacities. Current high-performance IR photon detection technologies—based on mercury cadmium telluride (MCT) [Ref 2] and strained-layer superlattice structures (SLS) [Ref 3]—offer high sensitivity, fast response, and high resolution; however, these photon detectors are costly in fabrication and need to operate at cryogenic temperatures, which requires expensive and bulky cooling systems that increase the cost and SWaP [Ref 4]. Moreover, die-to-die bonding of a compound semiconductor detection layer to a silicon readout integrated circuit (ROIC) sets a limit on overall FPA size, pixel size, and cost.

Therefore, there is a demand for migration to alternative technology for IR FPA sensors that can address the following two fundamental challenges: high-performance uncooled operation; and a simple, cost-effective integration at the wafer-scale with Si-based ROICs with significantly reduced SWaP, similar to or smaller than that of a commercially available compact video camera in visible spectral range, for more demanding naval tactical applications. In the past decade, with advances in materials science and nanofabrication, many relatively new materials and technologies have emerged and been explored for IR photodetectors [Ref 4]. These include colloidal quantum dots [Ref 5], 2D/1D materials (such as graphene [Ref 6], transition metal dichalcogenides [Ref 7], carbon nanotubes [Ref 8]), and heterostructures [Ref 9]. These recent investigations demonstrated great potential in developing high-performance IR FPA sensors. This SBIR topic aims to develop MWIR and/or LWIR IR FPAs using novel materials and designs that can operate at room temperature with the high performance and low SWaP requirements listed below.

The IR FPA sensor should achieve the following target performance specifications. The following specifications represent at least 4X improvement in D* and SWaP over conventional cooled IR imagers.

(a) specific detectivity of D* = 10^10 Jones [cm(vHz)/W] or more,
(b) pixel size: 15 µm or less,
(c) frame rate: 100 F/S or better,
(d) size and weight: 200 cm^3 or less, and 300 g or less, including lens and supporting electronics,
(e) power: 5 W or less.

The technology should definitely be compatible and suitable for fabricating large-format FPAs of at least 1024 x 1024 pixels, and have a path toward achieving IR color in MWIR and/or LWIR bands. Furthermore, CMOS compatibility will accelerate the increase in pixel count in future versions of the next-generation ultra-high-definition FPA.

PHASE I: Design, model, and simulate an innovative approach for an IR FPA sensor that can achieve the specifications listed above. Design, fabricate, and test in the laboratory at least one detector based on the proposed technology. Characterize the detector's performance based on the specifications above. Design a detector array to be fabricated and tested in Phase II. Use modeling and simulation to estimate the performance of the detector array, including SWaP. Develop a test plan and test procedures for the array to be developed in Phase II. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Optimize the design of the detector array. Develop modifications that can improve performance. Fabricate prototype detector array and test it in the laboratory to demonstrate all of the performance specification targets listed in the Description. Detail a scalable fabrication process that provides a roadmap toward cost-effective production. Conduct a trade study analysis of the array to establish the case for scalability to larger arrays. Prepare a Phase III transition plan.

PHASE III DUAL USE APPLICATIONS: Test and finalize the technology and methodology based on the research and development results developed during Phase II. Fully develop and transition the High-Performance Uncooled Infrared Imager based on the final design for various naval imaging applications stated in the topic Description.

The commercial sector can also benefit from this low-cost and low-SWaP infrared imager with fast response time in the areas of environmental monitoring, and noninvasive health monitoring and sensing. Commercialize the imager based on the technology developed in this SBIR effort for law enforcement, marine navigation, commercial aviation enhanced vision, medical applications, and industrial manufacturing processing.

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KEYWORDS: Microbolometer; uncooled; infrared; focal plane array; read-out integrated circuit; carbon nanotubes

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N231-028 TITLE: DIGITAL ENGINEERING - Artificial Intelligence/Machine Learning (AI/ML) Hull Mechanical & Electrical Controls

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Artificial Intelligence (AI)/Machine Learning (ML); Autonomy; Cybersecurity

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

OBJECTIVE: Develop an Artificial Intelligence/Machine Learning (AI/ML) engine capable of improving alignment, operation, recoverability, and fault detection for Hull, Mechanical, and Electrical (HM&E) control systems.

DESCRIPTION: An autonomous system that deconflicts, decomposes, and triages tasks in HM&E control systems is necessary in multi-enclave ships when inter-enclave commands secured by boundary defense and intrusion detection systems are required. While a ship is underway, a self-improving rules system for de-conflicting and prioritization can improve long-term operations and sustainment of Navy surface combatants, but software rules that codify normal inter-system operations equivalent to teams of sailors currently have little precedent, either in commercial or Navy domains.

The Ship Domain Controller (SDC) is a government-owned monitoring, controlling, and integrating system currently fielded on Navy combatants for ship control systems. Prior work on autonomous integration systems such as SDC are tightly integrated with legacy surface combatant platforms and have no ability to apply prioritization and de-confliction operations to HM&E control systems. The Navy seeks a system capable of prioritizing, de-conflicting, and decomposing tasks into control actions. Command messages must have cyber-secure message authentication from the system (refer to NIST 800-82 for details on the requirement and NIST-800-52, NIST 800-56, NIST 80-57, and FIPS 140-2 for guidance on implementation). Commands should be distinguishable from operator commands. An advanced AI algorithm should be developed and trained using sensor data taken from training sets and representative signal databases that will be supplied to Phase I awardees by the Navy.

Autonomous controls will greatly reduce cognitive burden on operators in the monitoring, operation, and actuation of engineering plants plus the detection, diagnosing, troubleshooting, and recovery of machinery casualties. This enables reductions in manning and provides more timely response to and recovery from engineering plant casualties and their impacts, improving the robustness of the plants and overall survivability of the ship.

PHASE I: Develop a concept of an advanced AI algorithm trained using sensor data taken from training sets and representative signal databases. Key technologies, commercial software, and libraries should be identified and demonstrated in a simulated environment. Developments during Phase I will identify further training sets desired to mature the effort in Phase II. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and deliver a mature AI/ML prototype that meets all requirements in the Description, with a final demonstration in a relevant environment with other Navy-owned HM&E control systems. Documentation and on-boarding guides will be furnished for other systems to interface with the AI engine.

PHASE III DUAL USE APPLICATIONS: Support Navy in transitioning the technology for Government use. Develop deployable designs with specific interface and storage requirements for the control systems. Control systems across manufacturing and process industries as well as in DOD can benefit from incorporating AI/ML decision making technologies; manpower reduction, operational efficiencies, troubleshooting and prognostics.

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KEYWORDS: Machine learning; Artificial Intelligence; Hull, Mechanical, and Electrical; Controls Automation; Ship Domain Controller; Boundary Defense and Intrusion Systems

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N231-029 TITLE: DIGITAL ENGINEERING - Software Incident Report Capture and Scripting

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Artificial Intelligence (AI)/Machine Learning (ML); Autonomy; Cybersecurity

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

OBJECTIVE: Develop a continuous event recording and incident capture tool for software test teams to enable test scripts that recreate system conditions so fixes may be efficiently validated.

DESCRIPTION: Complex Naval Control Systems (NCSs), such as the AN/SQQ-89A(V)15 Surface Ship Undersea Warfare / Anti-Submarine Warfare Combat System, enable sailors to perform complex missions in support of achieving national security objectives. NCSs can involve millions of source lines of code (SLOC). Despite rigorous testing, an NCS may field with numerous “low priority” software problem reports (SPRs) or bugs, software flaws that do not prevent successful mission execution, but which at least are irritating and at worst can extend the time required to achieve mission success.

The Navy seeks a method for capturing specific underlying conditions associated with manifestations of a bug, to enhance the Navy’s ability to diagnose the causes of the bug or at least to recreate the bug. Enabling capture of key conditions present during an observed software incident and producing scripting to enable faithful re-creation of the bug, will substantially improve the Navy’s ability to produce tactical code that better supports sailor use in pursuit of tactical objectives. This will reduce acquisition and maintenance costs. Currently, there are no solutions that enable capture of these key conditions during observed incidents.

Many NCSs include extensive recording capability, intended to enable reconstruction of tactically significant exercises and operations. However, this recording capability is not geared towards identifying the key attributes of system operation contributing to observed software bugs. As any observed bug would be associated with previously unknown software conflicts and contributing factors, it is impossible to determine in advance which system attributes would need to be recorded to ensure a bug could be recreated. However, it appears possible to use Artificial Intelligence (AI) and Machine Learning (ML) on full recordings involving bugs to develop an ontology of bug categories and the subset of system attributes required to recreate and diagnose the bug.

The desired solution will exist within the NCS and, upon a signal from a test engineer, would initiate analysis and capture of the conditions associated with a recent bug. The technology sought will involve concise capture of the nature of the bug, as observed by the user. The technology will also collect sufficient metadata regarding key system conditions to enable developers to diagnose the likely cause(s) of the bug, recreate the error, and validate a fix has been successful.

The technology will also have a capability available to tactical users, to capture information sufficient to diagnose and recreate "escaped bugs", software problems that do not manifest until after software has been released for tactical use.

The software incident report capture and scripting (SIRCS) technology should reduce the time required to find, fix, and repair (FFR) bugs by at least 25%. Improved FFR efficiency will enable the Navy to either reduce the time required to produce software with a set number of "low priority bugs," or substantially reduce the number of bugs present in software baselines produced under a standard release rate. The SIRCS technology will not need to capture all bugs accurately but will need to be able to identify when a bug has not been properly captured. A key attribute of the technology will be the ability of the bug ontology, once developed, to accurately synopsize key system conditions to support bug diagnosis and creation. A secondary attribute will be the ease with which a test engineer or other user can capture a concise definition of the bug as observed, as users will be unlikely to use a tool that is too cumbersome resulting in continued bugs.

The NCS will possess a mature logging function and ability to ingest scripts for automated testing. The Navy will have a clear definition of bug impact and likelihood to enable provisional categorization of bugs in advance of formal assessment by the configuration control board (CCB) associated with the NCS. Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DSS and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

All DoD Information Systems (IS) and Platform Information Technology (PIT) systems will be categorized in accordance with Committee on National Security Systems Instruction (CNSSI) 1253, implemented using a corresponding set of security controls from National Institute of Standards and Technology (NIST) Special Publication (SP) 800-53, and evaluated using assessment procedures from NIST SP 800-53A and DoD-specific (KS) (Information Assurance Technical Authority (IATA) Standards and Tools).

The Contractor shall support the Assessment and Authorization (A&A) of the system. The Contractor shall support the government's efforts to obtain an Authorization to Operate (ATO) in accordance with DoDI 8500.01 Cybersecurity, DoDI 8510.01 Risk Management Framework (RMF) for DoD Information Technology (IT), NIST SP 800-53, NAVSEA 9400.2-M (October 2016), and business rules set by the NAVSEA Echelon II and the Functional Authorizing Official (FAO). The Contractor shall design the tool to their proposed RMF Security Controls necessary to obtain A&A. The Contractor shall provide technical support and design material for RMF assessment and authorization in accordance with NAVSEA Instruction 9400.2-M by delivering OQE and documentation to support assessment and authorization package development.

Contractor Information Systems Security Requirements. The Contractor shall implement the security requirements set forth in the clause entitled DFARS 252.204-7012, "Safeguarding Covered Defense

Information and Cyber Incident Reporting," and National Institute of Standards and Technology (NIST) Special Publication 800-171.

PHASE I: Develop a concept for an embedded software incident report capture and scripting (SIRCS) technology to meet the parameters of the Description. The concept should be compatible with multiple software languages operating within a Red Hat Linux operating system. Demonstrate feasibility using an unclassified system that allows the Government to understand how the concept is extensible to NCSs in general and to the AN/SQQ-89A (V)15 in particular. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and deliver a prototype software incident report capture and scripting system based on the results of Phase I. The Phase II effort will involve use of the technology with the AN/SQQ-89A(V)15 system itself. The prototype software incident report capture and scripting capability will be evaluated by Navy subject matter experts (SMEs) familiar with both NCS prototype testing and NCS certification testing.

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

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use. The final SIRCS product will be an integrated capability to capture concise descriptions of bugs, together with sufficient metadata to enable the bug to be recreated and diagnosed. The technology arising from this research would initially be incorporated into systems undergoing test during both development and certification stages of software maturation. The technology developed could be put into use as early as the testing of the AN/SQQ-89A(V)15 Advanced Capability Build (ACB) prototype undergoing development testing in 2027, likely the SQQ-89A(V)15 ACB-29 build. As this ACB matures, use of the SIRCS technology will expand to include certification testing and testing associated with installation and check-out aboard Navy combatants.

Throughout the envisioned use of the technology by Navy test personnel, the company would be funded to expand the bug classes to which the SIRCS technology reliably applies. A minimum viable product (MVP) would involve capture of 100% of concise user bug descriptions, 80% appropriate bug severity assessments prior to formal CCB adjudication, and sufficient capture of correct metadata and script generation to more than offset the time spent attempting fix and repair based on incorrect metadata and script generation.

There is potential for a SIRCS capability to apply beyond Naval control systems to other DoD control systems. Industrial applications would include complex control systems where failures can result in catastrophic consequences, such as control systems for nuclear power and information technology.

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KEYWORDS: Software incident report; automated testing; naval control systems; find, fix, and repair; FFR; ontology of bug categories; AI/ML for bug characterization

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N231-030 TITLE: DIGITAL ENGINEERING - Model Centric Safety Analysis Tool

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Artificial Intelligence (AI)/Machine Learning (ML); General Warfighting Requirements (GWR)

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

OBJECTIVE: Apply Model Based System Engineering (MBSE) tools to create a model representing the safety process required to develop and deploy advanced Navy munition systems.

DESCRIPTION: Munitions (Missiles and Projectiles) require rigorous technical evaluation and assessment of safety-critical components and sub-components, including software. This currently involves the evaluation of the testing, evaluation, and verification of a munition's safety-critical features by System Safety Working Groups (SSWGs) and official Navy Safety Technical Panels. These include the Fuze and Initiation Safety Technical Panel (FISTRP); the Software System Safety Technical Review Panel (SSSTRP), and ultimately the Navy's Weapon System Explosive Safety Review Board (WSESRB). The WSESRB reviews the entire program's plan to address safety-critical issues for the munitions to mitigate the risk or criticality of hazardous events. Many component-related artifacts such as architectural drawings are developed for SSWGs and Technical Panels and are reused throughout this process. Due to the heterogeneous nature of munitions and explosives, their manufacture, storage, delivery application, and operational use, coupled with safety requirements spanning current and future designs, there is a necessity to automate the processes that qualify their fielding. Currently processes are performed manually with no automated solution. Because automated solutions do not currently exist, the US Navy seeks advances in data and architecture design to develop a MBSE framework with structured data schemas for advanced munition safety analysis and management. In addition to integrating requirements (e.g., Department of Defense [DoD] explosive safety guidelines) and data generation (e.g., test configurations, test metrics, test results) through such techniques as Native Programming Language (NPL), a model [based upon a subset of Department of Defense Architectural Framework (DoDAF) like views] is expected that will enable multiple tiers of decision analysis. These tiers may include not only safety integration but impacts on munition performance and life cycle costs.

The solution will provide a structure for integrating requirements and data of differing ontologies from multiple sources (e.g., DoD, Department of the Navy (DoN), Department of Transportation (DoT)) as well as their architecture to model the complex processes, requirements, and test data for safety qualification of different munition configurations. The resultant technology should provide a recognizable model comprising elements of the Data Models, Operational Level Models, and System Level Models necessary to support safety data and risk and hazard analysis.

The final product should provide a prototype digital model of the DoN safety framework that bridges relationships between explosive hazard classifications, explosive hazard mitigation and associated risks with requirements and testing processes. The final product shall also illustrate the decision analysis techniques that provide efficiencies. It is expected that a subset of existing munition program cases will be used to trace the conceptualized system performance across both operational and system safety level analysis events to support model validity and potential process efficiencies that could reduce development time and costs.

Additionally, MBSE based tools that specifically support different analysis areas are expected (that is, support differing metrics or multi-tier analysis capability). An example of the analysis metrics would be in support of artifacts extracted from the FISTRP, SSSTRP, WSESRB, and Insensitive Munitions (IM) requirements and processes. Multi-tier analysis would look for bridging this safety perspective model with other munition/missile system engineering or design tools.

PHASE I: Define the conceptual data model and architecture framework for modeling munition and missile safety development, test, and qualification process and analysis allowing for technology innovation. Demonstrate the process model concept meets the parameters in the Description and show feasibility through modeling and analysis. This period will include a static demonstration of use case applicability to illustrate the modeling of the processes to lay the groundwork for supporting program analysis. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and deliver a prototype active framework using the concept developed in Phase I. Demonstrate the prototype meets the parameters of the Description using a model centric approach. This prototype will result in a demonstration of multiple uses cases and perturbations that will emphasize tiered analysis in support of decision events.

PHASE III DUAL USE APPLICATIONS: Provide the final product and remain positioned to expand the use cases as well as safety and fault tree based analysis capabilities. The development of the model is available to expand upon multi-tier decision support tools and to more closely couple design, manufacturing, and program management decision events with discrete and stochastic based risk analysis. Commercial applications would include safety critical industry processes, especially those operating under multiple requirement sources (e.g., Environmental directives - both Federal and local). Examples of possible industries might include Nuclear, Geophysical (Mining), or Chemical.

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KEYWORDS: Model Based System Engineering; MBSE; DoD Architectural Framework; Digital Engineering for safety framework; Insensitive Munitions; Weapon System Explosive Review Board; STANDARD Missile program

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N231-031 TITLE: DIGITAL ENGINEERING - Automated Cavitating Waterjet Cleaning Device

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR)

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

OBJECTIVE: Develop an automated cavitating waterjet cleaning device for conformal hull array areas.

DESCRIPTION: Acoustic receive arrays mounted to the contours of Navy submarines and surface combatants provide detailed understanding of the undersea environment and the entities within that environment. However, these sensitive surfaces can easily become fouled by biological growth during deployment. This biofouling causes sound energy to impinge on the sonar arrays, clouding sonar images and effectively reducing array sensitivity.

Current practice for cleaning these hull-conformal acoustic receive arrays is to utilize divers to manually remove the biofouling. This is particularly true for conformal arrays onto which it is not possible to add tri-butyl tin oxide (TBTO), a powerful anti-fouling agent that is approved for the large sonar domes on surface combatants. Some commercially-available technologies exist to clean ship hulls; however, the Navy seeks a US-sourced technology approved for Navy-specific materials and technologies, which currently do not exist.

Hull-conformal acoustic arrays, often coated with anti-fouling materials, can cover large areas of the hull of a submarine or surface combatant. Using current practice, this results in a need to manually clean large, fouled surface areas, which comes with a concomitant risk to divers. A technology that could properly clean acoustic arrays could also be used for general hull cleaning to increase fuel efficiency and reduce flow noise.

The Navy seeks an automated cleaning device that will provide for automated cleaning of biofouling and allow a cleaning device to automatically clean a surface on a docked vessel on which biofouling has grown and not damage the surface being cleaned. Hull conformal acoustic arrays, such as the Large Vertical Array (LVA) present on select submarines, could be degraded in performance if the surface were damaged. Such an automated cleaning device would need to increase or decrease its cleaning cycle dependent on the amount of biofouling that has occurred to enable longer or more passes on biofouling that resists removal while touching only lightly on areas where there is little or no biofouling.
The envisioned result of the innovation sought is reduced damage to hull-conformal arrays and any anti-fouling treatment as well as reduced danger to divers charged with removing biofouling across large areas on the hulls of surface ships and submarines.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the

Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DSS and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

All DoD Information Systems (IS) and Platform Information Technology (PIT) systems will be categorized in accordance with Committee on National Security Systems Instruction (CNSSI) 1253, implemented using a corresponding set of security controls from National Institute of Standards and Technology (NIST) Special Publication (SP) 800-53, and evaluated using assessment procedures from NIST SP 800-53A and DoD-specific (KS) (Information Assurance Technical Authority (IATA) Standards and Tools).

The Contractor shall support the Assessment and Authorization (A&A) of the system. The Contractor shall support the government's efforts to obtain an Authorization to Operate (ATO) in accordance with DoDI 8500.01 Cybersecurity, DoDI 8510.01 Risk Management Framework (RMF) for DoD Information Technology (IT), NIST SP 800-53, NAVSEA 9400.2-M (October 2016), and business rules set by the NAVSEA Echelon II and the Functional Authorizing Official (FAO). The Contractor shall design the tool to their proposed RMF Security Controls necessary to obtain A&A. The Contractor shall provide technical support and design material for RMF assessment and authorization in accordance with NAVSEA Instruction 9400.2-M by delivering OQE and documentation to support assessment and authorization package development.

Contractor Information Systems Security Requirements. The Contractor shall implement the security requirements set forth in the clause entitled DFARS 252.204-7012, "Safeguarding Covered Defense Information and Cyber Incident Reporting," and National Institute of Standards and Technology (NIST) Special Publication 800-171.

PHASE I: Develop a concept for an automated cavitating waterjet cleaner that meets the parameters in the Description. Demonstrate the concept through modeling and analysis. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and deliver a prototype automated cavitating waterjet cleaner from concept development in Phase I. Demonstrate that the prototype meets parameters of the Description. The prototype will be tested on a representative bio-fouled test surface in a controlled body of water.
It is possible that the work under this effort will be classified under Phase II (see Description section for details).

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology for Navy use. Work with Navy subject matter experts to develop a design that can clean with minimal manning. In the event the Navy determines that the designs are appropriate for use with hull-conformal arrays, the Navy will refine system requirements and either levy the improved requirement on prime contractors producing towed arrays or will purchase prototypes and low rate initial production (LRIP) units from the company.,

Potential dual use of the automated cavitating waterjet cleaning technology would be any maritime or oceanographic surface or vessel that must be kept free of biofouling for customer enjoyment or functional performance. Examples would include piers, aquariums, rigging for oil and gas exploration, and cleaning of commercial vessels to achieve maximal fuel efficiency.

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KEYWORDS: Large Aperture Bow; LAB; biofouling; fuel efficiency; attack submarines; automated cleaning device for ships; biofouling removal

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N231-032 TITLE: Launchable Mini Glider for Variable Payloads

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Autonomy; General Warfighting Requirements (GWR)

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

OBJECTIVE: Develop a launchable mini glider sensor platform able to survive 48 hours in service within the water column.

DESCRIPTION: Unmanned gliders have demonstrated the ability to measure ocean environments for extended periods of time across vast ocean areas. As suggested by the term "glider," such devices leverage physics to facilitate movement through the water and, as such, are more energy efficient than unmanned vehicles that require positive propulsion to travel or maintain station. Existing gliders are larger than a shipping pallet and must be launched from the deck of a surface ship.

The Navy seeks to produce a launchable hybrid buoyancy glider sensor platform that survives 48 hours in the ocean in conditions up to sea state 6 (SS 6). The device will initially focus on measurement of the local sound speed profile (SSP), with a requirement that the device rise to the surface at least once every six hours to transmit collected environmental information to either satellites or proximate manned platforms involved in conducting Undersea Warfare (USW).

As there are numerous unmanned systems at advanced stages of development, proposals of greatest interest will reflect an understanding of the total life-cycle and infrastructure required to produce tactical utility. Therefore, the proposed technology should provide a high level concept for how the glider would interact with the variety of platforms that would leverage the information collected by the glider. For example, the data could be transmitted using existing protocols via satellite networks, via radio frequency (RF) to combatants and air platforms above the surface of the water, and/or via acoustic emissions to submerged platforms or sensors.

There are three standard form factors that could be launched from a wide variety of platforms:

1) the standard torpedo form factor (6.25 inches in diameter x 107 inches long)
2) the A-size sonobuoy form factor (4.875 inches in diameter x 36 inches long), and
3) the standard 3" countermeasure form factor (3 inches in diameter x up to 106 inches long)

Though past attempts suggest it is unlikely the glider endurance and performance could fit in something as small as an A-size sonobuoy, the smaller form factors could potentially accommodate other systems to facilitate the utility of the primary glider, such as communication devices to extend the range to which the data collected by the hybrid buoyancy glider could be transmitted.

Because the A-size form factor is compatible with all platforms that perform USW, proposers are advised that any A-size form factor element of a proposed system expanding the utility of the hybrid buoyancy glider would be expected to conform to the following objectives:

1. Packaging: LAU-126A Sonobuoy Launch Container (SLC) or equivalent
2. Weight: Max 39 lbs. (bare, not including the SLC)
3. Stowed Dimensions: 4.875” diameter x 36” length
4. Storage: 5 years shelf life
5. Launch Envelope: Full Sonobuoy production specification
6. Temperature – operational from -20°C to 50°C
7. Cost: In final form,

The initial payload desired for the glider platform would be the measurement of sound speed as a function of depth, the SSP already mentioned. However, the utility of the launchable device would increase in proportion to the flexibility of payload options the glider platform could accommodate.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DSS and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

All DoD Information Systems (IS) and Platform Information Technology (PIT) systems will be categorized in accordance with Committee on National Security Systems Instruction (CNSSI) 1253, implemented using a corresponding set of security controls from National Institute of Standards and Technology (NIST) Special Publication (SP) 800-53, and evaluated using assessment procedures from NIST SP 800-53A and DoD-specific (KS) (Information Assurance Technical Authority (IATA) Standards and Tools).

The Contractor shall support the Assessment and Authorization (A&A) of the system. The Contractor shall support the government’s efforts to obtain an Authorization to Operate (ATO) in accordance with DoDI 8500.01 Cybersecurity, DoDI 8510.01 Risk Management Framework (RMF) for DoD Information Technology (IT), NIST SP 800-53, NAVSEA 9400.2-M (October 2016), and business rules set by the NAVSEA Echelon II and the Functional Authorizing Official (FAO). The Contractor shall design the tool to their proposed RMF Security Controls necessary to obtain A&A. The Contractor shall provide technical support and design material for RMF assessment and authorization in accordance with NAVSEA Instruction 9400.2-M by delivering OQE and documentation to support assessment and authorization package development.

Contractor Information Systems Security Requirements. The Contractor shall implement the security requirements set forth in the clause entitled DFARS 252.204-7012, “Safeguarding Covered Defense Information and Cyber Incident Reporting,” and National Institute of Standards and Technology (NIST) Special Publication 800-171.

PHASE I: Develop a concept for a launchable device and any required supporting devices capable of meeting the required parameters for the purpose of measuring SSPs. Demonstrate that the key attributes of the concept's feasibility meet the parameters in the Description. Feasibility must be demonstrated through modeling and analysis. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and deliver a prototype launchable glider device and required supporting devices based on the results of Phase I. Additional testing of prototypes to support analyses of device survivability in the ocean environment would also be conducted by the company to support a decision on the part of the Navy.

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

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the launchable glider and any required supporting devices. Navy interest in a launchable device hosting a sensor module is focused on devices that can be easily launched from platforms conducting USW, which puts priority on solutions that fit one or more of the standard military form factors identified in the description. The core sound speed profile measurement capability would enable persistent measurement of the key factors associated with sound propagation.

Potential dual use of the launchable mini-glider device would be for ocean exploration, such as the oil and gas industry, and characterization of oceanographic properties for the study of marine wildlife.

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KEYWORDS: Sound speed profile; SSP; hybrid buoyancy glider; sensor module; expendable bathythermograph' XBT; launchable device; Sea State 6; SS 6

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N231-033 TITLE: Permanent Radio Frequency Transparent AN/SPY-1 Array Cover

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR)

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

OBJECTIVE: Develop a permanent Radio Frequency (RF) transparent protective cover for the AEGIS AN/SPY-1 Array Antenna to extend the life of the Room Temperature Vulcanizing (RTV) coating and reduce how often the ship will need to be resurfaced.

DESCRIPTION: Currently, the AEGIS AN/SPY-1 radar arrays are coated with a unique Room Temperature Vulcanizing (RTV) coating. The current RTV coating system must be resurfaced after approximately 9 years of service. The need for resurfacing is based on Material Condition Assessments (MCAs) determining repairs needed in the next scheduled ship availability. MCAs help to identify the type and level of severity of any surface corrosion or water intrusion in the AN/SPY-1 arrays. Commercial products with the combined requirements of strength and RF transparency that meet Navy test requirements for shock and transmission are not available.

Resurfacing requires a highly specialized process to strip and resurface the arrays. The current RTV coating is extremely difficult to apply and application requires special equipment, certification training, and unique talent. On spray day, RTV-157 mixture is applied to the whole AN/SPY-1 Antenna Array face, which consists of an aluminum structure and ceramic waveguide seals (windows). The RTV-157 mixture consists of RTV 157, Heptane, Oxsol 100, and tint. HAZMAT chemicals are used in the RTV 157 mixture to change it to a liquid form to spray on the array face. Chemicals are exhausted out to the atmosphere after a 24 hour cure period. The current AN/SPY-1 array resurfacing process generates a large volume of hazard material waste of approximately four (4) 55-Gallon Drums of Solid HAZWASTE (contains old RTV, rags used for chemical application, gloves, fire retardant paper used to cover the ship hull when applying the RTV) and one (1) 55-Gallons Drum of Liquid HAZWASTE (contains Heptane, Oxsol 100, Ethyl Acetate, Isopropyl Alcohol, RTV 157 mixture, tint).

Improper preparation or application of the RTV protective coating can result in reduced service life of the coating and possible radar performance degradation due to RF signal attenuation. Because the RTV is applied directly to the array face ceramic RF windows (i.e., waveguide seals), any coating deterioration can lead to water intrusion, corrosion of the aluminum array face substrate, and degradation of radar performance. Once this occurs, sea water will start to penetrate the Array Nests inside and salt crystal residue will start to form inside. Sea water and RF signals do not mix because sea water behaves optically like a metal. Therefore, the RF signal reflects back when it interacts with sea water. Furthermore, the thin coating of RTV provides virtually no impact protection for the RF windows, which are extremely vulnerable to damage from physical contact (e.g., hail, rogue waves, spent cartridges, etc.).

The AN/SPY-1 array cover must survive a nuclear thermal shock and demonstrate a low coefficient of expansion resulting in minimal mechanical forces transmitted to the array. Government Furnished

Information (GFI) on specific nuclear thermal shock requirements will be provided in Phase II in a classified environment. Any generated residue (ash) produced as a result of the thermal pulse must be easily wiped or washed away and any ash generated must not impact RF signal performance.

Navy seeks a permanent RF transparent protective cover for the AEGIS AN/SPY-1 Array Antenna to extend the life of the RTV coating and reduce how often the ship will need to be resurfaced. The permanent covers will be removable for replacement, refurbishment or repairs. Removed damaged covers will be refurbished off-site for the next ship requiring array maintenance. The cover must be designed to encapsulate the array face while allowing access to array alignment points.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DCSA and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

All DoD Information Systems (IS) and Platform Information Technology (PIT) systems will be categorized in accordance with Committee on National Security Systems Instruction (CNSSI) 1253, implemented using a corresponding set of security controls from National Institute of Standards and Technology (NIST) Special Publication (SP) 800-53, and evaluated using assessment procedures from NIST SP 800-53A and DoD-specific (KS) (Information Assurance Technical Authority (IATA) Standards and Tools).

The Contractor shall support the Assessment and Authorization (A&A) of the system. The Contractor shall support the government's efforts to obtain an Authorization to Operate (ATO) in accordance with DoDI 8500.01 Cybersecurity, DoDI 8510.01 Risk Management Framework (RMF) for DoD Information Technology (IT), NIST SP 800-53, NAVSEA 9400.2-M (October 2016), and business rules set by the NAVSEA Echelon II and the Functional Authorizing Official (FAO). The Contractor shall design the tool to their proposed RMF Security Controls necessary to obtain A&A. The Contractor shall provide technical support and design material for RMF assessment and authorization in accordance with NAVSEA Instruction 9400.2-M by delivering OQE and documentation to support assessment and authorization package development.

Contractor Information Systems Security Requirements. The Contractor shall implement the security requirements set forth in the clause entitled DFARS 252.204-7012, "Safeguarding Covered Defense Information and Cyber Incident Reporting," and National Institute of Standards and Technology (NIST) Special Publication 800-171.

PHASE I: Develop a concept of installing permanent, removable RF transparent covers over the AN/SPY-1 arrays. Demonstrate the feasibility of the concept in meeting Navy needs and establish that the concept can be developed into a useful product for the Navy. Feasibility will be established via computer modeling. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and deliver a prototype permanent RF transparent protective cover for the AEGIS AN/SPY-1 radar array for testing and evaluation based on the results of Phase I. Demonstrate system performance through prototype evaluation and testing, modeling, and analysis. Evaluate results and accordingly refine the prototype concept to ensure that the prototyped hardware clearly shows a path to development of a manufacturable, sea worthy hardened system. The prototype model is to be made available for Government demonstration or testing. Prepare a Phase III development plan to transition the technology to Navy use.

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

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning a permanent RF transparent protective cover for the AEGIS AN/SPY-1 radar array to Navy use. Facilitate transition of a permanent RF transparent protective cover for the AEGIS AN/SPY-1 radar array for sea trials to be demonstrated on a relevant vessel. Participate in a fleet demonstration aimed at transition with the intent to purchase and integrate the system into the US Navy AEGIS Fleet.

With the proliferation of flat panel arrays both in military and commercial radar and communications, high strength RF transparent protective covers will be required to extend service life of the emitter components.

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KEYWORDS: AEGIS Arrays; RF transparent Covers; Nuclear Thermal Shock; Radar; AN/SPY-1; Radio Frequency; RF

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N231-034 TITLE: Open Architecture Telemetry First Level Multiplexer with Array Power Distribution

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR); Microelectronics

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

OBJECTIVE: Develop a single Open Architecture Telemetry (OAT) component which combines the functionality of an OAT First Level Multiplexer (FLM) with the array power distribution component (power shunt).

DESCRIPTION: Towed acoustic receive arrays provide powerful insight into the undersea environment and the natural and man-made entities that exist under the surface of the ocean. Towed arrays are populated with hydrophones, and when there is increased hydrophone density in the towed array, it is possible to achieve a higher resolution understanding of the ocean environment. However, the resolution with which a towed array can measure the undersea environment is limited by the number of data channels in the array. The number of data channels is limited by the available data bandwidth and amount of power that can be utilized throughout the array.

The Navy has developed open architecture telemetry (OAT) to reduce Navy reliance on proprietary hardware vendors. This open architecture approach allows other vendors to participate in refinement of key design elements of Navy towed acoustic receive arrays.

To expand this open architecture approach beyond the current state of the art, the Navy seeks to develop an FLM independent of the channels themselves. By multiplexing the sensor data onto a separate high speed backbone, data can be transmitted at increased rates to enable a multi-fold increase in the number of individual sensor elements a towed array can use for a given cable design.

Multiplexing the hydrophone data transmitted in the array can only improve towed array resolution if the individual hydrophones and telemetry components can be powered, a capability that is beyond the current state of the art. Therefore, development of a power distribution system, or power shunt that can provide power to an increased number of individual hydrophones and their telemetry components with which the towed array is populated will also be necessary. Combining the FLM and shunt into a single package would reduce the overall footprint of telemetry components, providing additional space for sensing capabilities.

Towed arrays and their component parts must survive the range of environmental conditions to which the towed array might be subjected. The FLM will survive being towed under the conditions described in MIL-STD-167-1A.

The elements of the FLM and power shunt design that exist within the towed array itself must not interfere with the flow over the towed array, indicating that the dimensions of such elements of an OAT telemetry should be smaller than approximately 1” in diameter. Further, the FLM and power shunt design must not significantly increase the likelihood of array breakage while stowed or during deployment and retrieval.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DSS and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

All DoD Information Systems (IS) and Platform Information Technology (PIT) systems will be categorized in accordance with Committee on National Security Systems Instruction (CNSSI) 1253, implemented using a corresponding set of security controls from National Institute of Standards and Technology (NIST) Special Publication (SP) 800-53, and evaluated using assessment procedures from NIST SP 800-53A and DoD-specific (KS) (Information Assurance Technical Authority (IATA) Standards and Tools).

The Contractor shall support the Assessment and Authorization (A&A) of the system. The Contractor shall support the government’s efforts to obtain an Authorization to Operate (ATO) in accordance with DoDI 8500.01 Cybersecurity, DoDI 8510.01 Risk Management Framework (RMF) for DoD Information Technology (IT), NIST SP 800-53, NAVSEA 9400.2-M (October 2016), and business rules set by the NAVSEA Echelon II and the Functional Authorizing Official (FAO). The Contractor shall design the tool to their proposed RMF Security Controls necessary to obtain A&A. The Contractor shall provide technical support and design material for RMF assessment and authorization in accordance with NAVSEA Instruction 9400.2-M by delivering OQE and documentation to support assessment and authorization package development.

Contractor Information Systems Security Requirements. The Contractor shall implement the security requirements set forth in the clause entitled DFARS 252.204-7012, “Safeguarding Covered Defense Information and Cyber Incident Reporting,” and National Institute of Standards and Technology (NIST) Special Publication 800-171.

PHASE I: Develop a concept for OAT FLM with a power distribution system or power shunt and show it meets the parameters of the Description. Demonstrate the concept can feasibly meet the parameters through analysis and modeling. The Phase I feasibility demonstration and associated analysis should support a reasonable expectation that the technology could meet the performance parameters in the Description and provide reasonable expectation that additional sensor hydrophones could be accommodated. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and deliver a prototype system that would be tested in a controlled body of water, such as the deep waters of Lake Pend Oreille near Bayview, Idaho. Additional testing of prototypes to support analyses of FLM and power shunt survivability in the ocean environment will also be conducted by the company to support a decision on the part of the Navy.

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

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology for Navy use. Work with Navy subject matter experts to develop designs that would perform as desired when integrated with the other open architecture telemetry elements, towed array hydrophones, and towed array physical form factor. In the event the Navy determines that the designs are appropriate for incorporation into the OAT system, the Navy will refine system requirements and either levy the improved requirement on prime contractors producing towed arrays or will purchase prototypes and low rate initial production (LRIP) units from the company.

Potential dual use of the FLM and power shunt would be for arrays used in oil and gas exploration and other environmental sensing applications.

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KEYWORDS: First level multiplexer. FLM; power distribution; power shunt; towed acoustic receive array; open architecture telemetry; OAT; increased hydrophone density

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N231-035 TITLE: Automatic Target Recognition (ATR) in Complex Underwater Environments

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Artificial Intelligence (AI)/Machine Learning (ML); Autonomy

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

OBJECTIVE: Develop adaptive Artificial Intelligence / Machine Learning (AI/ML) automatic target recognition (ATR) algorithms to support Autonomous Undersea Vehicle (AUV) operations in complex environments.

DESCRIPTION: ATR algorithm performance is degraded in littoral waters because of the clutter created by the abundance of marine life in a complex underwater environment. Complex underwater environments are underwater areas with varied seabed composition, bottom clutter, and a significant amount of marine life. Current ATR capabilities are created for non-complex environments with homogenous seabed and limited marine life. As a result, current ATR capabilities lack the ability to discriminate between targets and clutter caused by marine life, reducing the ability to perform detection, classification, and localization of targets.

The Navy is seeking AI/ML ATR processing algorithms, or techniques to facilitate target identification in complex environments using acoustic, optical, and magnetic sensors. The resulting technology should provide a significant improvement in the performance and detection capability of ATR algorithms by reducing the Probability of False Alarm (Pfa) and improve operator work load. Improvements are considered significant when performance in complex environments approaches the current baseline requirements for performance in non-complex environments. The technology will be integrated into the Generalized ATR (GATR) system to improve performance and detection capability

AI/ML capability should incorporate information from new data sets into the ATR system as they are acquired, and re-optimize the ATR algorithms quickly across all known environments, including those of newly acquired data. Online Machine Learning (OML) algorithms can potentially be used to “learn” in the field based on operator-provided results without affecting prior performance. The information collected online can be used to refine the prediction hypothesis (classifier) used in the ATR algorithms. In addition, the information may provide input for automated methods of optimizing ATR performance across all known data sets.

The proposed effort will develop innovative OML algorithms for ATR that can incorporate human operator decisions to optimize probability of detection and probability of false alarm performance in new environments and for new target types. These algorithms will be integrated into mission and post-mission analysis systems in which operators review acquired data. Algorithms must be built for operation on the Nvidia Graphics Processing Unit (GPU) using the Compute Unified Device Architecture (CUDA). The OML algorithms and optimization tools developed in this effort will reduce program costs by minimizing the time required for optimizing ATR algorithms to perform well in complex operational environments where there is little or no data available.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DCSA and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

All DoD Information Systems (IS) and Platform Information Technology (PIT) systems will be categorized in accordance with Committee on National Security Systems Instruction (CNSSI) 1253, implemented using a corresponding set of security controls from National Institute of Standards and Technology (NIST) Special Publication (SP) 800-53, and evaluated using assessment procedures from NIST SP 800-53A and DoD-specific (KS) (Information Assurance Technical Authority (IATA) Standards and Tools).

The Contractor shall support the Assessment and Authorization (A&A) of the system. The Contractor shall support the government’s efforts to obtain an Authorization to Operate (ATO) in accordance with DoDI 8500.01 Cybersecurity, DoDI 8510.01 Risk Management Framework (RMF) for DoD Information Technology (IT), NIST SP 800-53, NAVSEA 9400.2-M (October 2016), and business rules set by the NAVSEA Echelon II and the Functional Authorizing Official (FAO). The Contractor shall design the tool to their proposed RMF Security Controls necessary to obtain A&A. The Contractor shall provide technical support and design material for RMF assessment and authorization in accordance with NAVSEA Instruction 9400.2-M by delivering OQE and documentation to support assessment and authorization package development.

Contractor Information Systems Security Requirements. The Contractor shall implement the security requirements set forth in the clause entitled DFARS 252.204-7012, “Safeguarding Covered Defense Information and Cyber Incident Reporting,” and National Institute of Standards and Technology (NIST) Special Publication 800-171.

PHASE I: Develop a concept to facilitate target identification in complex underwater environments using acoustic, optical, and magnetic sensors that meets the requirements described above. Demonstrate the feasibility of the concept in meeting Navy needs and establish that the concept can be feasibly developed into a useful product for the Navy. Feasibility will be established by testing and analytical modeling. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

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

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

PHASE III DUAL USE APPLICATIONS: Produce and support a final prototype that will be integrated into developmental and operational frameworks used by the MK18 Family of Systems (FoS). Additionally, AI/ML algorithms developed may be inserted onboard AUV's embedded processors. Technology developed under this effort is applicable to any domain that requires subsea platform autonomy such as subsea oil and gas pipeline inspection.

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KEYWORDS: Artificial Intelligence / Machine Learning; AUV / UUV; Automatic Target Detection; General ATR; Probability of false alarm; ATR capabilities; Complex water environments.

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N231-036 TITLE: Long-Range Acoustic Communications System

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Networked C3

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

OBJECTIVE: Develop a long-range acoustic communications system that supports paging submerged unmanned autonomous systems operating in deep- and shallow-ocean environments.

DESCRIPTION: The Navy is seeking to develop a long-range acoustic communications system capable of transmitting service-requests, alerts, and coordination messages to unmanned systems operating in deep and shallow ocean environments. The development of a long-range communications system to support unmanned maritime system operations in which both transmitter and receiver are submerged is challenging due to the size, weight, and power (SWaP) constraints imposed by most battery powered unmanned vehicles, and the impact of environmental properties on the characteristics of the acoustic channel. Due to the increase in absorption losses that acoustic signals undergo as their frequency increases, long-range acoustic-communication system must use low frequency bands and require an acoustic source with high electro-acoustic efficiency able to reach source levels above 190 dB re 1 microPa [Ref 5]. The commercial market and most state-of-the-art research on underwater acoustic communications have focused on increasing the transmission bit rate for short and medium range point-to-point applications. Some commercially-available long-range acoustic messaging systems integrate radiofrequency (RF) communications with an RF/acoustic surface gateway to reach undersea nodes from a surface station. Similar systems for submerged source and destination pairs that do not require surface relay infrastructure are not commercially available.

To address this gap, the long-range acoustic communications system proposed under this SBIR topic must be, at a minimum, capable of transmitting one-way through water to enable asymmetric acoustic communications at ranges up to 100 km in shallow ocean waters and up to 200 km in shallow-to-deep ocean waters. Shallow-water acoustic propagation environments featuring both upward-refracting and downward-refracting sound speed profiles can be considered. The transmitter should cover conical volumes with tunable apertures between 5 and 25 degrees. The communications system must transmit messages up to 125 bytes (uncoded) on a 12-hour cycle, and bursts of messages up to 64 bytes as needed. Additionally, the system must be robust to Doppler effects for relative transmitter-receiver speeds of up to 5 m/s. If a surface receiver is used, it must be able to receive acoustic messaging with minimal performance degradation at up to sea-state level 8 (based on Beaufort’s wind-force scale). In general, the communications system must be robust to small-scale variability in acoustic channel conditions. Finally, modulations and waveforms with low-probability-of-detection and low-probability-of-interception characteristics would be preferred.

The communications receiver is required to have a form factor capable of fitting within a medium-size UUV with a cylindrical shape not to exceed 12” radius and 10” length. The system including electronics, transducers or other transmitter/receiver hardware must weigh less than 5 lbs. SWaP constraints on the acoustic transducer geometry imposed by UUV configurations will drive the level of asymmetry expected in the long-range acoustic communication links enabled by the communications system. Similar SWaP guidelines apply to the transmitter module if deployed in a UUV. A power allowance of 200 W for transmit mode and 10 W for receive mode should be used as a design reference-power-budget for medium class UUVs. Deployment of a transmitter for larger platforms, both mobile and fixed, will also be considered. In the latter case, SWaP guidelines will be adjusted to the target platform.

To ensure interoperability with planned and future UUVs, solutions must also comply with the PMS 406's Unmanned Maritime Autonomy Architecture (UMAA). UMAA establishes a standard for common interfaces and software reuse among the mission autonomy and the various vehicle controllers, payloads, and C2 services in the PMS 406 portfolio of Unmanned surface and undersea vehicles (UxV). The UMAA standard for Interface Control Documents (ICDs) mitigates the risk of unique autonomy solutions applicable to just a few vehicles allowing flexibility to incorporate vendor improvements as they are identified; affect cross-domain interoperability of UxS vehicles; and allow for open architecture (OA) modularity of autonomy solutions, control systems, C2, and payloads. UMAA standards and required ICDs will be provided during the Phase I effort.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, to perform on advanced phases of this contract as set forth by DCSA and NAVSEA to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

All DoD Information Systems (IS) and Platform Information Technology (PIT) systems will be categorized in accordance with Committee on National Security Systems Instruction (CNSSI) 1253, implemented using a corresponding set of security controls from National Institute of Standards and Technology (NIST) Special Publication (SP) 800-53, and evaluated using assessment procedures from NIST SP 800-53A and DoD-specific (KS) (Information Assurance Technical Authority (IATA) Standards and Tools).

The Contractor shall support the Assessment and Authorization (A&A) of the system. The Contractor shall support the government's efforts to obtain an Authorization to Operate (ATO) in accordance with DoDI 8500.01 Cybersecurity, DoDI 8510.01 Risk Management Framework (RMF) for DoD Information Technology (IT), NIST SP 800-53, NAVSEA 9400.2-M (October 2016), and business rules set by the NAVSEA Echelon II and the Functional Authorizing Official (FAO). The Contractor shall design the tool to their proposed RMF Security Controls necessary to obtain A&A. The Contractor shall provide technical support and design material for RMF assessment and authorization in accordance with NAVSEA Instruction 9400.2-M by delivering OQE and documentation to support assessment and authorization package development.

Contractor Information Systems Security Requirements. The Contractor shall implement the security requirements set forth in the clause entitled DFARS 252.204-7012, "Safeguarding Covered Defense Information and Cyber Incident Reporting," and National Institute of Standards and Technology (NIST) Special Publication 800-171.

PHASE I: Develop a concept for a long-range acoustic communications system that meets the requirements in the Description. Establish feasibility by developing system diagrams as well as Computer-Aided Design (CAD) models that show the transmitter concept and provide estimated weight and dimensions of the concept. Feasibility will also be established by computer-based simulations that show the system's capabilities are suitable for the project needs. The hardware design shall include an assessment of the SWaP for the acoustic transmitter and receiver, as well as a notional transducer geometry that accommodates the space constraints imposed by medium-size UUVs. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Based on the results of Phase I and the Phase II Statement of Work (SOW), develop and deliver a prototype system for in-water testing and measurement/validation of the Phase I performance attributes. The system prototype shall include a transmitter receiver pair, and the corresponding software and application programming interface (API) descriptions. Test the prototype system, first in a controlled laboratory environment, then in an in-water (saltwater) environment, to determine its capability to meet all relevant performance metrics outlined above and in the Phase II SOW. Performers are expected to explore opportunities for at-sea experimentation to further demonstrate the feasibility of the system. Demonstrate the prototype system performance in both environments (laboratory and in-water) and present the results in two separate test reports to the Government. Use the results to correct any performance deficiencies and refine the prototype into a pre-production design that will meet Navy requirements. Prepare a Phase III SOW that will outline how the technology will be transitioned for Navy use.

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

PHASE III DUAL USE APPLICATIONS: The company will support the Navy in transitioning the technology to Navy use. Work with Navy subject matter experts to develop an acoustic communications system for UUVs.

If successful, the long-range acoustic communications system could be applied to other unmanned Navy assets including buoys and subsea nodes. These assets have communications requirements, some of which require covert communications for which this system could provide a solution. In addition to such DoD applications, the communication system could be used in commercial oil, gas, and oceanographic sensing applications.

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KEYWORDS: Underwater acoustic communication systems; long-range underwater acoustic communications; assured underwater C2; Secure underwater acoustic communications; adaptive modulation; channel estimation and equalization.

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N231-037 TITLE: DIGITAL ENGINEERING - Gun Weapons Systems Synthetic Unmanned Aerial Systems Imagery Data Set

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Artificial Intelligence (AI)/Machine Learning (ML); Autonomy

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

OBJECTIVE: Develop a synthetic imagery dataset of Unmanned Aerial Systems (UAS) using machine learning (ML) for computer vision discriminator applications.

DESCRIPTION: Unmanned Aerial Systems (UAS) pose a threat to the US Navy (USN) surface fleet. Counter-UAS results in successful negation of UAS threats by USN effectors. It requires the ability to detect, identify, discriminate, and engage in a cost-effective manner. In order to increase the automation of surface sensors' ability to detect, identify, and discriminate UAS, large data sets of image and video data must be collected. The number and variety of UAS and the need for all aspect coverage make physical data collections costly in terms of time and money. The USN seeks automated visual synthetic data generation using ML to develop these large data sets. The produced data sets will train algorithms. Synthetic data generation is a rapidly growing field. It is being applied to many different use cases including autonomous vehicle navigation and advanced driver-assistance systems as well as security systems and manufacturing automation. While these areas of research and development are newly advancing, specific use needed by the Government is not available. One particular technique that may be applicable is Deep Convolutional Generative Adversarial Networks (DC GANs) but other synthetic techniques are viable. The solution should provide data as seen at a nose-on view, top-down aerial view, and broad side view (i.e., plan, profile, and various oblique angles). The solution should demonstrate realism of the dataset through analysis and modeling.

The solution will contain a synthetic dataset of frame-by-frame UAS images (not video sequences) in both visible and thermal bands that is useful for application to the training, validation, and testing of ML and artificially intelligent sub-systems for Naval Gunnery Systems. The solution should produce a dataset that conforms to commonly available public standards and contains images and labels of ground truth objects in accordance with class ontology, such as the Jet Propulsion Laboratory Semantic Web for Earth and Environmental Terminology (SWEET). The dataset should contain at least 3 types of group 1 UAS and at least 2 types of group 2 UAS. These UAS used to create datasets may be commercial products. The synthetically generated data shall be photo-realistic for both the visible and thermal imagery with high definition (HD) resolution.

The labels should be at minimum rectangular labels, with segmentation labels being the objective. The dataset should also have diverse object and scene composition with variations in object size, orientation, background, lighting, and atmospheric conditions. The perspective and size of observation should also vary ranging between 2 pixels in the smallest dimension up to the full size of the image frames.

The dataset should also be appropriately partitioned by the band of synthetic imagery (visible and thermal). It should also follow image dataset convention in the split of training for the training of ML systems; validation for the initial testing of the algorithm performance; and test for model performance verification with distinct data from the other sets. Each band of data will contain these three sub-sets.

PHASE I: Develop a concept for automated synthetic generation dataset. Demonstrate its technical feasibility using analytical models, simulations, and testing. Modeling should demonstrate several produced image datasets in both the visible and thermal bands. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and deliver a prototype automated synthetic generation dataset as described in the Description and based on the results of Phase I. Demonstrate that the prototype meets the parameters of the Description through initial laboratory testing to confirm the design, functionality, and modelling underlying the theory of automated synthetic generation to evaluate and assess the sufficiency of the synthetic dataset. The prototype dataset will be provided to the Government for testing in a digital format using common file formats.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the automated synthetic generation technology to Navy use through testing and further development to facilitate the adaptation of the technology to Navy use in Naval Gunnery applications. The prototype will provide the foundation upon which to train, validate, and test UAS detection systems.

The product itself may have limited applications in the commercial sector. However, the tools and process developed to create this dataset will be extremely valuable for the creation of additional datasets for commercial applications. These include autonomous vehicle automation, security systems, and manufacturing automation.

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KEYWORDS: Deep Convolutional Generative Adversarial Networks; Synthetic Data Generation; Synthetic Dataset; Unmanned Aerial Systems Imagery; UAS; Counter-UAS; Artificial Intelligence for visual image processing

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N231-038 TITLE: Perceptually Lossless Unmanned Underwater Vehicle (UUV) Sensor Data Compression

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Artificial Intelligence (AI)/Machine Learning (ML); General Warfighting Requirements (GWR)

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

OBJECTIVE: Develop an innovative data compression capability for the UUV sensor data that can increase onboard storage and enable sending large amounts of sensor data acoustically through the water column and Over the Horizon (OTH) using limited bandwidth transmissions including acoustic, radio, and satellite links.

DESCRIPTION: The Maritime Expeditionary Mine Countermeasures Unmanned Undersea Vehicle (MEMUUV) Family of Systems (FoS) program has an interest in increasing the capability of sending high-resolution sonar and camera images and video files OTH using limited bandwidth. Additionally, the Mine Warfare community uses large volumes of imagery data to build Automatic Target Recognition (ATR) data sets for training and calibration of ATR systems. Today's through water transfer rates are on the order of 80 bps; however, in the near future it is anticipated that the program will leverage transfer rates of up to 4 kbps at distances between 1500m-4500m. The transmission of compressed data will need to overcome physical challenges such as low signal-to-noise ratios, strong rapidly varying multi-path, and noise interference that with today's technology results in relatively high error rates. Unique research and development will be required to achieve the required data compression for sonar images due to the speckle noise content. It should be anticipated that file sizes up to 40 MB should be compressed with a visually lossless ratio of at least 10:1.

The Navy seeks tangible improvement over today's image and data compression rates. State of the art lossless compression methods can currently be expected to achieve 2:1 to 4:1 compression, while perceptually lossless compression methods may achieve 10:1 compression or better [Ref 1].

Recognizing that off-the-shelf (OTS) codecs may not be optimal for sonar and undersea optical modalities, an innovative compression technique is sought for compression of sonar, camera, and video data so that high resolution images and videos can be transmitted over the limited bandwidth, error-prone links.

Concepts are desired that are both bandwidth efficient and error tolerant [Refs 1, 3, 5]. For purposes of this SBIR topic, "visually lossless" means the compressed imagery retains the feature details necessary for mine identification by, or training of, human analysts. It is noted that the Human Visual System with masking (HVSm) correlates well with human perception and is the preferred metric in recognizing perceptual losslessness [Refs 1 and 2]. Offers should notionally quantify expected improvement of the proposed technology. Image compression solutions may be in the form of hardware, software, or both.

Hardware proposals should address integration considerations (e.g., size, weight and power [SWaP] constraints) for small and medium class UUVs such as the MK 18 Mod 1 and Mod 2.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DCSA and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

All DoD Information Systems (IS) and Platform Information Technology (PIT) systems will be categorized in accordance with Committee on National Security Systems Instruction (CNSSI) 1253, implemented using a corresponding set of security controls from National Institute of Standards and Technology (NIST) Special Publication (SP) 800-53, and evaluated using assessment procedures from NIST SP 800-53A and DoD-specific (KS) (Information Assurance Technical Authority (IATA) Standards and Tools).

The Contractor shall support the Assessment and Authorization (A&A) of the system. The Contractor shall support the government's efforts to obtain an Authorization to Operate (ATO) in accordance with DoDI 8500.01 Cybersecurity, DoDI 8510.01 Risk Management Framework (RMF) for DoD Information Technology (IT), NIST SP 800-53, NAVSEA 9400.2-M (October 2016), and business rules set by the NAVSEA Echelon II and the Functional Authorizing Official (FAO). The Contractor shall design the tool to their proposed RMF Security Controls necessary to obtain A&A. The Contractor shall provide technical support and design material for RMF assessment and authorization in accordance with NAVSEA Instruction 9400.2-M by delivering OQE and documentation to support assessment and authorization package development.

Contractor Information Systems Security Requirements. The Contractor shall implement the security requirements set forth in the clause entitled DFARS 252.204-7012, "Safeguarding Covered Defense Information and Cyber Incident Reporting," and National Institute of Standards and Technology (NIST) Special Publication 800-171.

PHASE I: The company will develop a concept for compressing the MEMUUV sonar, video and imagery that meet the requirements in the Description. Demonstrate the feasibility of the concept in meeting Navy needs and establish that the concept can be developed into a useful product for the Navy. Feasibility will be established by analytical modeling and feasibility testing. The Phase I Option, if exercised, will include the initial concept design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Based on the results of Phase I and the Phase II development plan, develop and deliver an image compression (hardware and/or software) prototype for evaluation. The prototype will be evaluated to determine its capability in meeting the performance goals defined in the Phase II development plan and the Navy requirements for data compression. System performance will be demonstrated through prototype evaluation with MEMUUV sonar and camera data. Evaluation results will be used to refine the prototype into an initial design that will meet Navy requirements. Prepare a Phase III development plan to transition the technology to Navy use by identifying any remaining cyber or security requirements, training packages, and sustainment costs.

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

PHASE III DUAL USE APPLICATIONS: Support the Navy and other Government and commercial entities (e.g., NOAA, NGIA and underwater survey companies) in transitioning the technology to a fielded system within MK 18 Program of Record or other commercial applications. Conduct efforts to perform any remaining integration or fielding requirements to include training, technical manuals, cyber security, sustainment, and other engineering services. Mature the manufacturing process of any image compression and minimized data loss hardware and software from initial Low-Rate Production (LRIP) through Full Rate Production (FRP). The Phase III will provide the contract instrument for the PMO to apply sustainment and product improvement during the product life cycle.

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KEYWORDS: Data compression; image compression; sonar image compression; lossless image compression; visually lossless image compression; sonar image compression algorithms.

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N231-039 TITLE: Boat & Combatant Craft Electric Drive Propulsion System

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR); Quantum Science

OBJECTIVE: Develop electric drive propulsion technology for aboard boat and combatant craft to add redundancy, increase fuel economy, reduce signature, and increase payload capacity at loiter and low speeds.

DESCRIPTION: Small vehicle electric drive propulsion technology is prevalent in other industries especially automotive. However, a capability that is marinized and meets the mission requirements of U.S. Navy boat and combatant craft does not exist. Boats and Combatant craft operate eighty (80) percent of the time at slow and loiter speeds while the propulsion systems are designed for higher cruise speeds. Engines rated for cruise speeds tend to be very inefficient at loiter speeds resulting in inefficient fuel consumption.

By introducing electric drive propulsion, boats and combatant craft can operate on electric power generated by a group of smaller generators or engines operating at an efficient power and fuel consumption, thereby reducing total ownership cost instead of having large diesel engines operating in non-ideal conditions. Total ownership cost is reduced through reduced fuel consumption and less/lower cost maintenance. Less maintenance is achieved through operating an engine at a lower speed rating or at a more optimum power rating and lower cost is achieved by having smaller more operator-accessible and maintainable systems. Additionally, electric propulsion at lower boat speeds can decrease the level of sound emitted from the boat, reducing a boat’s noise signature and increasing its tactical advantage. Finally, there is added redundancy with multiple means to generate electrical power to maintain performance of the craft. The technology shall be evaluated against existing boat specifications, original manufacturer data, and existing life cycle operating data. A marine configured electric drive propulsion system does not exist in the operational profile required for 425 – 550hp at an engine shaft speed range of 500-4000 rpm at the output of the marine gear as well as required boat endurance and range for boats and combatant craft operated by DoD and U.S. Navy.

PHASE I: Develop a concept for a marine configured electric drive propulsion system for a relevant vessel similar to a U.S. Navy 30-40 foot Patrol Boat that meets the requirements in the Description. Demonstrate the feasibility of the operational concept via physics-based modeling and simulation. Within the feasibility study, define the components of the propulsion system and hull, mechanical and electrical interfaces required, the power control management system as well as functional design concepts of the system. Provide a preliminary concept design and an associated component validation plan. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and deliver a prototype operational electric drive propulsion system capable of being integrated with a US Navy 30-40 foot Patrol Boat. Evaluate the prototype to determine its capability in meeting the performance goals defined in the Phase II SOW and the Navy requirements for the 30-40 foot Patrol Boats. Demonstrate system performance through prototype evaluation and testing, modeling, and analysis. Evaluate results and accordingly refine the propulsion system concept. Ensure that the prototyped hardware clearly shows a path to development of a sea worthy hardened system. On request, the prototype model is to be made available for Government demonstration or testing. Prepare a Phase III development plan to transition the technology to Navy use.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the electric drive propulsion system to Navy use. Support the Navy in transitioning a fully hardened electric drive propulsion system for sea trials to be demonstrated on a relevant vessel. Ensure that the system passes an underway test to be developed for the defined test platform. Support for participation in fleet demonstration is aimed at transition and integration of the system into the US Navy Patrol Boat Fleet.
A propulsion system of this type should benefit working craft in the fishing, oil, or research industries operating in the open water environment.

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2. Naval Surface Warfare Center. Carderock Division, Combatant Craft Division; US Navy 30-40 foot Combatant Craft Hybridization Specification

KEYWORDS: Electric Drive Propulsion Systems; U.S. Navy 34-ft Patrol Boat; U.S. Navy 40-ft Patrol Boat; Mine Counter Measures Operations; Force Protection Operations; Distributed Maritime Operations and Littoral Operations in a Contested Environment

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N231-040 TITLE: Rugged High-Temperature Superconductor Wire Bundles for Shipboard Installation

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR)

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

OBJECTIVE: The US Navy is seeking a rugged high-temperature superconducting (HTS) wire bundle for installation on a Navy vessel either during the shipbuilding process, or after the ship is delivered to the Navy, preventing the need for fixed length cables.

DESCRIPTION: HTS technology has been developed over the past several decades for multiple applications. There have been several demonstrations of HTS in coils for ship propulsion motors and wind generators; as power cables in the grid between transfer stations; and most recently, nuclear fusion reactors. These applications use the HTS conductor in either a coil form factor (motors, generators, fusion reactors), or in the grid as a 3-phase, high-voltage cable. The Navy is looking at alternative uses of HTS technology that do not require 3-phases or high-voltage, which will change the cables topology, and in some cases make it simpler. However, the simple HTS cable will need to be rugged enough for shipboard installation and use, with immediate application in degaussing systems.

US Navy ships must meet magnetic signature specifications to safely transit throughout the world’s oceans and waterways. To accomplish this, a degaussing system is installed on the ship so it can maintain a low-magnetic signature while underway. The principle of degaussing is to mitigate the magnetic signature of the ship by installing a series of coils in three different axis internal to the hull of the ship, which counteract the signature created by the ship within the earth’s magnetic field. When the cables are energized, a uniform magnetic field is produced throughout the ship.

Traditionally, advanced degaussing systems use bundles of insulated copper cables to generate the magnetic fields necessary to maintain a ship’s magnetic signature. Recently, the Navy has adopted HTS cables and associated support hardware for use within the advanced degaussing system aboard the LPD 28 (USS Ft Lauderdale). When installing a copper degaussing loop, the cable is pulled through many spaces, which may include conduit through bulkheads and tanks, or the cables may be hung in open passageways and compartments. After the cable is pulled along its intended path, it is cut and terminated at the junctions near the power supply.

HTS cable installation differs from copper cable installation. Current HTS cables are manufactured at the factory to a pre-determined length with pre-assembled connectors enabling fast installation into HTS-specific junction boxes. The cables cannot be cut to length at the time of installation and connection. If cable paths need to be re-routed, extra lengths of cable will be required. If the required length of cable is not readily available, they will have to be custom manufactured at the factory. Changing cable configurations will also affect management of magnetic signature. Remanufacture of cable lengths will also add significant cost and result in untenable lead times. The limited bend radius of HTS cables is a function of the cable's fabrication as a bundle of HTS wires on the inside of a double-walled, corrugated, vacuum cryostat.

The Navy is interested in concepts for a second generation (2G) HTS wire bundle that can be pulled throughout the ship inside a pre-installed cryostat and cut to length at the time of installation. The bundle will need to withstand tensions associated with pulling it through either rigid-pipe or flexible, corrugated cryostats with a small bend radius. The bundle should fit within a pipe or corrugated tube with an inner diameter of 0.80 inches. The bundle should withstand 1,000 lbf of tension. The bend radius may be as tight as 12 inches, with a straight run of cryostat 1 ft to 100 ft before making additional bends. The bundle may be 650 ft to 820 ft in length. The bundle must not only rely on the strength of the laminations since there are various lamination configurations that may be used with different tension ratings. A test length of cable should be a minimum of 150 ft with 40 conductors, each with a minimum Ic of 100 A. To demonstrate its flexibility, the bundle must fit in a pipe or tube with a diameter less than 1 inch, make at least six 90 degree turns with a minimum radius of 12 in, spaced 3 ft, and 50 ft apart; have the ability to solder the HTS conductors after installation of the bundle in the cryostat; demonstrate voltage isolation of 600 V both before and after pulling; and demonstrate retention of the Ic after being pulled through a cryostat. Finally, the test bundle must prove that it can withstand up to 1,000 lbf of tension.

The installed HTS bundle must carry up to 4000 Amp Turns once terminated and connected. The power supplied to the bundle will be 100 A at 4 Volts. The bundle must be insulated from the cryostat to ensure there are no electrical shorts between the bundle and the cryostat. The bundle will be cooled to cryogenic temperatures using gaseous helium at a range of 50 to 80 K.

PHASE I: Provide a concept for the HTS bundle that will meet the requirements within the Description. The concept must prove feasibility through modeling of the bundle for mechanical strength while under tension, flexibility of the bundle, and predicted electrical isolation characteristics. Preliminary testing of a short length of the concept is desirable to demonstrate the bundles capability to retain the HTS critical current (Ic) after being subjected to tension. 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 full-scale prototype of the HTS bundle installed in a cryostat that demonstrates it can meet the requirements in the Description. The demonstration should be accomplished by fabricating the bundle and testing its maximum operating current (Ic) prior to installation in a cryostat; installing it in a cryostat containing minimum radius bends; and then retesting the bundle's maximum operating current (Ic) while in the cryostat.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology as a component of the HTS degaussing system. The initial platform that the technology is expected to transition to is LPD 17 Class ships, or other future Navy ship designs.

Additional industries that may benefit from the product developed from this SBIR topic may be in electric grid power distribution, wind generators, or in future superconducting areas of generators or fusion reactors.

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KEYWORDS: High-Temperature Superconductors; HTS; cryostat; rugged HTS bundles; advanced degaussing; HTS degaussing; shipboard HTS systems

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N231-041 TITLE: Improved Distance Measurement During Underway Replenishments (UNREPs)

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Autonomy;General Warfighting Requirements (GWR)

OBJECTIVE: Develop a portable device to replace the current phone/distance line capable of accurately measuring the distance between two ships and providing wireless communications during Underway Replenishments (UNREPs).

DESCRIPTION: The US Navy's DDG-51 Class Destroyers are typically at sea for long stretches of time. Frequent resupply is required to sustain the ships at sea with UNREP. During connected UNREPs, two ships operate at 180-200 ft apart. The ships separation is continuously monitored to maintain a safe operating distance. The current process for distance measurement involves tying a rope to one ship and manually tensioning the rope between the two ships. This is manpower intense and risky. The Navy requires the development of an innovative means of distance measurement and emissions controlled (EMCON) compliant wireless communications during UNREPs.

There is a need to replace the phone/distance line with a less manpower intense system that is more flexible in location. This can be with one or two devices working in concert. The development of an improved phone/distance system to meet the Navy needs will require overcoming the following technical challenges. First, the device(s) must be able to maintain a high degree of accuracy at all times when measuring distance and provide clear communications during rough sea states and inclement weather. Environmental conditions include such hazards as rain, sea spray, and fog, all of which can disrupt the signals used in contemporary distance measuring devices and communications systems. The improved distance measuring system must be accurate in such conditions in order to prevent loss of life and shall be mounted on two moving platforms. The device must be able to compensate for this motion and maintain an accurate reading. Additionally, the device should be man-portable, compact for storage and transport, and pose no fire hazard, as it will be used in the proximity of aviation fuel. The communications system shall provide clear communications in similar conditions.

Research into distance measurement devices has revealed several methods that could potentially meet the Navy's need. There have been numerous advances in distance measuring techniques across industry but no device has been adequately demonstrated to be a replacement for the existing Navy phone and distance line. Some technologies are accurate, but not viable in exceptionally adverse environments. Other technologies have emissions which may render it unsuitable for Navy use. Many candidate devices are not the most portable or cost-effective solution for the Navy. Further innovation is needed to reduce acquisition costs and produce a viable product for the Navy.

PHASE I: Develop a concept for an improved device(s) for distance measurement during UNREPs and communications that meets the requirements above. Demonstrate the feasibility of the concept in meeting Navy needs and establish that the concept can be developed into a useful product for the Navy. Feasibility of the distance measuring device will be established via computer modeling. The communications device will need to meet shipboard communication requirements. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Based on the results of Phase I and the Phase II Statement of Work (SOW), develop and deliver a prototype distance measurement system and communications device for evaluation. The prototype(s) will be evaluated to determine capability in meeting the performance goals defined in the

Phase II SOW. Product performance will be demonstrated through prototype evaluation, modeling, and demonstration over the required range of parameters. An extended test in a maritime environment will be used to refine the prototypes into a design that will meet Navy requirements. Prepare a Phase III manufacturing and development plan to transition the distance measuring system and communications device to Navy use.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the improved distance measuring system and communications device to Navy use. Develop installation, maintenance, and operations manuals for the distance measuring device to support transition to the fleet.

There is a need in commercial applications for distance measuring devices that are accurate in inimical conditions. Notable examples include such varied fields as mining and autonomous cars.

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KEYWORDS: Laser Range-Finder; Ranging; Underway Replenishment; UNREP; Distance Measurement; Inimical Conditions; Refueling at Sea

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N231-042 TITLE: Pressure-Tolerant Electronically-Steered Antennas (ESAs) for Satellite Communications on Unmanned Undersea Vehicles (UUV)

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Cybersecurity; Networked C3

OBJECTIVE: Develop pressure-tolerant electronically-steered antennas (ESAs) to enable high data rate communications on Unmanned Undersea Vehicles (UUVs).

DESCRIPTION: The Navy is looking to pressure-tolerant ESAs for use on UUVs to facilitate the sending and receiving of large data sets in far forward and open-water locations. The commercial market lacks steerable antennas appropriate for UUV integration. Breakthrough advances in silicon technologies in recent years have enabled a significant increase in capability of ESAs, such as but not limited to, phased array antennas, while per-element costs have also been greatly reduced. The Navy looks to leverage these recent advances to develop pressure-tolerant ESAs for UUVs. The closest commercial equivalents would be planar phased arrays used in terrestrial applications. Such arrays are not suitable for UUV applications targeted by the Navy, as they are not able to withstand hydrostatic pressures. Other Navy Satellite Communications (SATCOM) applications use mechanically pointed gimballed dish antennas, but dish antennas must be housed in air-backed radomes to withstand hydrostatic pressure, and they occupy a large volume on the target platform.

Maximizing aperture area, while making a mechanically robust ESA, will be challenging, posing unique mechanical and electrical design constraints. Additionally, the ESA must have as large an antenna aperture area as possible, which drives designs with minimum mechanical structure. The ESA must also provide high radio frequency (RF) performance coupled with electronic steering capabilities to track fast-moving Proliferated Low Earth Orbit (PLEO) satellites as they pass in/out of view. In addition to enabling transfer of large data sets, PLEO Data links will enable use of High Assurance Internet Protocol Encryptor (HAIPE) network devices, enabling encrypted data links.

Current commercial UUV transmit/receive antennas project omni-directional RF energy in all directions, whereas ESAs are generally limited to larger manned platforms such as surface vessels and aircraft. Development of pressure-tolerant ESAs compatible with size, weight, and power (SWaP) constraints of UUVs is challenging. The available SWaP within UUVs varies greatly by class and design, but rough order of magnitude (ROM) allowances are provided in the table below. It is noted that the values in this table are provided for guidance only – they are not to be considered formalized requirements against which the proposals will be adjudicated. Additionally, it is noted that these ESAs are primarily targeted for large and extra-large UUVs, but will also be considered for medium UUVs, if sufficient RF performance can be achieved within the SWaP constraints listed.

Pressure-Tolerant Electronically-Steered Antennas (ESAs)

for Satellite Communications on Unmanned Undersea Vehicles (UUV)

UUV Class	**Medium**	**Large**	**Extra-Large**
ROM Volume	*216 in^3 (6" cube)*	*1728 in^3 (12" cube)*	*5832 in^3 (18" cube).*
ROM weight in air	5 lbs	64 lbs	216 lbs
ROM Operating Power (W)	250 W	350 W	500 W

ROM Standby Power (W)	5 W	10 W	20 W
ROM Seawater Pressure Tolerance (psig)	870	1,000	1,000

These SWaP challenges are exacerbated by the requirement to withstand large hydrostatic pressures experienced during UUV missions. Larger surface areas are required to get the desired RF performance, so a prime challenge is optimizing the ESA to fit within the existing UUV platforms. Another challenge is the pointing of the beam: it is desirable to support multiple simultaneous links across the full band, with beam steering accomplished through a fully solid-state design. If this (full solid-state beam pointing) is not achievable, then pointing can be achieved with minimal mechanical steering. The desired RF performance attributes include:

a) Tunable across 5 – 33 GHz frequency range
b) G/T of at least 10 dB/K in Ku and K bands
c) EIRP of at least 36 dBW gain in 10 – 15 GHz freq range and 38 to 43 dBW in Ka Band
d) Ability to receive GPS (L1, L2, L5)

In addition to RF performance, proposers should include the pointing method of the resultant beam(s), the control of the beam's side lobes, and the main lobe width(s), while minimizing size, weight, power, and cooling (SWaP-C) associated with the solution. Proposers should also highlight the novelty of their approach.

The technical merit of the proposed solutions will be evaluated on factors including:

1. G/T and EIRP over the 5 – 33 GHZ frequency range
2. Ability to support multiple simultaneous links across the full band (5-33 GHz) to include multiple Low Earth Orbit (LEO)/Medium Earth Orbit (MEO) constellations
3. Estimated unit cost per ESA
4. Maximum volume and maximum aperture dimension
5. Estimated weight of the system
6. Beam steering methodology: solid state or minimal mechanical steering
7. Maximum power draw by the array when in use and during standby
8. Suitability of array design to operate/survive over the variety of operational depths over which PEO-USC UUVs operate

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DCSA and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

All DoD Information Systems (IS) and Platform Information Technology (PIT) systems will be categorized in accordance with Committee on National Security Systems Instruction (CNSSI) 1253, implemented using a corresponding set of security controls from National Institute of Standards and

Technology (NIST) Special Publication (SP) 800-53, and evaluated using assessment procedures from NIST SP 800-53A and DoD-specific (KS) (Information Assurance Technical Authority (IATA) Standards and Tools).

The Contractor shall support the Assessment and Authorization (A&A) of the system. The Contractor shall support the government's efforts to obtain an Authorization to Operate (ATO) in accordance with DoDI 8500.01 Cybersecurity, DoDI 8510.01 Risk Management Framework (RMF) for DoD Information Technology (IT), NIST SP 800-53, NAVSEA 9400.2-M (October 2016), and business rules set by the NAVSEA Echelon II and the Functional Authorizing Official (FAO). The Contractor shall design the tool to their proposed RMF Security Controls necessary to obtain A&A. The Contractor shall provide technical support and design material for RMF assessment and authorization in accordance with NAVSEA Instruction 9400.2-M by delivering OQE and documentation to support assessment and authorization package development.

Contractor Information Systems Security Requirements. The Contractor shall implement the security requirements set forth in the clause entitled DFARS 252.204-7012, "Safeguarding Covered Defense Information and Cyber Incident Reporting," and National Institute of Standards and Technology (NIST) Special Publication 800-171.

PHASE I: Develop a concept for a directional acoustic transmitter that meets the requirements in the Description. Establish feasibility by developing system diagrams, as well as Computer-Aided Design (CAD) models that show the ESA concept and provide estimated weight and dimensions of the concept. Feasibility will also be established by computer-based simulations that show the antenna's RF performance and pointing capabilities are suitable for the project needs. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Based on the results of Phase I and the Phase II Statement of Work (SOW), develop and deliver a prototype system for in-situ (on water) testing and measurement/validation of the Phase I performance attributes. Test the prototype system, first in a controlled laboratory environment, then in an on-water environment, to determine its capability to meet all relevant performance metrics outlined in the Phase II SOW. Testing shall characterize the RF and beam pointing performance, coupled with the communication function required for closing links with various commercial SATCOM providers. The ability to meet the hydrostatic pressure tolerance requirements shall be demonstrated by analysis or testing. Demonstrate the prototype system's performance in both environments (laboratory and in-water) to the Government and present the results in two separate test reports. Use the results to correct any performance deficiencies and refine the prototype into a pre-production design that will meet Navy requirements. Prepare a Phase III SOW to transition the technology to Navy use.

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

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use and support further refinement and testing of the ESA functionality following successful prototype development and demonstration. If successful, in addition to UUV applications, these ESAs could be applied to other unmanned Navy assets including buoys, subsea nodes, and unmanned surface vehicles (USVs). In addition to such DoD applications, these antennas could be used in commercial oil, gas, and oceanographic sensing applications, where the exchange of large data sets is required.

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KEYWORDS: Electronically Steerable Antennas; ESAs; Phased Arrays; Unmanned Undersea Vehicles; UUVs; Data Exfiltration; High Data Rate; Proliferated Low Earth Orbit Satellite Communication; PLEO

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N231-043 TITLE: Extreme Cold Weather Resistant Gasket Material

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR)

OBJECTIVE: Develop an advanced, cold weather resistant gasket material capable of being used in a ship's external gaskets.

DESCRIPTION: The US Navy's DDG-51 Class destroyers utilize many elastomer seals and gaskets throughout the ship with many exposed to the environment. As the Navy sails increasingly into Polar regions, seals and gaskets are exposed to extreme cold weather leading to performance degradation and premature seal failure resulting in a limited operating environment. Market research has not resulted in a Navy approved material that can survive in the Arctic environment across the spectrum of required seals and gaskets. A new cold weather resistant gasket is needed to replace the existing neoprene gaskets and seals.

The development of a cold weather resistant gasket materials that meet the Navy need will require innovation to overcome technical challenges. The gasket material must meet the mechanical requirements of the Navy to include sustained heavy loads and other forces associated with ship motion, exposure to the harsh maritime environment, saltwater immersion, exposure to industrial chemicals, jet fuel, and fire resistance. Additionally, the gasket material must have excellent performance with minimal loss of mechanical properties at temperatures as low as -50°F while remaining a cost-effective solution for the Navy.

Research into cold weather resistant gaskets has identified several materials that could potentially be developed to meet the Navy's need. There are materials available which demonstrate the required temperature resistance; however, none of these materials have been demonstrated to meet the Navy's full set of requirements. Additional innovation is required to produce a viable product for the Navy.

PHASE I: Develop a concept for cold weather resistant gasket materials that meets the requirements described above. Demonstrate the feasibility of the concept in meeting Navy needs and establish that the concept can be developed into a useful product for the Navy. Feasibility will be established by coupon development and laboratory testing and demonstration of the manufacturability of the materials. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Based on the results of Phase I and the Phase II Statement of Work (SOW), develop and deliver prototype louver gaskets for evaluation. The prototypes will be evaluated to determine capability in meeting the performance goals defined in the Phase II SOW. Product performance will be demonstrated through prototype evaluation, modeling, analytical methods, and demonstration over the required range of parameters including numerous cycles of various compressive loads. An extended test in a maritime environment will be used to refine the prototypes into a design that will meet Navy requirements. Prepare a Phase III manufacturing and development plan to transition the innovative new gasket material for Navy use.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the cold resistant elastomer to Navy use. Develop installation and maintenance manuals for the new gasket material to support transition to the fleet.

Numerous potential private sector uses for cold weather resistant gaskets, with applications in the commercial shipping industries, as well as Arctic construction. Other commercial applications include commercial research and cryogenics.

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KEYWORDS: Cold Resistant Elastomers; Operational Temperature; Arctic Hardening; Gasket material in Polar regions; Polar operations; Environmental exposure

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N231-044 TITLE: DIGITAL ENGINEERING - Expeditionary Virtualized Training Unit for Undersea Warfare Decision Support System (USW-DSS)

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR)

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

OBJECTIVE: Modernize Undersea Warfare Decision Support System (USW-DSS) training by leveraging advances in virtualization and gamification.. Develop portable expeditionary unit that can deliver this training throughout the Fleet.

DESCRIPTION: The AN/UYQ-100 USW-DSS provides warfighters aboard carrier strike group (CSG) platforms (CVN, CGs/DDGs), Surveillance Towed Array Systems (SURTASS) ships, embarked Destroyer Squadron Staffs, and key shore sites to collaboratively plan and execute Anti-Submarine Warfare (ASW) missions. USW-DSS contains applications for (1) environmental analysis, (2) collaborative search planning, (3) force management, (4) a shared tactical picture composed of networked tactical decision aids, sensor tracks, and sensor metrics, (5) search execution measures of effectiveness, (6) graphics storage and recall, and (7) ASW briefing support.

The Navy seeks to (1) improve training for USW-DSS, (2) virtualize USW-DSS to a) reduce operating costs, b) minimize downtime, c) increase infrastructure agility, and d) enable faster provisioning of updates across fielded USW-DSS instantiations, and (3) develop an expeditionary unit that can host both the virtualized core USW-DSS program and integrated USW-DSS training.

Despite the known power of integrated training, it has been prohibitive to develop integrated training that can span the diversity of user experiences, from the global understanding required by the Commander Task Force (CTF) at Theater USW Operations Centers (TUSWOC) to the meteorological focus of Naval Oceanographic Processing Facilities (NOPF) to the ship-focused usage aboard individual combatants. But advances in artificial intelligence and machine learning (AI/ML) are poised to both enable individualized integrated training and power faster decisions for improved warfighting outcomes. The power of AI/ML to achieve these outcomes are being piloted in medicine to increase the speed and accuracy of the estimated $10 trillion spent globally on health care [Ref 2]. In 2019 the Harvard Business Review estimated AI would add $13 trillion to the global economy over the next decade, guiding decisions on everything from crop harvests to bank loans [Ref 1]. Combining the power of AI/ML approaches being piloted in medical education with the power of AI/ML to guide decisions is anticipated to improve USW-DSS warfighting outcomes both by improving mission effectiveness at the theater level and reducing the time to achieve mission goals. Improvements of at least 10% in both time to success and mission effectiveness are desired.

A key enabler of AI/ML is agile development and software virtualization, which enables processes to more efficiently access available processing power and data storage. The current USW-DSS software is developed using Development Security Operations (DevSecOps) pipelines. USW-DSS is designed to run on the Navy's Consolidated Afloat Network Enterprise Services (CANES). However, there are numerous versions of CANES, inhibiting provisioning updates across the Fleet. Virtualizing USW-DSS would allow infrastructure to be seen as simply a service, or Infrastructure as a Service (IaaS), enabling provisioning updates and associated training across a greater percentage of the USW-DSS installations across the Fleet. The Navy seeks a solution that will enable USW-DSS to become virtualized.

Finally, there exist instances where USW-DSS may be desired but there is not a CANES infrastructure to host USW-DSS. The solution should enable an expeditionary processing infrastructure sufficient to host the virtualized USW-DSS and associated training. The infrastructure must achieve two outcomes. First, the envisioned expeditionary infrastructure will allow deployment of USW-DSS to platforms or shore sites that do not possess the CANES infrastructure on which USW-DSS currently runs. Second, it will afford older platforms actively tasked with ASW missions the opportunity to receive the most capable USW-DSS builds available even if the fielded version of CANES available is unable to accept the latest USW-DSS updates. The integrated training capability will meet a 10% increase in mission effectiveness and 10% reduction in time to mission success across a range of simulated missions across varying environments and stages of mission complexity. The solution may choose to focus on the element(s) of integrated training and AI/ML decision support that provide the greatest performance improvements relative to mission effectiveness and reduction in time to mission success. The minimum viable product (MVP) required to achieve successful transition is a combination of a powerful integrated training capability together with a credible virtualization design and expeditionary infrastructure architecture. Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DCSA and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

All DoD Information Systems (IS) and Platform Information Technology (PIT) systems will be categorized in accordance with Committee on National Security Systems Instruction (CNSSI) 1253, implemented using a corresponding set of security controls from National Institute of Standards and Technology (NIST) Special Publication (SP) 800-53, and evaluated using assessment procedures from NIST SP 800-53A and DoD-specific (KS) (Information Assurance Technical Authority (IATA) Standards and Tools).

The Contractor shall support the Assessment and Authorization (A&A) of the system. The Contractor shall support the government's efforts to obtain an Authorization to Operate (ATO) in accordance with DoDI 8500.01 Cybersecurity, DoDI 8510.01 Risk Management Framework (RMF) for DoD Information Technology (IT), NIST SP 800-53, NAVSEA 9400.2-M (October 2016), and business rules set by the NAVSEA Echelon II and the Functional Authorizing Official (FAO). The Contractor shall design the tool to their proposed RMF Security Controls necessary to obtain A&A. The Contractor shall provide technical support and design material for RMF assessment and authorization in accordance with NAVSEA Instruction 9400.2-M by delivering OQE and documentation to support assessment and authorization package development.

Contractor Information Systems Security Requirements. The Contractor shall implement the security requirements set forth in the clause entitled DFARS 252.204-7012, "Safeguarding Covered Defense Information and Cyber Incident Reporting," and National Institute of Standards and Technology (NIST) Special Publication 800-171.

PHASE I: Develop a concept for complex decision support system training within a virtualized software baseline on portable processing hardware that could be carried by two people. Demonstrate the concept meets the parameters in the Description. Feasibility will be shown through modeling and analysis on an unclassified system. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and deliver a prototype USW-DSS system with AI/ML-powered integrated training based on the results of Phase I. The prototype integrated training infrastructure will demonstrate it meets the parameters in the Description. The Phase II prototype will be hosted in a secure cloud environment to be provided by the Navy and evaluated by Government subject matter experts to validate the improvements achieved by the prototype.

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

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use. The final product will be an integrated training capability that leverages AI/ML to improve mission effectiveness that enables virtualization of USW-DSS and the integrated training capability within an expeditionary computational infrastructure. Of the total envisioned Phase III capability, the MVP required to achieve successful transition is a combination of a powerful integrated training capability together with a credible virtualization design and expeditionary infrastructure architecture. Work with the USW-DSS prime integrators to develop and produce the expeditionary units and perform any USW-DSS installations aboard CANES to which the company's technology applies, both at shore sites and aboard combatants tasked with ASW mission execution.

Potential for dual use for monetary decision support, which is a $13 trillion market opportunity. The medical training use of the integrated training technology developed under this SBIR topic would be of particular benefit to global health providers, where provision of virtualized and expeditionary units could disproportionately benefit communities where traditional healthcare infrastructure is either damaged or wholly lacking.

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KEYWORDS: Consolidated Afloat Network Enterprise Services (CANES); Infrastructure as a Service (IaaS); integrated training with a virtualized design; Artificial Intelligence (AI) in training; Undersea Warfare Decision Support System (USW-DSS); expeditionary unit

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N231-045 TITLE: Multi-Spectral, Multi-Sensor Image Fusion

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Artificial Intelligence (AI)/Machine Learning (ML); General Warfighting Requirements (GWR)

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

OBJECTIVE: Develop video image fusion processing algorithms that produce a video stream with quality exceeding that produced by individual sensors operating separately in different visible and infrared bands.

DESCRIPTION: Electro-optic and infrared (EO/IR) video imaging sensors (cameras) are widely used for situational awareness, surveillance, and targeting. The Navy is deploying such cameras in multiple spectral bands and in differing formats to cover everything from narrow field of view (NFOV) up to very wide field of view (WFOV). Multiple spectral bands are useful because different bands, for example the near infrared (NIR) and the mid-wave infrared (MWIR) bands, “see” targets differently, especially under different lighting and environmental conditions. While each camera has its own strengths and weaknesses, taken collectively and properly interpreted, the combined video data can reveal far more than any single imaging sensor can individually. Consequently, the camera systems are integrated to provide coordinated and optimized coverage to meet the various mission requirements.

The effectiveness of the combined imaging sensor system depends on how well the copious amount of video image data that the various cameras produce is processed and evaluated in real time, either by human operators or by automated methods. Even with the most judicious use and coordination of these sensors, the amount of video image data produced is far in excess of what a single human operator can absorb and process. Automated aids can considerably reduce the burden on the human operator. However, there are still many situations where there is no substitute for a clear picture delivered in real time without need of the operator flipping between bands and between NFOV and WFOV cameras to assimilate the best view. Efficient algorithms for fusing imagery taken across multiple wavelengths bands in the highly complex maritime environment simply do not exist. While available technologies address some aspects of the problem, for example automated image interpretation (facial recognition, crop monitoring with satellite imagery, etc.), no commercial application approaches the requirements for real-time, multi-spectral, multi-sensor, image fusion presented by modern naval operations.

The Navy needs an innovative video image fusion technology, realized and demonstrated as a coherent set of image processing algorithms, that ingests imagery from multiple sensors operating in different bands to produce an output video stream that exceeds the quality of the imagery obtained from any of the individual sensors taken separately. At a minimum, the content captured by each sensor should be aggregated in the output video without loss of detail or resolution. However, the goal is to produce output that exceeds the quality (resolution, contract, noise, etc.) of the individual sensors. That is, algorithms that selectively combine and “blend” regions of image data taken from the individual sensors represent the minimum acceptable solution. Algorithms that smartly fuse video image data to reduce clutter, improve

target resolution, increase apparent dynamic range, mitigate the effects of adverse environmental conditions, reveal additional target information, and improve the capture of dim, fast moving targets (for example, targets travelling at mach 3 at the resolution limit of the sensor) are of particular interest.
It should be assumed that the fused video stream will be viewed directly by weapon system operators as well as further processed through additional image processing systems. Therefore, the solution should be optimized with both purposes in mind and the resulting fused video output be available in real time. Of particular interest is whether the fused video aids or inhibits the performance of automatic target detection, tracking, recognition, and identification algorithms. While the goal of this effort is not to develop detection, tracking, recognition, and identification algorithms, the solution must be compatible with these functions. Therefore, the solution should clearly show that the fused video will enhance these functions or clearly show that these functions must be applied prior to fusion of the input video streams to be effective. In order to deploy to a tactical system, the solution must be computationally efficient and the processor load presented by the algorithms is a key metric that must be addressed, minimized, and verified in demonstration of the solution. In addition, the technology should be fundamentally extensible to multiple sensors operating across the visible to long wave IR band.

The goal is to fuse imagery from sensors that have overlapping fields of view. The goal is not to stitch the output of sensors with adjacent fields of view. Solutions should not assume that the input video is identical in FOV, resolution, dynamic range, or frame rate. Furthermore, frame capture between the sensors should not be assumed synchronous. However, solutions should anticipate that sufficient video metadata is available from each sensor to align the video inputs temporally and, to a high degree, spatially. The solution should be agnostic to sensor format, frame rate, resolution, etc., and accept non-compressed Class 0 motion imagery as well as compressed inputs. Imagery and metadata input will be compliant with (and therefore the solution must be compliant with) MIL-STD-2500C National Imagery Transmission Format Standard, Motion Imagery Standards Profile (MISP), Motion Imagery Standards Board (MISB) Standard (ST) 1606, MISB ST 1608, MISB ST 1801, MISB ST 0902, and MISB ST 1402. At a minimum, the solution should be demonstrated on video generated from a minimum of two sensors operating in different bands. The bands, formats, and native resolutions chosen are at the discretion of the proposer. Demonstration need not include operation with actual sensors. Demonstration with collected data is acceptable. However, the Government will not provide collected data during development of the solution. The Government will also not provide tactical or developmental hardware during the effort so the solution should include the means of demonstrating the fusion algorithms on surrogate processors and displays.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DSS and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

All DoD Information Systems (IS) and Platform Information Technology (PIT) systems will be categorized in accordance with Committee on National Security Systems Instruction (CNSSI) 1253, implemented using a corresponding set of security controls from National Institute of Standards and Technology (NIST) Special Publication (SP) 800-53, and evaluated using assessment procedures from

NIST SP 800-53A and DoD-specific (KS) (Information Assurance Technical Authority (IATA) Standards and Tools).

The Contractor shall support the Assessment and Authorization (A&A) of the system. The Contractor shall support the government’s efforts to obtain an Authorization to Operate (ATO) in accordance with DoDI 8500.01 Cybersecurity, DoDI 8510.01 Risk Management Framework (RMF) for DoD Information Technology (IT), NIST SP 800-53, NAVSEA 9400.2-M (October 2016), and business rules set by the NAVSEA Echelon II and the Functional Authorizing Official (FAO). The Contractor shall design the tool to their proposed RMF Security Controls necessary to obtain A&A. The Contractor shall provide technical support and design material for RMF assessment and authorization in accordance with NAVSEA Instruction 9400.2-M by delivering OQE and documentation to support assessment and authorization package development.

Contractor Information Systems Security Requirements. The Contractor shall implement the security requirements set forth in the clause entitled DFARS 252.204-7012, “Safeguarding Covered Defense Information and Cyber Incident Reporting,” and National Institute of Standards and Technology (NIST) Special Publication 800-171.

PHASE I: Develop a concept for a video fusion system that meets the objectives stated in the Description. Demonstrate the feasibility of the concept in meeting the Navy’s need. Analyze the effect on image quality and predict the benefits to target detection, tracking, and identification. Feasibility shall be demonstrated by a combination of analysis, modeling, and simulation. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and demonstrate a prototype sensor fusion system (suite of coded algorithms) based on the concept, analysis, architecture, and specifications resulting from Phase I. Demonstration of the multi-spectral, multi-sensor fusion system shall be accomplished through test of a prototype in a laboratory environment using real-time or collected imagery data. At the conclusion of Phase II, prototype software shall be delivered to NSWC Crane along with complete test data, sample image files (both input and output), installation and operation instructions, and any auxiliary software and special hardware necessary to run the prototype.

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

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology for Government use. Develop tactical code specific to Navy sensor systems, processing hardware, and existing software interfaces. Establish software configuration baselines, produce support documentation, and assist the Government in the integration of the multi-spectral, multi-sensor fusion algorithms into existing and future imaging sensor systems.

The technology resulting from this effort is anticipated to have broad military application. In addition, there are law enforcement and security applications. Scientific applications include processing of satellite and aerial imagery, medical imagery, and imaging of natural events such as complex weather phenomena.

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KEYWORDS: Video Imaging; Imaging Sensors; Image Fusion; Image Processing; Automatic Target Detection; Target Resolution.

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N231-046 TITLE: Revolutionized Undersea Training Target Motors

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR)

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

OBJECTIVE: Modernize, innovate, and improve the efficiency of the MK39 Expendable Mobile Anti-Submarine Warfare (ASW) Training Target (EMATT) motor that leverages the advancements in printed circuit board (PCB) stators, as well as the reduction in space, noise, and weight of the motor enabling additional capabilities of the EMATT.

DESCRIPTION: The MK39 EMATT is the US Navy's low cost, expendable, training target which simulates the acoustic and dynamic characteristics of submarines and is used as a versatile alternative to real submarines for training US Navy Fleet sonar operators. The EMATT is an 'A' size 4.875 inch diameter vehicle that fits into a Sonobuoy Launch Container (SLC), is 3 feet long, and weighs 21 lbs. It is powered by a Li SO2 battery pack that generates 40 volts for the operation of the electronics system and a brushless direct current motor. Together, the battery and motor propel the EMATT for programmed speeds of 3 to 12 knots. The motor design requires a RPM of 4050, with at least a torque of 1.15 N-m. Test point efficiency is required to be greater than 80%. Overall, the weight of the motor is not to exceed 2 pounds or a length of 2.5 inches. Currently, the system lacks the capability to emulate tactically realistic dynamic maneuvers of submarines for effective ASW training. This topic seeks to increase the efficiency of the current generation motor over a range of speeds, thus conserving energy, improving cooling, reducing weight, and minimizing acoustic noise. The motor technology to be explored is the technologically challenging goal of this SBIR topic. Alternatively, current commercial applications for oceanography profiling, water sampling and other underwater data collection applications utilizing brushed and brushless DC motor designs can benefit from research and development in this field. Improved propulsion efficiency, increased payload capacity, and prolonged endurance is desirable for these applications.

Production cost of the new motor is expected to be less than $1,250, which is equivalent in cost of the existing motor. Post Phase II, the cost will be equivalent to the current MK39 MOD 3 EMATT but yield greater than a 5% increase in energy efficiency leading to a 5% reduction in EMATT procurement cost (greater than a $375K reduction per year) for the same amount of training time. Once proven, the technology may have reach into other UUV programs and also contribute to improved EMATT emulation of subs with a higher sprint speed.

PHASE I: Develop the concept for candidate motor technologies that meet the requirements as discussed in the topic Objective and Description. Determine the feasibility of developing devices for 'A' size vehicles that may be readily integrated and not impact the hydrodynamic performance or acoustic mission of the existing MK39 Mod 3 design through modeling and simulation. Determine technical feasibility of motor technologies that meet the Navy's needs. Define the proposed concept and explain how it can be developed into a useful product, improving the Mk39 EMATT for the Navy. The Phase I Option, if exercised, will include the initial concept design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Based on the results of Phase I concept develop, and deliver a prototype for validation as appropriate. The prototype will be evaluated to determine its capability in meeting the initial design specifications and the Navy requirements for increased endurance and higher sprint speeds to better emulate threat submarines and create more effective ASW training. System performance will be demonstrated through prototype evaluation using modeling, simulation, and/or analytical methods over the required range of parameters. Evaluation results will be used to refine the prototype into an initial design that will meet Navy requirements. The prototype should be delivered at the end of Phase II, ready to be flown and tested by the government. A quantity of 10 prototype motors are to be provided to the Government for testing by the end of Phase II.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology for Navy use. Support the Navy during In-Water testing and validation of the delivered prototypes in an operationally relevant environment. Integrated Phase II prototype motors will be incorporated into the MK39 EMATT and in PMS 404, ASW Training Targets.

The MK39 EMATT with an improved propulsion system would improve its suitability for numerous commercial applications, including oceanography profiling, water sampling, and other underwater data collection applications. The improved propulsion efficiency could provide enhanced endurance at slower speeds, which is very desirable for these data collection applications.

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KEYWORDS: Expendable Mobile Anti-Submarine Warfare Training Target; Anti-Submarine; ASW; MK39 EMATT; ASW Targets; stable hydrodynamic speed; propulsor; efficient motor; Printed Circuit Board, PCB stator

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N231-047 TITLE: Alternative Materials and Fabrication Processes for US Navy Propulsor Shafting

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR)

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

OBJECTIVE: Develop low-cost non-traditional materials and repeatable, reliable, efficient, and robust manufacturing processes suitable for large, thick, waterborne propulsor shafting subjected to long-duration complex stress states.

DESCRIPTION: The primary application for this technology is to identify, investigate, demonstrate, and validate non-traditional, non-metallic materials and associated manufacturing technology for the fabrication of submarine propulsor shafting to address design demand signals in support of future submarine platform development. Such materials may include, but are not limited to, carbon fiber reinforced polymer and glass fiber reinforced polymer. Such manufacturing processes may include, but are not limited to, wet filament winding, towpreg winding, and dry fiber infusion.

Traditional metallic submarine propulsor shafts are at the limit of their capability due to weight and industrial base. While non-metallic propulsor shafting is already in-service in the surface ship fleet (Littoral Combat Ship), the current scale/size is insufficient for meeting targeted performance metrics of both current (e.g., Virginia-Class) and future (e.g., SSNX) submarine platforms. The technology introduced by the effort described herein will facilitate increased usage of non-traditional materials in US Navy propulsor shafting to enable broadened design trade space and arrangement options for existing propulsor components (e.g., shaft-line light-weighting, increased propulsor weight, increased payload, etc.), improved performance (e.g., increased torque capacity), improved fatigue life (i.e., may be possible to design for life of ship or reduced frequency of shaft change-outs), and decreased lifecycle/maintenance cost (i.e., improved corrosion performance reduces need for refurbishment/repair).

The proposed research will investigate alternative materials and efficient fabrication processes that produce repeatable, reliable, and robust large, thick, cylindrical structures capable of interfacing with existing metallic structure and providing, at a minimum, equivalent performance relative to legacy submarine propulsor shafting. Material(s) and fabrication process(es) proposed in support of this effort will be demonstrated and verified at full scale to provide adequate structural properties and characteristics, efficient, robust and repeatable processes, and appropriate quality assurance. Material and fabrication process evaluation, selection, and demonstration will include a combination of coupon, sub-element, and prototype design, fabrication, and testing. A key challenge will be understanding the effect of scaling from coupons to full scale articles on material properties and material quality. Structural design calculations and numerical analysis (where applicable) may be used in support of design and development.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DSS and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

All DoD Information Systems (IS) and Platform Information Technology (PIT) systems will be categorized in accordance with Committee on National Security Systems Instruction (CNSSI) 1253, implemented using a corresponding set of security controls from National Institute of Standards and Technology (NIST) Special Publication (SP) 800-53, and evaluated using assessment procedures from NIST SP 800-53A and DoD-specific (KS) (Information Assurance Technical Authority (IATA) Standards and Tools).

The Contractor shall support the Assessment and Authorization (A&A) of the system. The Contractor shall support the Government's efforts to obtain an Authorization to Operate (ATO) in accordance with DoDI 8500.01 Cybersecurity, DoDI 8510.01 Risk Management Framework (RMF) for DoD Information Technology (IT), NIST SP 800-53, NAVSEA 9400.2-M (October 2016), and business rules set by the NAVSEA Echelon II and the Functional Authorizing Official (FAO). The Contractor shall design the tool to their proposed RMF Security Controls necessary to obtain A&A. The Contractor shall provide technical support and design material for RMF assessment and authorization in accordance with NAVSEA Instruction 9400.2-M by delivering OQE and documentation to support assessment and authorization package development.

Contractor Information Systems Security Requirements. The Contractor shall implement the security requirements set forth in the clause entitled DFARS 252.204-7012, "Safeguarding Covered Defense Information and Cyber Incident Reporting," and National Institute of Standards and Technology (NIST) Special Publication 800-171.

PHASE I: Identify suitable candidate material systems, an associated manufacturing approach, and conceptual design of a representative shaft-like cylindrical structure of sufficient fidelity to serve as a basis for preliminary structural analyses. Perform initial feasibility demonstration of fabrication efficiency and structural performance via a series of static and fatigue coupon tests using selected materials and corresponding fabrication processes. Two areas of focus will be understanding how coupon properties and quality relate to full scale material, and on exercising/refining existing and/or developing new test methods suitable for accurate and representative characterization of cylindrical structures. It is expected that coupons will be of sufficient size to support characterization of material-level response and interrogation of relevant composite material failure modes.

The Phase I Option, if exercised, will include the definition, development, and documentation of a proposed non-metallic shaft design, including an approach for structural validation testing, to be further developed in Phase II.

PHASE II: Develop a plan for, execute selected fabrication on, and conduct initial testing in support of a building block test program for the proposed material system and corresponding manufacturing process to develop innovative propulsor shafting. The building block test program should include the generation of needed material property information in support of design and analyses, to include elastic constants, strengths, and fatigue data. The proposed material system and manufacturing process may be verified via fabrication and subsequent testing of representative curved and/or cylindrical test articles, to be defined by the contractor, subjected to static and fatigue testing. It is recommended that data generated be compared to legacy information, if applicable/available, to verify structural adequacy. Refine preliminary shaft design, proposed structural validation approach, and corresponding documentation developed under Phase I Option.

Work with NAVSEA to identify structural requirements in support of shaft design.

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

PHASE III DUAL USE APPLICATIONS: Work with the Navy to transition the technology for Navy use and mature the proposed technologies for transition to platform application, including use on the SSN(X) platform. Validate the proposed materials and corresponding manufacturing approach via definition and development of a full-scale article to be subjected to a combination of non-destructive and destructive inspection in support of quality assurance verification. Validate the proposed design via mechanical testing of scale article(s), including long-term, high-cycle, fatigue verification testing, for which governing load conditions of interest will be provided by NAVSEA. Validation of the proposed design and manufacturing approach should include definition and exercising of critical design details under high-cycle fatigue loading.

Technology developed under this effort is directly applicable to other US maritime Navy applications, including large, unmanned, deep-sea submersibles, which offer the ability to enhance mission operability while minimizing risk to fleet personnel. In addition, technology developed under this effort is not relegated to US maritime Navy use and is applicable to commercial (and non-Defense US Government sectors) use of composites in similar applications. While the technology for designing and fabricating composite cylindrical structures currently exists both in the defense and commercial markets, the ability to fabricate high-quality, large-diameter, thick-walled, cylindrical structures to be subjected to high-cycle complex stress states with consistency and repeatability while maintaining both fiscal and schedule efficiency is currently lacking. Non-defense and/or commercial applications that may benefit from the developed technology may include wind energy, rocket motor casings, oil and gas piping, and submersibles targeting deep-sea scientific exploration.

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KEYWORDS: Propulsor Shafts; Fiber-Reinforced Polymer Composite; Non-Metallic Materials; Wet Filament Winding; Towpreg Winding; Dry Fiber Infusion.

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N231-048 TITLE: Signal Processing for Underwater Explosion Detection and Localization

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Artificial Intelligence (AI)/Machine Learning (ML); Autonomy

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

OBJECTIVE: Develop innovative signal processing techniques for use with existing ultra-short baseline (USBL) arrays to supplement current detection and location estimation techniques of underwater explosions.

DESCRIPTION: In Mine countermeasure (MCM) operations, neutralizers containing a relatively small amount of explosives are deployed against naval mines. The neutralizers approach the target and are detonated, which can cause a sympathetic detonation or lower order reaction in the naval mine. Current operations require a follow-on mission to detect and localize the detonation. Innovative signal processing algorithms could provide the location of this detonation by correlating the last known neutralizer location and the expected target location. This additional confirmation would eliminate the need for time-consuming follow-on missions. Utilizing existing hardware, especially equipment already located in the operation area, such as communications buoys, would allow this capability to be integrated into the fleet with minimal impacts.

The Navy is seeking to develop innovative signal processing algorithms to utilize acoustic data collected by an array of transducers with an USBL. The company will develop signal processing algorithms and a low-power processor board to host and run the processing algorithms. The processor board is required have a form factor capable of fitting within an A-sized sonobuoy diameter, with a height not to exceed 2.5 inches. An initial desire is to not exceed plus or minus 250 yards range accuracy, and not exceed plus or minus 5 degrees bearing accuracy.

Initial testing will occur on the processor board to determine power consumption. Analysis will be performed to show how this additional power consumption would affect the system. An initial desire is to not exceed 35 W electrical power consumption, with a further desire of reducing that even lower. Testing for the algorithms and processor board will culminate in an assessment of the prototype's ability to estimate the location at which an underwater explosion occurred. This test will be planned to occur during live fire or underwater explosion testing. Previously recorded data may be utilized for this assessment in the event that no such opportunity occurs. Additionally, the signal processing algorithms will be assessed for their ability to distinguish between the neutralizer explosion and the resulting reaction from the naval mine.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the

Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DCSA and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

All DoD Information Systems (IS) and Platform Information Technology (PIT) systems will be categorized in accordance with Committee on National Security Systems Instruction (CNSSI) 1253, implemented using a corresponding set of security controls from National Institute of Standards and Technology (NIST) Special Publication (SP) 800-53, and evaluated using assessment procedures from NIST SP 800-53A and DoD-specific (KS) (Information Assurance Technical Authority (IATA) Standards and Tools).

The Contractor shall support the Assessment and Authorization (A&A) of the system. The Contractor shall support the government's efforts to obtain an Authorization to Operate (ATO) in accordance with DoDI 8500.01 Cybersecurity, DoDI 8510.01 Risk Management Framework (RMF) for DoD Information Technology (IT), NIST SP 800-53, NAVSEA 9400.2-M (October 2016), and business rules set by the NAVSEA Echelon II and the Functional Authorizing Official (FAO). The Contractor shall design the tool to their proposed RMF Security Controls necessary to obtain A&A. The Contractor shall provide technical support and design material for RMF assessment and authorization in accordance with NAVSEA Instruction 9400.2-M by delivering OQE and documentation to support assessment and authorization package development.

Contractor Information Systems Security Requirements. The Contractor shall implement the security requirements set forth in the clause entitled DFARS 252.204-7012, "Safeguarding Covered Defense Information and Cyber Incident Reporting," and National Institute of Standards and Technology (NIST) Special Publication 800-171.

PHASE I: Develop a concept for the signal processing algorithms and a low-power processor board that meets the requirements in the Description. Establish feasibility by developing system diagrams as well as Computer-Aided Design (CAD) models that show the concept and provide estimated weight and dimensions and computer-based simulations that show the system's capabilities are suitable for the project needs. The ability to distinguish between the neutralizer detonation and a sympathetic detonation of the mine will also be assessed in this Phase I effort. Any limitations of the program of record USBL arrays to distinguish between these events will be documented in the Phase I effort. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Based on the results of Phase I and the Phase II Statement of Work (SOW), develop and deliver a prototype system for in-water testing and measurement/validation of the Phase I performance attributes. Test the prototype system, first in a controlled laboratory environment, then in an in-water (saltwater) environment, to determine its capability to meet all relevant performance metrics outlined above and in the Phase II SOW. This test will be planned to occur during live fire or underwater explosion testing. Prepare a Phase III SOW that will outline how the technology will be transitioned for Navy use.

Provide, as part of the Phase II final report, a recommendation regarding how the product could be integrated into current programs of record. Provide an initial assessment of the space and power required for this integration.

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

PHASE III DUAL USE APPLICATIONS: Provide technical support for the incorporation of the signal processing algorithms and transition them for Navy use. If feasible, these algorithms may be incorporated onto existing processors onboard naval programs of record or their processor board may incorporate into the system. If incorporated into the system, the board would be required to meet all applicable system performance specification requirements of the program of record.

There is the potential to utilize the products developed under this effort in commercial applications for the monitoring of commercial fisheries, oceanic research, and the oil and gas industries.

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KEYWORDS: Underwater Explosion Detection; Acoustic Signal Processing; Ultra Short Baseline; USBL arrays; real-time processing; battle damage assessment; acoustic source localization

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N231-049 TITLE: DIGITAL ENGINEERING - Artificial Intelligence/Machine Learning Video Processing and Packaging

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Artificial Intelligence (AI)/Machine Learning (ML); Networked C3

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

OBJECTIVE: Develop an automated tool to identify video images of interest using Artificial Intelligence/Machine Learning (AI/ML) to be sent to warfighters in real time.

DESCRIPTION: Today's military camera systems can collect vast amounts of video data. However, the copious amounts of data do not translate into actionable information because the video data is not analyzed until long after data collection has occurred. This problem is exacerbated for video collected from planes and helicopters, where weight and manning restrictions significantly reduce the amount of display space and human attention that can be devoted to video imagery in real time. This problem is particularly severe for maritime patrol and reconnaissance aircraft and maritime helicopters, where the proliferation of other sensor types reduces the emphasis on real-time video analysis. There are no known capabilities to solve this situation.

The Navy is seeking an automated tool to identify significant snippets of video data and package these snippets into minimized data packages using AI/ML so they can be transmitted to decision-makers in real time. This video curation and video compression can significantly improve situational awareness during tactical operations.

Advancement in deriving understanding from raw video has made great strides in areas such as facial recognition and the derivation of information from video obtained from self-driving vehicles. However, there has been less advancement in automated recognition of important anomalies in maritime video collected from aircraft.

The technology sought would initially flag potentially important video snippets to be triaged by a sensor operator aboard the aircraft but would mature over time to reduce the number of useless video snippets for each important video segment. As the concept of operations associated with the envisioned AI/ML curation of tactically significant video is still uncertain, the exact requirements to be levied on the technology sought by this topic cannot yet be determined. However, it should be presumed that the operator aboard the aircraft would not be able to devote more the 5 minutes per hour to validation of AI/ML-curated snippets.

The Tactical Common Data Link (TCDL) used by maritime aircraft is capable of greater bandwidth than prior tactical data link networks, such as Link 16. However, curating important snippets is not sufficient if the size of the resulting video cut is too large to pass in real time. Therefore, a complementary innovation in compression and packaging of the video is required to minimize the size of the data transmitted while retaining the original resolution.

The combination of high-qualify AI/ML curation of maritime video with minimal snippet size at required video quality will provide Theater Undersea Warfare (TUSW) decision makers accessing the Networked Architecture for Undersea Theater Integrated C2 Advantage (NAUTICA) system of systems and particularly the AN/UYQ-100 Undersea Warfare Decision Support System (USW-DSS) access to a wealth of crucial video information they often do not see until hours after the information has become of little importance.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DSS and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

All DoD Information Systems (IS) and Platform Information Technology (PIT) systems will be categorized in accordance with Committee on National Security Systems Instruction (CNSSI) 1253, implemented using a corresponding set of security controls from National Institute of Standards and Technology (NIST) Special Publication (SP) 800-53, and evaluated using assessment procedures from NIST SP 800-53A and DoD-specific (KS) (Information Assurance Technical Authority (IATA) Standards and Tools).

The Contractor shall support the Assessment and Authorization (A&A) of the system. The Contractor shall support the government’s efforts to obtain an Authorization to Operate (ATO) in accordance with DoDI 8500.01 Cybersecurity, DoDI 8510.01 Risk Management Framework (RMF) for DoD Information Technology (IT), NIST SP 800-53, NAVSEA 9400.2-M (October 2016), and business rules set by the NAVSEA Echelon II and the Functional Authorizing Official (FAO). The Contractor shall design the tool to their proposed RMF Security Controls necessary to obtain A&A. The Contractor shall provide technical support and design material for RMF assessment and authorization in accordance with NAVSEA Instruction 9400.2-M by delivering OQE and documentation to support assessment and authorization package development.

Contractor Information Systems Security Requirements. The Contractor shall implement the security requirements set forth in the clause entitled DFARS 252.204-7012, “Safeguarding Covered Defense Information and Cyber Incident Reporting,” and National Institute of Standards and Technology (NIST) Special Publication 800-171.

PHASE I: Develop a concept for using AI/ML to curate maritime video and compress the curated video snippets for timely transmission (within minutes). Demonstrate that the concept meets key attributes as discussed in the Description Feasibility will be demonstrated through modeling or analysis. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and deliver a prototype video processing and packaging system that meets the parameters in the Description from the concept developed in Phase I. The prototype system will be trained using trothed video recordings from a range of significant and representative TUSW exercises and tested using trothed video recordings from TUSW exercises and operations other than the video used for training.

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

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use. Work with Navy subject matter experts to determine the range of acceptable validation by sailors aboard the aircraft and required image quality as a function of visual conditions. In the event the Navy determines that the technologies are appropriate for incorporation into video systems for maritime aircraft, the Navy will work with the company and the prime for the maritime video systems to refine system requirements and either levy the improved requirement on prime contractors producing video systems or will purchase expeditionary prototypes and low rate initial production (LRIP) units from the company.

Potential dual use of the maritime video curation and packaging could be for search and rescue associated with losses over large bodies of water. The technology could also be deemed appropriate for curation of other sensor collections over vast areas (radar, lidar), depending on the capabilities of the company's innovative technologies.

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KEYWORDS: Theater Undersea Warfare; TUSW; video curation; artificial intelligence and machine learning; AI/ML; Networked Architecture for Undersea Theater Integrated C2 Advantage; NAUTICA; Undersea Warfare Decision Support System; USW-DSS; video compression in real

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N231-050 TITLE: Autonomous Crane System for Payload Motion Control

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Artificial Intelligence (AI)/Machine Learning (ML);Autonomy;General Warfighting Requirements (GWR)

OBJECTIVE: Develop technology to eliminate or greatly reduce the need for tag line handlers when transferring boats, craft, and other cargo loads.

DESCRIPTION: Crane lifting operations are inherently hazardous. Loads suspended from a single hook store substantial potential energy and are not easily controlled when the crane is attached to the deck of a ship that is moving in response to the wind and wave conditions at sea. In order to lift and maneuver large cumbersome loads aboard ships, tag line handlers are used to prevent unsafe pendulation and unwanted rotations. Tag line handlers are frequently exposed to hazards because the lines must be tended on a moving deck, which can be wet from sea spray or rain, and be in close proximity to the moving payload. The Navy seeks the development of a cargo stabilization system to accommodate different load types in a safe and timely manner without requiring assistance from tag line handlers. The desired solution will operate effectively without a load on the hook and up to the rated Safe Working Load (SWL) of the crane. Horizontal oriented loads such as boats as well as vertically oriented loads will be accommodated and stabilized. The system shall be capable of accommodating 6 degree of freedom ship motions on an Expeditionary Fast Transport (EPF) in sea state 3 (as defined by NATO STANAG 4194) and must be capable of performing a minimum of 5 lifts in less than an hour. Navy is seeking a system that can stabilize the load for the entire duration of the time it is suspended.

The commercial industry approach to this challenge is to design special purpose lifting devices, which are often designed in conjunction with the platform from which they will operate, to incorporate mechanisms to isolate the lifting device from the platform motion. The solution sought by the Navy is more general purpose and must be applicable to existing crane installations and capable of lifting a variety of cargo types. The solution sought by the Navy differs from commercial off-the-shelf approaches in that it should be able to be implemented on existing cranes with reasonable modifications. If the crane is installed on a vessel that launches and recovers watercraft with personnel aboard, then the system must comply with the Personnel Lifting requirements listed in the ABS Guide for Certification of Lifting Appliances [Ref 3].

PHASE I: Develop a computer model concept for an autonomous cargo stabilization system. Navy is seeking a system that can stabilize the load for the entire duration of the time it is suspended. Feasibility shall be demonstrated by a combination of analysis, modeling, and simulation. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and deliver a detailed design of a full-scale stabilization system. Fabricate a prototype scale working model of the stabilization system at no smaller than a 1/9th geometric scale. Demonstrate the stabilization on an appropriately scaled model of an ISO standard twenty-foot equivalent (TEU) container, while being subjected to motions representative of a fully developed high-end sea state 3 on an Expeditionary Fast Transport (EPF).

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning a full scale stabilization system to Navy use through testing and further development to facilitate the adaptation of the technology to Navy use in shipboard applications at sea state 3.

The use of stabilization system technology being sought by the Navy to facilitate moving equipment and cargo using cranes aboard ships had its start in private industry to improve both worker safety and to reduce the time required operating cranes in order to construct multi story high rise buildings. Construction of offshore wind farms is another area where shipboard cranes and stabilization during lifting operations is required. This need is expected to grow significantly in the area of load management on land and on the sea.

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KEYWORDS: Dynamic Stabilization; Shipboard Cranes; Cargo Pendulation; Wave Induced Ship Motion; Sea State; Tag Line Handlers

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N231-051 TITLE: Underwater Diver-Applied Composite Patch Repair for Crack Arresting

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR)

OBJECTIVE: Develop an underwater, diver-applied, composite patch repair capability for crack arresting that is applicable to multiple hull materials and will be considered for longer-permanent repair or be categorized as a temporary emergent repair.

DESCRIPTION: The superstructure of the Ticonderoga-class cruisers, which is composed of aluminum (Al) alloy 5456, has been determined to be susceptible to cracking across its aluminum alloy. The Navy recognized that this aluminum alloy will become sensitized at higher temperatures as a result of the heat treatment processing received during the manufacturing process. As a result of this sensitization, there have been many issues with cracking in the aluminum. Sensitization refers to a harmful microstructure that increases the corrosion susceptibility in Al 5XXX series alloys. Sensitized Al is observed in 5XXX alloys that have magnesium contents greater than 3 percent weight content and operate at temperatures reached by simple solar exposure. Conventional repairs for the Ticonderoga-class superstructure must be done in a "dry environment". Furthermore, they include completely cutting out and removing the affected sections, and conducting hot work (welding) repairs. Moreover, the Independence class Littoral Combat Ships (LCS) and the Expeditionary Fast Transport (EPF) ships have also utilized aluminum for structural components in the hulls and superstructures, raising additional concerns regarding stress corrosion cracking, fatigue, and sensitization. In some situations, a weld repair cannot be performed, as called out in ASTM G67, which states "a mass loss greater than 60 mg/cm2 cannot be welded because cracks will form in the area adjacent to the weld repair". Where applicable, conventional repairs are time consuming and costly. For instance, a waterborne weld repair can take upwards of $500,000 and two weeks to repair. Dry docking a ship requires a cost of approximately $1,000,000 and repairs take one month at minimum. Additionally, the burden to prepare and move the ship to dry dock falls on the crew, reducing their availability for other tasking.

A case study of the Royal Navy and its Type 21 Frigates has shown that an above water composite repair patch procedure is an effective alternative to conventional repairs. It has also shown that this type of repair could be considered durable, and potentially classified as a long-term temporary repair lasting at least 10 years in service. In response, the U.S. Navy has developed an approved above water procedure for repairing an affected aluminum alloy area of concern and preventing crack growth while restoring the integrity of the compromised area utilizing composite patching. The U.S. Navy has applied this above water composite repair patch procedure to the 5456-H116 aluminum alloy superstructures and decks aboard CG-47 class ships, and is currently in service aboard eleven different ships of that class. Since then, the conceptual viability of underwater composite patching technology has been proven through initial research conducted at the Naval Post-graduate School (NPS). This work is publicly available in Lieutenant Commander Robyn W. Bianchi's 2018 Thesis and Dissertation, which can be located at the web address under the "References" section.

The Navy desires an underwater composite patching technology that will be able to withstand the loading experienced in the dynamic environment of a waterborne US Navy vessel. The proposed solution will have a minimum lifespan of 6 months to 1 year in the saltwater environment across a temperature range of 40 to 90ºFahrenheit for cracks measuring up to 12 inches in length. This flexibility will allow for more robust Shipyard planning. The successful proposer will also investigate, estimate, simulate, and verify the repair's expected lifespan across the extended underway periods of US Navy vessels. The proposed underwater composite patching solutions will also be applicable to hulled vessels of varying materials, including composite, aluminum, steel, and fiberglass. While these cracks are well within the Navy's

capabilities to repair, an underwater, diver-applied composite patch offers the warfighter the potential to extend operational time and save money.
Currently, weld crack repairs on steel hulled vessels are common. A small crack weld repair on a steel hulled vessel costs just under $400,000 and takes 10 days for vessels that have a refined/approved procedure. Aluminum hulled vessels currently cannot be welded underwater in accordance with an approved procedure, thus increasing the 10 day timeline to as long as one month with costs exceeding $1,000,000. The ideal patching capability proposed will cost less than $1,000 per application and would require 2 days or less for repair time. This repair time must encompass the time necessary for divers to apply the patch as well as the total cure time. The proposed composite patching technology will delay or eliminate the need for crack repairs outside of a ship's regularly scheduled dry dockings. Currently, crack repairs occur at least once per fiscal quarter. Permanent crack repairs can then be scheduled once the ship enters its extended dry-docking availability. This capability will lower demand within our Navy shipyards and reduce the need to contract private yards. The proposed solution's threshold use will be temporary emergent repairs whereas its objective use will be for permanent patch repair for crack arresting. This technology could also be applied to commercial vessels and help them save cost or time associated with weld repair delays as there are very few solutions of this nature commercially available. Most solutions pertain to sail boats that are made of fiberglass or composite hull structures. All commercial vessels with aluminum or steel hulls require either underwater welding or dry-docking solutions.

The technology will be tested against the qualification requirements of Department of Defense Manufacturing Process Standard, MIL-STD-1689A, Fabrication, Welding, and Inspection of Ship Structure.

PHASE I: Develop a concept for the fabrication and application process of underwater composite patching. Determine the feasibility of the proposed composite patching and recommendations for improvement on any associated manufacturing processes. Feasibility shall be demonstrated by a combination of analysis, modeling, and simulation as stated in the Description. The Phase I Option, if exercised, will include the initial design specifications, load testing results, and capabilities description to build a full scale prototype solution in Phase II.

PHASE II: Develop a full scale prototype and procedure shall be developed and delivered to the Government for final testing and evaluation. The system shall include recommended composite and epoxy type and manufacturing materials and procedures. An initial evaluation of the system will be performed on a waterborne US Navy vessel or representative substitute platform. The system will also go through preliminary qualification testing based on a test plan developed by the Government IAW MIL-STD-1689A. Final test and evaluation will take place at the Navy Experimental Diving Unit, Panama City, FL. Lastly, it will be determined if composite patching repairs could be used as permanent or temporary emergent repairs. Describe in extensive detail the conditions under which the solution would be considered as a permanent or temporary emergent repair, including but not limited to water temperature, salinity, and other criteria.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use. Deliver an operational system to the Government for qualification testing in accordance with MIL-STD1689A, Fabrication, Welding, and Inspection of Ship Structure. Provide composite and epoxy materials necessary for qualification testing. Provide all required training to safely conduct the procedure. After successful qualification, deliver the systems to the Navy's Emergency Ship Salvage Material (ESSM) program where they will be maintained and ready for issue. Train ESSM personnel in the operation and maintenance of the delivered systems. Provide all drawings of the system to support fabrication, maintenance, and overhaul.

This technology also has the potential to impact commercial industry. The concept of saving time and money with waterborne patch repairs vice entering dry dock or contracting divers to perform underwater welding would be applicable to maritime vessel maintenance and repair communities associated with commercial shipping and transportation industries.

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KEYWORDS: Composite repair; Underwater repair; Navy Ship repair; Composite Patch; Underwater Composite Patching; Navy Hull Patching

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N231-052 TITLE: Advanced Reliable Wide-Range Hydrodynamic Hull Appendage

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR)

OBJECTIVE: Develop an Advanced, Reliable, Wide-Range Hull Hydrodynamic Appendage (HHA) that provides fuel savings over a broad range of Froude numbers (0.15 – 0.75).

DESCRIPTION: Unmanned Surface Vessels (USVs) and combatants require affordable, reliable, fuel efficient, proven hull forms. Commercially available hull designs provide a good baseline for affordable, reliable, proven hull forms; however, they are typically not designed for fuel efficient operations at the same broad operational speed ranges required for military vessels, i.e., lower transit speed, endurance range speed, and higher sustained sprint speed. The speed time profile for a USV will vary highly between peace time and war time operations, making broad range fuel efficiency more critical. Existing HHAs (stern flaps, wedges, interceptors, bow bulbs, etc.) [Refs 1 and 2] have demonstrated the ability to reduce hull resistance, and thereby, improve fuel efficiency; however, their benefits vary across the ship's speed range, and have not provided a consistent benefit across a broad range of Froude numbers (0.15 – 0.75). Additionally, some of the HHAs rely on shipboard hydraulic systems, which can lead to cost and reliability issues.

A reliable, wide-range HHA is required to enable commercially available hull designs to provide affordable, reliable, fuel efficient capability. Development of a reliable, wide-range HHA will better enable a modified Commercial Off The Shelf (COTS) hull-form to meet USV and combatant operational requirements, improving the autonomous systems endurance, persistence, and reliability. The development targets hulls 150'-400' in length.

Innovation is required to develop an advanced HHA that provides fuel savings across a wide range of Froude numbers and provides reliable operation with minimal maintenance. Additionally, the HHA must be readily integrated into an existing hull form, such that it does not require significant modification of existing commercial hull forms. The advanced HHA will provide a 5-10% fuel efficiency benefit at minimum across a wide operational speed range per Froude number range provided previously, and shall target an acquisition cost of less than $750K per unit to provide a Return on Investment (RoI) within 1-2 years. The number of units required is dependent on how broadly the technology can be applied; for planning purposes ~10-20 units would be required over a 10 year period. The advanced HHA's performance will be assessed against the power delivered ratio for a hull form without an HHA as compared to a hull form with an HHA. The HHA shall be designed for (a) a 25-year service life, (b) fail safe operation, (c) 80% reliability, and (d) preventative maintenance requirements of no more than once per year. A reliability assessment shall be completed to assess whole system reliability, broken down by subsystems and components, to validate improvements relative to current systems (e.g., hydraulic actuated interceptors or trim tabs).

PHASE I: Develop a concept for an advanced, reliable, wide-range HHA that explores methods to incorporate reliability and fail-safe operations into the system. Identify how the system would integrate into a range of USV and combatant hull forms. Conduct computational fluid dynamic (CFD) studies to demonstrate the feasibility of the concept and potential energy savings to hull forms across a wide Froude number range per range provided previously and verify integration requirements. Conduct reliability assessment broken down by subsystems and components. Provide final concept for an advanced, reliable, wide-range HHA.

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 full-scale or model-scale prototype of an advanced, reliable, wide-range HHA. The design shall be applicable to multiple hulls; however, only one prototype is required for one USV or combatant hull. Evaluate the prototype system through model or full-scale testing. Validate 5-10% fuel efficiency benefit across a wide operational speed range, relative to baseline hull performance. Update the reliability assessment based on final configuration and component selection, and document improvements to reliability.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the advanced reliable wide range HHA to Navy use. Based on the evaluations completed under Phase II, make further modifications and improvements (compatibility with all Navy requirements), and refine the design for Navy specific USV or combatant uses. Work with the Navy in the implementation of an advanced, reliable, wide-range HHA on higher speed Naval platforms, such as MUSV or LCS. Work to identify commercial applications for Fast Support Vessels (FSVs) and ferries. In coordination with the Navy, conduct full-scale shipboard evaluations to validate effectiveness in a relevant environment to verify fuel savings are achieved.

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KEYWORDS: Hull Appendage; Hull Resistance; Stern Flap; Stern Wedge; Interceptor; USV Fuel Saving

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N231-053 TITLE: Improved Electromechanical Actuators for Aircraft Carrier Flight Deck Applications

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR)

OBJECTIVE: Improve the existing configuration of Electromechanical Actuators (EMAs) to lower in a safe, controlled manner in the event of a system or component failure for Aircraft Carrier flight deck applications.

DESCRIPTION: Aircraft Launch and Recovery (ALRE) is a critical part of aircraft carrier flight deck operation as the carrier aviation depends on the system for launching and landing aircrafts during flight deck operations. ALRE includes Jet Blast Deflectors (JBDs), Integrated Catapult Control System (ICCS), Barricade Stanchions, and Landing Signal Officer Display Systems (LSODS) , which utilize EMAs as the mechanism to raise and lower the operative components.

EMAs are an alternative to hydraulic actuators, which require which require multiple hydraulic pumps that require pumps, pipes, and valves and lead to fluid contamination, oil leakage, or fire due to hot breaks. EMAs convert electricity to motive force. The force created can be used to move large doors, operate switches for sorting conveyor systems, or move powered valves. Commercially EMAs are used in platforms such as landing gear, steering actuation, doors, brakes, and primary and secondary flight controls.

In the Navy, EMAs are used extensively on the CVN78 flight decks to raise and lower JBDs, Integrated ICCS, Barricade Stanchions, and LSODS. Existing EMAs are unable to lower in the event of mechanical or select electrical failures, creating a risk to flight deck operations, including loss of aircraft. JBD unit number three (3) poses the greatest risk to emergency flight recovery operations, which elevates the focus to develop a solution specific to this location. However, the need to improve reliability and reduce maintenance requirements persists for all flight deck EMA applications. The existing EMAs that actuate the JBDs are ineffective at lowering in the event of system or component failure, which poses significant risk to emergency aircraft recovery. There have been several documented cases of prevented JBD panel lowering incidents on aircraft carriers and successful outcome of this project is considered critical in support of carrier flight operations and in direct support of mission readiness. The current EMA applications, specifically on JBD 3, creates a critical need for a solution for an improved EMA that will lower in a safe, controlled manner in the event of a system or component failure.

During aircraft carrier launch operations, the JBD functions as a physical safety barrier between the aircraft engine-nozzle exhaust and any equipment or personnel that are located behind the aircraft. A JBD is installed directly aft of each catapult and consists of either four or six aluminum panels. These panels raise from the flight deck and, in operational position, divert the aircraft's jet blast upward. The panels become an integral part of the flight deck surface when lowered to their stowed position. The focus of this SBIR topic is to improve the current EMAs that actuate JBDs for safe and rapid manually-controlled lowering capability during emergency operations due to system or component failure. This action would ideally occur remotely, however, if a proposed solution occurs locally, then the time to deploy and activate the lowering action will be a major evaluation factor in meeting the time requirement.

The JBD actuators exist in a severe environment where frequent exposure to seawater, jet fuel, grease, and other debris, and includes periods of submersion from accumulation of these elements. The JBD must remain raised if there is a loss of normal operating power and emergency lowering must commence upon manual control only. The physical space is highly constrained due to their proximity to other ship structure, systems, and components. The existing space dimensions are 14L x 36W x 1.8H feet with an approximate volume of 600 square feet occupied by in-situ machinery.

Below are the requirements and technical data for JBDs.

Dimensions: 6 feet wide with six (6) panels operating simultaneously in adjacent series along the length dimension at 14 feet and raised to a height of 10.7 on the aft arrangement. They raise simultaneously to an angle of 50 degrees from a horizontal position relative to the flight deck.

Weight of Existing Panel: 5,200 lbs.

Static Force (needed to overcome the weight of each panel): 38,000 lbs.

Time to Lower (in the event of system or component failure):not more than 12 minutes.

Method of Lowering: initiated manually, either remotely or locally.

Safety Risks: must not pose any human-machine interface safety risks.

NOTE: Technologies that achieve fully-lowered JBDs in the safest manner, which could entail remote operation, and in the shortest time will receive evaluation preference. Technologies that introduce the least time consuming maintenance requirements will also receive evaluation preference.

The current design employs a mechanical clutch that disengages the EMA from the actuator and a mechanical brake that controls the descent rate of the JBD lowering action. Consideration should be given for alternative technologies that effect a manually-controlled emergency lowering operation such as locally or remotely controlled electro-hydraulics, pneumatics or other compressed gas cylinders and rams; coil springs; electro-magnetic cushioning; or any other novel dynamic control technologies, devices, or materials, or any configurations thereof that would integrate any existing means for lowering large heavy hinged objects in a rapid and safe manner under manually-controlled operation. Further consideration could also be given to effect a cascading action by leveraging raised panels as resistance in lowering adjacent panels in subsequence, thereby limiting the power demands to the final remaining upright panel.

PHASE I: Develop a concept for improved EMAs for Aircraft Carrier Flight Deck applications that meet the requirements in the Description. Demonstrate the feasibility of the concept in meeting Navy needs and establish that the concept can be developed into a useful product for the Navy. Feasibility of the electromechanical actuator will be established via computer modeling. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and deliver a prototype and demonstrate that it can meet the needs of the Navy. Initial testing of the system will be on subscale demonstrators progressing to full-scale system testing at a location and facility to be determined. Testing must demonstrate performance, environmental robustness, shipboard shock and vibration, and maintainability. Product performance will be demonstrated through prototype evaluation, modeling, and demonstration over the required range of parameters. An extended test in a maritime environment will be used to refine the prototype into a design that will meet Navy requirements. Prepare a Phase III manufacturing and development plan to transition the electromechanical actuators to Navy use.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the EMAs to Navy use. Manufacture and install, on a candidate Gerald R. Ford and Nimitz Class aircraft carrier, one EMA system for shipboard test and evaluation. Plan to produce units for forward fit to CVN-81 and follow, and back-fit of the entire class of in-service carriers.

Improved speed, precision, movement, and manual override to EMAs can be a substitute in any format or industry where this technology is currently being utilized such as mechanical systems, industrial machinery, computer peripherals, printers, opening and closing dampers, locking doors, braking machine motions, 3d printers, and commercial aircraft manufacturing.

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KEYWORDS: Aircraft Carriers; Electromechanical Actuators;; Aircraft Launch and Recovery;; Jet Blast Deflectors;; Flight Deck operations; Emergency Lowering of JBDs.

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N231-054 TITLE: Structural Design Process for High-Cycle Fatigue Performance of Composite Materials

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR)

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

OBJECTIVE: Develop, execute, and validate methodologies to efficiently establish high-confidence design allowable for high-cycle fatigue performance of composite materials and structures.

DESCRIPTION: The United States (US) maritime Navy uses laminated fiber-reinforced composite materials in a variety of submarine external non-pressure hull applications, including sonar bow domes, an assortment of composite hydrodynamic fairings, acoustic windows, access panels, grates, and cover plates. Maximum cyclic load requirements for these types of applications typically range from 10^6 to 10^7 cycles. Fatigue is usually accounted for implicitly during the structural design process by defining factors of safety for stress analyses that are known to provide the required fatigue life for the material system of interest. This design approach has been confirmed in select instances by testing a representative full-scale part to demonstrate adequate residual strength after applying a complete lifetime of cyclic loads. There is increasing US maritime Navy interest in using composite materials in high-cycle applications that will require sustaining a much larger number of load cycles (perhaps on the order of 10^9) over the life of the structure. Composites are attractive for these applications for weight reduction, corrosion resistance and associated through-life cost savings, design flexibility, and potential fabrication cost and schedule benefits relative to metallic designs. However, for high-cycle applications, fatigue becomes a dominant driver of the structural design. This larger load cycle requirement introduces significant challenges that are currently outside the Navy community experience accumulated from prior maritime Navy composites applications. Testing without interruption at an assumed 5-Hz cycle rate, it takes well in excess of 6 years to exercise 10^9 load cycles for a single test. Under those circumstances, it is difficult to provide timely and cost-effective material and/or structural testing support for design activities. These issues can be mitigated via the identification, development, and demonstration of efficient test methods to reduce the time required to apply the full lifetime of load cycles, and/or establishment of technically justified methods for obtaining necessary test results with cycle counts reduced to manageable levels, in support of the generation of high confidence material design allowable.

Some methods have been developed in support of more efficient evaluation of high-cycle fatigue performance of composites using non-traditional test techniques. A large majority of these methods rely on some form of accelerated test rate, or frequency, to expedite the process typically required of executing coupon-level experiments comprised of high cycle counts using standard servo-hydraulic equipment. While this is commonly accepted practice for characterizing high-cycle fatigue performance of metallic materials, there are several challenges associated with such methods as they pertain to composite material high-cycle fatigue characterization. Such challenges include a) overheating of the test specimen, b) introduction of viscoelastic effects resulting in artificial response, c) wear of the test equipment, and d) lack of suitable instrumentation technologies for accurately measuring specimen response. Other non-traditional test methods developed for evaluating high-cycle fatigue performance of composites rely on flexural test configurations to leverage small, stiff specimen geometries that provide an opportunity to evaluate both tensile (bottom surface) and compressive (top surface) response. However, such methods often result in maximum stress/strain states at the point of load application (for the cases of 3-and-4-point bending) and, as a result, typically produce limited relevant data from a given test.

The efficient test methods and approaches the Navy seeks should be applicable to a range of non-metallic materials (e.g., Glass Fiber Reinforced Polymer [GFRP] and Carbon Fiber Reinforced Polymer [CFRP]), reinforcement architectures (e.g., unidirectional, woven), processing techniques (e.g., autoclave-cured, out-of-autoclave oven vacuum bag cured, infused), and fatigue test stress ratios (i.e., R=-1, 0.1, 1). In addition, the resulting methods and approaches should be capable of developing, with high confidence, material design allowable pertinent to typical composite failure modes, including but not limited to the following: in-plane tension, in-plane compression, interlaminar shear, and bolt bearing. Such methods and approaches will permit the development and validation of a) design criteria, b) efficient and robust material selection processes, c) efficient static, fatigue, and environmental characterization in support of structural design, and d) efficient static, fatigue, and environmental testing for structural verification. Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DSS and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

All DoD Information Systems (IS) and Platform Information Technology (PIT) systems will be categorized in accordance with Committee on National Security Systems Instruction (CNSSI) 1253, implemented using a corresponding set of security controls from National Institute of Standards and Technology (NIST) Special Publication (SP) 800-53, and evaluated using assessment procedures from NIST SP 800-53A and DoD-specific (KS) (Information Assurance Technical Authority (IATA) Standards and Tools).

The Contractor shall support the Assessment and Authorization (A&A) of the system. The Contractor shall support the government's efforts to obtain an Authorization to Operate (ATO) in accordance with DoDI 8500.01 Cybersecurity, DoDI 8510.01 Risk Management Framework (RMF) for DoD Information Technology (IT), NIST SP 800-53, NAVSEA 9400.2-M (October 2016), and business rules set by the NAVSEA Echelon II and the Functional Authorizing Official (FAO). The Contractor shall design the tool to their proposed RMF Security Controls necessary to obtain A&A. The Contractor shall provide technical support and design material for RMF assessment and authorization in accordance with NAVSEA Instruction 9400.2-M by delivering OQE and documentation to support assessment and authorization package development.

Contractor Information Systems Security Requirements. The Contractor shall implement the security requirements set forth in the clause entitled DFARS 252.204-7012, "Safeguarding Covered Defense Information and Cyber Incident Reporting," and National Institute of Standards and Technology (NIST) Special Publication 800-171.

PHASE I: Define, develop, and demonstrate an experimental approach to efficiently evaluate the high-cycle (> 10^8 cycles) fatigue performance of non-metallic materials using novel coupon specimen geometries and/or test methods. Results of the proposed experimental approach shall be compared to currently available relevant fatigue data and/or limited experimental fatigue data generated under the proposed effort using traditional experimental techniques to substantiate the approach. The feasibility of the specimen and/or test method design should be supported by analysis and/or simulation. The Phase I Option, if exercised, will include documentation of performance demonstration and conceptual specification of proposed improvement and/or refinement to the resulting approach to be further developed in Phase II.

PHASE II: Refine, demonstrate, validate, and deliver the experimental approach developed in Phase I by conducting a suite of experiments on multiple material systems targeting a range of composite failure modes exercised under high-cycle fatigue loading. Demonstration of the proposed approach shall include testing on both CFRP and GFRP materials. Validation of experimental results generated using the proposed approach shall be established via comparison with relevant currently available material fatigue databases (where applicable) and/or verification testing using traditional experimental methods.
Work with NAVSEA to identify relevant cycle counts and stress ratios of interest in support of experimental testing.

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

PHASE III DUAL USE APPLICATIONS: Assist the Navy in transitioning the technology to Navy use and propose and define an article(s) to be fabricated and subjected to a representative lifetime cyclic load spectrum in order to validate the proposed experimental methodology for developing fatigue design allowable. Work with NAVSEA to identify a representative cyclic profile in support of defining an applicable load spectrum comprised of relevant load magnitudes, cycle counts, and stress ratios in support of experimental verification testing.

Efficient experimental methods developed under this effort are not relegated to US maritime Navy use and are applicable to the commercial (and non-Defense US Government sectors) use of composites in high-cycle fatigue applications (> 10^8 cycles), such as wind energy. While current wind energy design methodologies facilitate general robustness and lack a general need for significant design margin (relative to manned US Navy platforms), the opportunity to leverage developments in experimental testing to promote efficient characterization of high-cycle fatigue performance certainly offers the opportunity to reduce maintenance costs and associated down-time, improving operational efficiency and overall power output. Any industry that leverages the use of composites for fatigue-critical applications comprised of moderate to high load cycles would benefit from this technology.

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KEYWORDS: High-Cycle Fatigue; Composite Materials and Structures; Design Allowable; Glass Fiber Reinforced Polymer; Carbon Fiber Reinforced Polymer; Non-Metallic Materials

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N231-055 TITLE: Centralized Automated Fault Monitoring

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Autonomy;Networked C3

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

OBJECTIVE: Develop a centralized automated fault monitoring system capable of integrating sensor and fault data across ship systems to provide a holistic view of current faults across various ship systems to enable fault management, response, and understanding of the impact on mission readiness.

DESCRIPTION: Current technology informs ship watchstanders of faults and alarms from various control systems throughout the ship. However, watchstanders must interpret multiple alarms and determine the impact to ship systems, the ship as a whole, and the impact to overall mission effectiveness. A fault monitoring capability to aggregate system data into a user interface, allowing for complete ship fault monitoring, will reduce the burden on the crew and provide increased situation awareness to the watchstander.

PMS 515, FFG 62 Constellation Class Program Office, seeks a centralized automated fault monitoring capability to integrate numerous ship systems providing data and alarm inputs in order to improve the crew’s situational awareness of overall ship status and mission effectiveness. By aggregating all faults into one common structure and platform level system, the cognitive load on the operator can be decreased and the ability to make data-driven decisions based on complex information will be greatly improved. The centralized automated fault monitoring system will receive various ship systems’ fault data and sensor outputs and convert them into a human-readable and intuitive User Experience (UX) to provide an aggregate viewpoint of the overall ship system and platform health. This will enable operators to visualize the mission impact of various faults and alarms on ship control systems (e.g., up/down, failure mode, performance). The centralized automated fault monitoring system should categorize and prioritize alarm information with the goal of displaying compiling, automating, and reducing burdens on the watchstanders to assist with understanding the influence a component alarm has on the overall mission effectiveness of the system.

The centralized automated fault monitoring system must be capable of collecting, integrating, and displaying data from all ship control systems and must include an interface to support data export. This will enable data analysis by watchstanders in real time as well as evaluation by the Program Office, In-Service Engineering Agents (ISEAs)s, and subject matter experts. The system will also inform maintenance and logistical requirements. Proposers should develop a solution that is Modular Open Systems Approach (MOSA) compliant to allow for cross-platform compatibility and future capability improvements. Because of the unique and specific nature of the multiple FFG 62 subsystems, of which data will be collected, there are currently no commercial solutions to allow for subsystem data integration and/or data exportation. Testing will be iterative throughout the phases in order to test accurate data consolidation, user experience, and secure cyber footprint. This solution must have the ability to achieve Navy accreditation and certification in order to be installed on an operational vessel in accordance with the latest guidance including, but not limited to, Authorization to Operate and Risk Management Framework policies.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DCSA and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

All DoD Information Systems (IS) and Platform Information Technology (PIT) systems will be categorized in accordance with Committee on National Security Systems Instruction (CNSSI) 1253, implemented using a corresponding set of security controls from National Institute of Standards and Technology (NIST) Special Publication (SP) 800-53, and evaluated using assessment procedures from NIST SP 800-53A and DoD-specific (KS) (Information Assurance Technical Authority (IATA) Standards and Tools).

The Contractor shall support the Assessment and Authorization (A&A) of the system. The Contractor shall support the government's efforts to obtain an Authorization to Operate (ATO) in accordance with DoDI 8500.01 Cybersecurity, DoDI 8510.01 Risk Management Framework (RMF) for DoD Information Technology (IT), NIST SP 800-53, NAVSEA 9400.2-M (October 2016), and business rules set by the NAVSEA Echelon II and the Functional Authorizing Official (FAO). The Contractor shall design the tool to their proposed RMF Security Controls necessary to obtain A&A. The Contractor shall provide technical support and design material for RMF assessment and authorization in accordance with NAVSEA Instruction 9400.2-M by delivering OQE and documentation to support assessment and authorization package development.

Contractor Information Systems Security Requirements. The Contractor shall implement the security requirements set forth in the clause entitled DFARS 252.204-7012, "Safeguarding Covered Defense Information and Cyber Incident Reporting," and National Institute of Standards and Technology (NIST) Special Publication 800-171.

PHASE I: Develop a concept for an automated fault monitoring system that integrates data from numerous ship systems with an ability to assess the faults and alarms' impact to the ship's mission readiness. The concept must show that it can feasibly meet the requirements of the Description. Feasibility shall be established through modeling and simulation of concept.

The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Based on the results of Phase I and the Phase II Statement of Work (SOW), generate system architecture diagrams that provide a high-level, and detailed system design as well as develop a comprehensive automated fault monitoring prototype that is capable of demonstrating the implementation and integration into the ship systems' environment for testing and evaluation. Demonstrate the technology's accuracy, repeatability, and functionality, adhering to the requirements outlined in the

Description. Perform a system demonstration in a simulated environment. Prepare a Phase III development plan to transition the technology to Navy use.

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

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use and support further refinement and testing of the centralized automated fault monitoring system's functionality following successful prototype development and demonstration. Testing will be accomplished by real-time demonstration of the developed capability with operational users in order to gauge successful metrics for accuracy, readability, and implementation of data feeds into a singular location/user interface and mission impact analysis. Support the Navy for test and validation to certify and qualify the system for Navy use.

This solution has applicability across the Navy on most if not all platforms with complex/automated ship control systems. This technology has the potential to increase both mission effectiveness and readiness of the Navy's Fleet. This capability can be applied to commercial applications with multiple diverse and complex systems, including aviation and commercial maritime operations.

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KEYWORDS: Fault monitoring; automated fault impact assessment; integrated alarm data; network fault management; centralized system data; multi-sensor data fusion

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N231-056 TITLE: DIGITAL ENGINEERING - Intelligent Capture of Digital Imaging for Systems Engineering, Modeling, and Training

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Artificial Intelligence (AI)/Machine Learning (ML); General Warfighting Requirements (GWR)

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

OBJECTIVE: Develop a high-capacity digital video imagery recording system that provides intelligent selection and efficient organization and storage.

DESCRIPTION: Electro-optic and infrared (EO/IR) imaging sensors (cameras) are widely used for situational awareness, surveillance, and targeting. However, no matter the application, the amount of raw data generated is enormous. This is especially true for large format, high resolution, and extremely high frame rate video sensors. The ability of human operators to monitor, comprehend, and respond to such video streams is therefore taxed, especially over extended periods and during stressful engagements. Therefore, these systems incorporate image processing features that aid the human operator. For some systems, this may be as simple as displaying alerts that guide the operator's attention to specific regions of interest (ROIs) based on predefined thresholds or characteristics. For increasingly sophisticated systems, the operator will be aided by a suite of machine-learning (ML) enabled image processing algorithms that accurately recognize ROIs, identify targets of interest, and generate alerts that take into consideration conditions that are completely new and unknown to the particular operator. To do this efficiently and accurately, these algorithms must be trained on the most extensive and relevant set of digital video image data possible. By necessity, this data must be continuously updated to reflect new conditions and evolving threats. While commercial image data recorders are readily available, "smart" recorders, where every piece of recorded data is necessary, valuable, and readily useful, do not exist – especially with the capacity required for operational use.

A co-requisite need arises from the systems engineering process as applied to the development, test, evaluation, validation, and sustainment of EO/IR imaging sensor systems. Requirements for system performance naturally define parameters such as resolution, dynamic range, and spectral bandwidth. But these specifications, though essential, don't fully capture the ability of a system to help a human operator discern a target in a complex and rapidly changing maritime seascape subject to the caprices of wave and weather. Effective system development and validation, especially for those systems incorporating sophisticated image processing and decision aids, depends on evaluating performance against a wide range of imaging conditions. However, this cannot be done exclusively at outdoor test ranges (which are expensive). A great deal of system development, particularly the design of the image processing subsystem, must be done using captured imagery. In addition, a library of representative video images provides a digital "standard" against which system performance can be defined and evaluated throughout the systems engineering process, starting from requirements definition and system modeling. This is especially true as acquisition programs move to a full model-based systems engineering (MBSE) approach. If properly executed, digital models, based on properly updated and validated data, can be used throughout a system's life, from research and development through operation and sustainment. Finally, a library of imaging data is essential for training personnel and training ML algorithms.

In both cases, the key is a readily accessible library of captured image data, broad in extent, and organized and stored for ready retrieval in a way conducive to the particular task at hand. The Navy, therefore, needs an intelligent recording system (recorder) that captures, sorts, compresses, and stores video image data. The "intelligent" aspect of the solution means that the recorder should operate autonomously, without operator input needed to initiate recording (although the provision for operator/external-directed capture should be included with sufficient buffering to account for operator response time) and without manual curation of the stored video. For simple systems, where ambient conditions can be controlled and the overall scene does not change appreciably, this can be accomplished through simple motion detection. However, for a warship at sea, the scene is constantly evolving such that economical use of storage capacity demands a conditional recording strategy that is highly selective and dynamic.

In deciding what video to capture and how it is sorted and compressed for storage, the recorder should utilize metadata embedded within the video file. This includes not just the metadata provided organically from the imaging sensor (camera) but also metadata generated by image processing subsystems. In particular, the metadata will be augmented by ML-enabled subsystems that, for example, identify ROIs within the broader image frames. The recorder may also incorporate ML-based algorithms in the decision process if those algorithms facilitate accurate identification of video of interest. Video of interest can include both typical events and atypical events and may, in the limiting case, be captured as a still image photo (SIP). Beyond this, the solution is expected to develop the methodology for identifying which video samples warrant recording. It should also be noted that the metadata associated with each video sample is not fixed, and as image processing subsystems increase in sophistication and system hardware and software is updated, the available metadata may well expand. Therefore, acceptable solutions must be extensible. Likewise, the solution should be agnostic to sensor format, frame rate, resolution, etc., and allow recording of non-compressed Class 0 motion imagery and compressed inputs. The video will be compliant with (and therefore the solution must be compliant with) MIL-STD-2500C National Imagery Transmission Format Standard, Motion Imagery Standards Profile (MISP), Motion Imagery Standards Board (MISB) Standard (ST) 1606, MISB ST 1608, MISB ST 1801, MISB ST 0902, and MISB ST 1402. The recording system should include a loop recording component, an intelligent image processor, and a non-volatile long-term storage component with removable media. The loop recording component will receive synchronized imagery, audio, and augmented metadata from the EO/IR sensor (and the sensor image processing subsystems) in native resolution and framerate for a minimum of two hours (with a goal of 24 hours). The solution will select, capture, and sort video or SIP samples for compression, organization, and storage. The loop recorder and storage component, though distinct and separable, shall be designed for performance as a complete system. The intelligent image processor may form a distinct component or be distributed between the loop recorder and storage components as necessary.

Examples of events that would trigger automatic recording include suboptimal operation of an artificial intelligence/machine learning (AI/ML) subsystem, sensor degradation or failure, incidents at sea, detection of targets of interests or threats, and engagements. However, the solution will also include a capability for the operator to choose direct recording manually. The volatile storage component will automatically store and curate video and SIP samples with the corresponding metadata. In addition to automatic content curation, the storage component shall use the available storage efficiently to maximize the recording capacity with minimal operator input. Solutions may utilize adaptive compression, foveated imaging, bandwidth prioritization techniques, or other methods to control the quality of video compression so that semantically meaningful elements of the scene are encoded with the highest fidelity, while background elements are allocated fewer bits in the transmitted representation. The amount of compression applied to ROIs must be variable, ranging from no compression at all to full compression as applied to the entire image. The amount of compression applied to ROIs will be determined by presets, cues from the image processing subsystem, or dynamically determined by the recorder based on the metadata available. The efficiency of the storage component will be based on the size of the stored content compared to the original (uncompressed) video and SIP content selected for recording. The impact of image compression on ROIs should be minimal as determined by analysis with an image quality evaluator. The image quality evaluator shall be proposed as part of the solution.

The sensor subsystems that will provide the augmented metadata are currently in development and may include autonomous detection and tracking, aided target recognition, image fusion, turbulence mitigation, and super-resolution. These sensor subsystems are not considered part of the intelligent recorder system. For maximum utility, the intelligent recorder shall function in two distinct modes. The first mode is the operation of the loop recording component in real-time in conjunction with the intelligent image processor and long-term storage component. In this mode, the loop recorder acts as an interface and buffer (if buffering is needed). Alternately, the loop recorder shall operate separately and collect imagery for later ingestion by the intelligent image processor either by intermittent connection to the loop recorder or by physical transfer of removable storage media. In this way, one intelligent recorder system can service multiple imaging sensors (with multiple loop recorders). By extension, the intelligent recorder system should be compatible with previously recorded imagery data from other sources. Examples include image data from historical collections and imagery from systems that already include their own recording system. In this latter case, it is understood that the performance of the intelligent recorder system may not be optimal.

Prototypes developed under this effort are not intended for deployment and need not be hardened according to environmental shipboard standards. Size, weight, and power (SWaP) of the prototype are not constrained; however, the prototype is intended for benchtop use. The solution should be fundamentally scalable, but the prototype should include and demonstrate the capability to handle video from four input channels simultaneously. The Government cannot guarantee that recorded data or image processing algorithms can be made available, so the proposed approach should anticipate the need to capture imagery from representative sensors (visible and infrared) and process the data through simple algorithms that emulate the sensor image processing subsystems through the generation of additional metadata. In this way, the solution and the imaging data used to demonstrate it should remain unclassified. However, the solution should include no constraint or feature that precludes its use on classified systems. For example, the loop recorder and storage components should allow for future encryption of the storage media. Proprietary video or SIP file formats shall not be used.

Two prototype intelligent recording systems shall be delivered under the effort along with peripheral hardware and software necessary to offload the captured data, access it, examine it, and prepare it for permanent transfer and storage on a Government-owned network. User interface software shall also be delivered that enables efficient management of the system. This includes manual (operator directed) recording and SIP capture, search (time, location, source, keywords, and other metadata elements), and playback, and any editing tools, compression tools, and tools needed to manage settings (directly or remotely), file formats, and organization of the image library. At the conclusion of the effort, prototypes and peripherals will be delivered to Naval Surface Warfare Center (NSWC), Crane Division, Crane, Indiana.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DSS and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

All DoD Information Systems (IS) and Platform Information Technology (PIT) systems will be categorized in accordance with Committee on National Security Systems Instruction (CNSSI) 1253, implemented using a corresponding set of security controls from National Institute of Standards and Technology (NIST) Special Publication (SP) 800-53, and evaluated using assessment procedures from NIST SP 800-53A and DoD-specific (KS) (Information Assurance Technical Authority (IATA) Standards and Tools).

The Contractor shall support the Assessment and Authorization (A&A) of the system. The Contractor shall support the government's efforts to obtain an Authorization to Operate (ATO) in accordance with DoDI 8500.01 Cybersecurity, DoDI 8510.01 Risk Management Framework (RMF) for DoD Information Technology (IT), NIST SP 800-53, NAVSEA 9400.2-M (October 2016), and business rules set by the NAVSEA Echelon II and the Functional Authorizing Official (FAO). The Contractor shall design the tool to their proposed RMF Security Controls necessary to obtain A&A. The Contractor shall provide technical support and design material for RMF assessment and authorization in accordance with NAVSEA Instruction 9400.2-M by delivering OQE and documentation to support assessment and authorization package development.

Contractor Information Systems Security Requirements. The Contractor shall implement the security requirements set forth in the clause entitled DFARS 252.204-7012, "Safeguarding Covered Defense Information and Cyber Incident Reporting," and National Institute of Standards and Technology (NIST) Special Publication 800-171.

PHASE I: Develop a concept for an intelligent recorder system that meets the objectives stated in the Description. Define the video event identification methodology that triggers recording and demonstrate the feasibility of the concept in meeting the Navy's need. Analyze the effect on image quality and recorder performance from the techniques proposed for image compression and storage. Feasibility shall be demonstrated by a combination of analysis, modeling, and simulation as stated in the Description. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and demonstrate a prototype intelligent recorder system based on the results of Phase I. Demonstration of the intelligent recorder system shall be accomplished through production and test of a prototype in a representative (but protected) environment (for example, from a pier) or by use of raw collected imagery data and laboratory demonstration. At the conclusion of Phase II, two final prototypes along with the peripheral equipment and software necessary for their operation shall be delivered to NSWC Crane along with complete test data, updated specifications, interface documents, capabilities description, and sample image files (video and SIP) recorded by the prototypes.

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

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology for Government use. Develop deployable designs with specific interface and storage requirements. Harden the designs for shipboard use. Establish hardware and software configuration baselines, produce production-level documentation, and transition the intelligent recorder into production. Assist the Government in the integration of the intelligent recorder with deployed imaging sensor systems.
The technology resulting from this effort is anticipated to have broad military application. In addition, there are numerous law enforcement and security applications. Scientific applications include the recording of natural events such as wildlife behavior, weather, and astronomical observations.

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KEYWORDS: Intelligent Recorder; Machine Learning; Image Processing; Imaging Sensor; Video; Metadata

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N231-057 TITLE: Real-Time Training Heat and Load Monitoring Kits for Ground Forces

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Artificial Intelligence (AI)/Machine Learning (ML); Biotechnology; General Warfighting Requirements (GWR)

OBJECTIVE: Develop a Heat Illness Prevention System (HIPS) kit that provides technologies for real-time monitoring to prevent exertional heat illness in a training environment, at scale, for active-duty service members – specifically for Marine Corps and Army personnel.

DESCRIPTION: The U.S. Army Medical and Material Development Agency (USAMMDA), under the Health Readiness and Performance System (HRAPS) program of record has developed a suit of technologies and capabilities for use in a training environment. In addition, the U.S. Army Research Institute of Environmental Medicine (USAIRIEM) has developed several critical heat strain state algorithms that estimate core body temperature, heat illness risk, and predict heat stroke. Together, the HRAPS technologies and algorithms have been combined into a prototype heat illness prevention system. The HIPS has been used in a prototype form with Special Forces (Ranger Assessment and Selection Program – 75th Ranger Regiment) Sapper Leader Course (169th Engineers), and with regular trainees to include 198th Infantry Brigade (Ft. Benning), Maneuver Support Center of Excellence (MSCoE), and with the U.S. Marines – Marine Corps Recruiting Depot – Parris Island. While these prototypes are useful in the management and prevention of exertional heat illnesses in the training environment, they are comprised of separate technologies and do not scale to support the numbers for Marine Corps and Army training environments, requiring further science and technology to ensure that the technologies and algorithms support the scale needed.

The HIPS system is composed of core system capability with additional add on components. The key technical challenges require addressing the scale requirements provided below (threshold), and then the additional add on components (objective). The core system is comprised of an on-body sensor system and local phone status app.

On-Body Sensor System Requirements:

1) Human factors: Wearable with minimal comfort impact and functional for extended periods of time: Threshold is 4 days, Objective is 7 Days
    a) While we do not explicitly define size/weight requirements these will be constrained by the human factors and expected wear/function times.
2) Environment: 50+ ºC, fully immersible in water
3) Battery life: Threshold is 4 days, Objective is 7days
4) Communications: Bluetooth Low Energy (BLE)
5) Scalability: Ability to use on large Company size units simultaneously, e.g., 500 – 600 individuals
6) Gang charging systems to manage devices in at least multiples of 25
7) Sensors:
    a) Skin temperature (every 5s)
    b) Heart Rate Threshold is every 5s; Objective is ECG waveform
    c) 3 axis accelerometry
8) Must run Government Furnished algorithms in real time on the device to determine heat strain risk state:
    a) Estimated Core Body Temperature (ECTemp)
    b) Adaptive Physiological Strain Index (aPSI)
    c) Gait Instability Index (GInI) aka Wobble Index
    d) Heat Stroke Prediction Algorithm

   e) Exertional Heat Illness Alerting Algorithm (EHIAA)
9) Data logging capable of storing and downloading high resolution data from all sensors exceeding the battery life time
10) Must be manageable for Company size group by 1 or 2 staff members

Local Phone Applications (App):
1) Receive and display transmissions from the On-Body Sensor System: Android (Threshold), Android and Apple (Objective)
2) Display status for a defined set training Company personnel on individual tiles that represent the EHIAA algorithm and change colors based upon risk level
3) Tiles ordered by EHI risk level
4) Must have the ability to define sub-groups of personnel and display these sub-groups independently

Additional Capabilities (Objective):
If the Threshold requirements have been met, then the following Objective capabilities are desired.
1) Individual Smart Watch or Phone
   a) Provide individuals with their own display of their own data
   b) Alert to pre-set thresholds based upon EHIAA, aPSI, or ECTemp
   c) Ability to track geo-location
   d) Ability to transmit heat strain state and geolocation to a web-server application through cellular communications (Threshold) or other long-range means (Objective)
   e) Provide the ability to only transmit data that by itself does not constitute either personal identifiable information (PII) nor protected health information (PHI).
2) Web-application
   a) Display geo-location and heat strain state
   b) Allow different log-ins to provide independent events with their own view of participants

In addition, this effort requires the compilation of training materials and the ability to support training units in the issue and roll out of the HIPS monitoring system.

PHASE I: Develop a concept and prototype for a HIPS kit that provides technologies for real-time monitoring to prevent exertional heat illness in a training environment. Demonstrate the feasibility of the proposed concept (hardware/software HUD-centric system) to meet Marine Corps infantry needs through a set of specific Phase I deliverables. As part of Phase I the Government will provide at least one heat strain risk algorithm to support testing.

Deliverables specific to this SBIR topic (in addition to the standard Phase I deliverables identified in the DON instruction for this BAA) include: 1) an initial prototype kit; 2) documentation that kit components can achieve the request requirements listed in topic call; 3) concept of operations for how the kit will be employed by end users; and 4) human subjects testing plan for testing that will occur during Phase II. No Human Subjects Research can be conducted as part of Phase I.

PHASE II: Based on the results of Phase I deliverables evaluation, performers will develop a working proof-of-concept of the HIPS kit for the ground forces. This phase shall include prototyping the HIPS kit, conducting critical design reviews, and demonstrating that initial capabilities are sufficient for existing training environments. The prototypes will be evaluated to determine their capability to meet ground force needs and requirements for a heat monitoring system.

Deliverables include: 1) a final bill-of-materials (BOM); 2) all component parts and specs; and 3) proof of concept devices (at least 100) for evaluation.

Human Subjects Research is expected to be conducted as part of Phase II, but may be done in partnership with a Government lab as part of ongoing active-duty service member (e.g., Marine Corps or Army) research.

PHASE III DUAL USE APPLICATIONS: Support the Marine Corps and Army with transitioning and integrating the HIPS kits into existing training environments. Assist with certifying and qualifying the HIPS kits for Marine Corps and Army use. Assist in writing Marine Corps and Army device user manual(s) and system specifications/materials. As appropriate, focus on scaling up manufacturing capabilities and commercialization plans that will extend the technology to the civilian with a focus on athletic activities – e.g., collegiate, endurance races, etc.

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KEYWORDS: Infantry; Training; Heat; Safety; Monitoring, Wearables

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N231-058 TITLE: Alternate Lubrication Mechanisms for Small UAV and Attritable Weapon Systems

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR)

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

OBJECTIVE: Develop new and innovative lubricating fluid (oil, fuel, and/or grease) supply/delivery system technologies for rolling element bearings in small Unmanned Aerial Vehicle (UAV) engines and/or attritable/expendable weapon systems to replace current architectures–thereby reducing overall system weight, cost, complexity, and maintenance requirements/burden due to fluid leaks and lubricant shelf life during extended storage.

DESCRIPTION: While numerous efforts have been made into enabling oil-free technologies [Ref 1] and alternative bearings (including air [Ref 2] and magnetic bearings [Ref 3]), rolling element bearings utilizing fluid lubrication remain prevalent within U.S. Navy platforms. Fluid-lubricated rolling element bearings provide excellent load-carrying capacity, low friction operation, and damping properties when properly lubricated [Ref 4]. Novel delivery methods for lubricants could allow for realization of the advantages of rolling element bearings without the drawbacks of the supporting hardware typically required to provide lubrication supply [Ref 5].

Traditional flow-through and recirculating rolling element bearing lubrication systems which utilize pressurized oil and/or fuel require parts such as supply/scavenge pumps, reservoirs, sumps, plumbing/pipes, and seals, which can account for up to 30% of overall propulsion system weight, volume, and cost in small limited-life engines. In addition, the shelf-life limitations of lubricants used in these systems (such as oil, fuel-oil mixtures, grease) can lead to corrosion or increased maintenance actions during long-term storage. Innovative technologies which enable replacement of traditional lubrication schemes for small, limited-life engines and attritable weapon systems are being sought to reduce total system ownership cost.

It is recommended that the small business partner with a component or engine manufacturer, with aerospace experience in UAV and/or attritable systems, to increase potential of tech transition and future commercialization. Transition will require collaborating with small engine Original Equipment Manufacturers (OEMs) interested in drop-in replacements, modifying current designs, or incorporating new lubrication mechanisms within new engine designs.

PHASE I: Develop and subscale test a proof-of-concept mechanism which has potential to eliminate traditional lubrication schemes. Design approaches should demonstrate, through tribological experimentation, modeling, and/or subscale testing, the ability to prevent adverse surface deterioration such as overheating, galling, spalling or seizure ofrotating mechanical systems under relevant operating conditions for a representative UAV or attritable engine system architecture mission cycle. Relevant applications of interest include mechanical systems supporting ranges of 150-1500 lbs of equivalent load which can rotate anywhere between 15,000 to 75,0000 rpm at up to 250 degrees Fahrenheit for durations of 5 hours or greater depending on application.

PHASE II: Contractors are encouraged to collaborate with commercial OEM's for UAV and/or attritable engine systems for Phase II activities. Develop detailed design of the concept(s) developed in Phase I with a focus on development, design, and demonstration of a full-scale prototype UAV or attritable engine system utilizing the novel lubrication mechanism proposed. Validation testing should be performed under relevant engine operating conditions including loads, speeds, and temperatures expected for intended applications. Testing should provide comparison data against traditional fuel, oil, and/or grease lubricated architectures and assess the feasibility of the designed system to replace these architectures. A preliminary assessment shall be made of potential long-term storage benefits.

PHASE III DUAL USE APPLICATIONS: Continue to improve upon any deficiencies in the technology noted within Phase II. Analyze and test the manufacturability, ease of installation, and logistical burden of the lubrication method.

The commercial small UAV market is much larger than the military and would benefit equally from these technologies.

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KEYWORDS: Lubrication systems, rolling element bearings, mechanical systems, engines, small Unmanned Aerial Vehicle, UAV, attritable propulsion, fuel, oil, grease, long-term storage

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N231-059 TITLE: Orbital Angular Momentum (OAM) Laser Transformer

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR)

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

OBJECTIVE: Develop an Orbital Angular Momentum (OAM) mode transformer that spatially tailors light beams for high-power laser applications.

DESCRIPTION: Fiber lasers are well suited to a variety of Navy needs because they can create compact high-power sources through active gain regions kilometers long, have a large surface area for cooling, and exhibit high temperature and vibrational stability for extended lifetimes on moving platforms. These lasers have been primarily limited to infrared wavelengths between 1-2 microns, but recent advancements that selectively excite Orbital Angular Momentum (OAM) modes of light in multimode optical fibers have demonstrated power-scalable methods to efficiently extend fiber lasers across the visible band [Refs 1, 2]. Current multimode fiber methods lack a robust spatial mode conversion device both for use at the input of the fiber as well as to mode-convert the output back into a high beam-quality Gaussian-shaped beam.

This SBIR topic seeks the development of a small Size, Weight, Power and Cost (SWAP-C) mode transformation device that can receive multiple inputs from Gaussian-shaped beams of large-mode area (LMA) or conventional single-mode fibers (SMF) and convert them into desired OAM modes of a custom fiber [such as in reference 2 and 3]. The mode transformer must be fully pigtailed with at least two, preferably three, LMA/SMF input fibers carrying light at 1 micron, 1.5 microns and 2 microns wavelengths respectively, and the fiber at the output in which each input wavelength should be converted to a specified OAM mode of first radial order and angular order L, respectively. While any specific device would yield outputs at two specific OAM values of L (three preferred), the range of desired OAM values L may vary between ±5 and ±40, based on the application. Output mode purities in the output fiber (as measured by standard interferometric techniques such as [Refs 4, 5, or others] should exceed 10 dB (15 dB preferable) and overall device losses should be

An intermediate step towards device development may involve demonstrating OAM mode outputs in free space rather than in the output fiber, and for such proposals, it is important for the performer to provide quantitative metrics that connect the attributes of the free space mode with the one that would eventually be obtained in the output fiber. For instance, a proposed free-space demonstration would have to be much lower loss than 1 dB to account for subsequent coupling losses into the desired OAM mode of the output fiber. Performers are free to explore one or a combination of several promising small SWaP-C mode transformation technologies such as metasurfaces [Ref 6] multi-plane lightwave converters,[Ref 7] free-form optical setups, fiber-based [Ref 8] or 3D-written[Ref 9] photonic lanterns, or other suitable technology approaches not listed here. (Approaches relying on bulky devices such as spatial light modulators will not be considered competitive.)

PHASE I: Develop detailed simulations that could result in a fully designed optical system. The design should be capable of achieving the highest output OAM values within the loss, purity, and power-handling specifications mentioned above. Experimentally demonstrate low loss, high mode purity, and high power handling attribute of at least one (preferably all) component(s) within the designed system. It would suffice to demonstrate free-space modes at this juncture, though fiber would be available to further test performance if sufficient progress is made in program goals.

PHASE II: Deliver a compact device with two (three preferred) LMA/SMF pigtails, each carrying a different wavelength (1 micron, 1.5 microns, and 2 microns) at the input yielding three desired OAM modes in the output fiber (each wavelength input mapped to one specific OAM mode at the output). Demonstrate all performance metrics in the performers' facilities and delivery of one prototype device to the Government for testing. The specific OAM values L and the kind of fiber to be supplied will be subject to Government requirements during the execution of this phase.

PHASE III DUAL USE APPLICATIONS: Incorporate the mode transformer into a laser for use in a planned ONR Innovative Naval Prototype. Mode transformation technologies are already playing a critical role in several commercial applications such as super-resolution biological fluorescence microscopy, space-division multiplexed optical communications systems for a tremendous increase in optical fiber bandwidth, modalities for imaging, and all-optical machine learning and image processing. The technology developed in Phase II is expected to impact several such applications in addition to the Government's interests in developing high-power lasers at non-standard wavelengths.

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KEYWORDS: High power lasers; Orbital Angular Momentum; Mode transformations; Spatial beam shaping; Multimode fibers; metasurfaces; multiplane lightwave converters; 3D-written photonic lanterns

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N231-060 TITLE: Predictive Tool for Aging Effects on Performance of Phenolic-Based Thermal Protection Materials

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

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

OBJECTIVE: Develop an innovative approach for the prediction of performance vs. age of phenolic based composite thermal management materials such that the service life can be predicted.

DESCRIPTION: Carbon/phenolic materials are very effective in providing thermal protection to underlying substrates in high heat flux, short life applications such as Submarine-launched Ballistic Missile (SLBM) Reentry Body heatshields, missile nozzle skirts, and Vertical Launch System liners. However, it is suspected that the physical/chemical characteristics of phenolic materials change with age (since manufacture) and that these changes may affect the performance of these materials in applications with extended storage/service lives prior to use.

Performance of phenolic ablator materials in reentry and other Navy applications are evaluated with legacy ablation/decomposition codes such as CMA [Refs 4, 5], FIAT [Ref 6], or the more recent ICARUS [Ref 7]. These codes all operate with a single set of age = Zero physical, thermal, and chemical parameters for the base phenolic resin material. One key performance metric of the material is the back-side temperature rise at “time = t seconds” after exposure to “Heatflux = Q Btu/Ft2.in.hr” with “age = T years after manufacture/deployment”. Also of interest is the prediction of change in physical and mechanical properties with depth or other location parameters. Changes that would predict or give insight into activation of accelerated ablation mechanisms or surface roughness development are particularly useful. It is also highly desirable to integrate the predictive methodology into a current generation Thermal Management System ablative/decomposition code of the type developed from the Charring Material Ablator (CMA) legacy code [Refs 4, 5].

The goal of this SBIR topic is to develop models, parameters, and algorithms that predict changes in these base parameters with age or storage life and other environmental conditions, and to embed or integrate these models, parameters, and algorithms into a current generation CMA code. It is expected that models should be able to predict age related performance effects up to 60 years after manufacture. The ability to predict changes in surface removal rates and changes to in-depth ablation mechanisms by effects such as ply separations, ply-lift or “cobra” effects is highly desired. Accelerated aging methods have recently been evaluated in order to gain insight into potential aging mechanisms [Ref 8]. Models and tools developed in the subject effort should identify possible accelerated or artificial aging mechanisms. Identification of an accelerated aging method(s) and execution of the code/tool against an accelerated aged material will be a key aspect of code validation.

PHASE I: Seek to understand the phenolic aging phenomenon and identify basic aging mechanisms amenable to algorithm development. Identify a path forward for implementation of the algorithm(s) into one of the current or legacy CMA codes.

PHASE II: Further develop the algorithms and identify underlying material physical/chemical/thermal parameters that are affected by age. A predictive performance tool based on age shall be developed and validated. It is anticipated that this tool will be based on one of the current or legacy CMA codes. However, if not, an alternate approach that is amenable for an age T=0 baseline/initial design purpose as well as predictive performance at T=XX years must be proposed. Accelerated aging methods may be utilized but must be proven as activating the appropriate phenolic aging mechanisms. Samples of Navy aged and unaged (non-tactical) materials may be made available to Phase II awardees for this purpose. Identification of a non-destructive, or in-situ assessment technique to go along with the predictive tool development would also be of interest.
Demonstrate the predictive capability of the tool using contractor or Navy-supplied materials, an accelerated aging method, and laboratory or arc-jet ablation testing.

PHASE III DUAL USE APPLICATIONS: Phase III opportunity to perform predictive age assessments of current fielded hardware in conjunction with an ongoing surveillance program or predictive age assessments of new build hardware for new programs and development/execution of an appropriate sampling strategy.

Phenolic-based composite material thermal protection systems are used in commercial space applications and by NASA. These components will be subject to similar concerns with regard to performance after time in storage, or performance during planetary reentry after extended mission times.

The overall commercial product from this activity is expected to be a plug-in for a legacy code or a re-write of an existing decomposing ablator code taking advantage of current computer coding developments. This plug-in or code would be attractive to many Navy/DoD components, such as Navy Strategic Systems Programs (SSP), and Primes developing phenolic composite heatshields for future applications as well as NASA and commercial Access-to-Space entities. Such a code would also be of interest to current programs seeking to extend the service life of their in-service materials.

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KEYWORDS: Ablation, Phenolic, Aging Mechanisms, Composite Materials, Thermal Management Materials

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N231-061 TITLE: Verification of Intelligent Autonomous Systems Containing Artificial Intelligence Components

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Artificial Intelligence (AI)/Machine Learning (ML);Autonomy

OBJECTIVE: Develop a user-friendly toolbox of methods for verification of neural network and computer vision elements at both the individual component property level and at the system level for closed-loop intelligent autonomous systems. Methods should be automated and scalable to the greatest extent possible and assist the user in applying to complex autonomous systems in challenging naval environments.

DESCRIPTION: Neural Networks and related methods in Computer Vision are being considered for a wide range of future autonomous naval systems, including in roles that have some degree of safety, time, or mission criticality. A safety critical example would be the use of computer vision as a perceptual mechanism for aerial probe and drogue refueling. In this task, a tanker aircraft puts out a fuel hose with a stabilizing drogue that trails behind the aircraft. An intelligent autonomous air system would need to maneuver in close proximity to the tanker in order to safely attach a refueling probe to a coupler mechanism on the end of the hose and to maintain a safe relative position and state while making the transfer. A mission critical example would be an autonomous undersea system searching an area using sidescan sonar imagery and a color camera and using neural networks-based methods to identify the ocean bottom type, detect and classify objects of interest on the sea bottom, and determine their pose. A time critical example is autonomous navigation and semantic mapping of dynamic, coastal areas with low cost, expendable autonomous systems without GPS within a specific time window. In this case, neural network and computer vision methods could be used both in perception, reasoning, and in developing effective policies for discovering and identifying mission-relevant and area access-relevant relationships between geometry, mapping, objects, and entities.

The last five years has seen significant advances in methods for verification of correctness of neural network and computer vision more broadly at both individual component and systems level (e.g., Maribou, Verisig, Fast and Complete, Robustness Analyzer for Deep Neural Networks (ERAN), Neurify, Runtime Shielding, other reachability-based methods, etc.). These methods provide alternatives such as: (1) Transforming or approximating the Artificial Intelligence (AI) element into a symbolic abstraction that lends itself better to verification, guaranteeing properties or proving the absence of adversarial examples, (2) Making verification part of the learning process with the goal of directing the learning to have a set of desired properties that can be quantified during learning, or (3) Ensuring the desired global properties at a systems level, such as with run-time shielding, reward shaping, watchdog monitoring, barrier certificates, etc. to protect against outputs that would lead to the system entering an unsafe or otherwise undesirable state. The methods individually have different challenges in terms of (1) their ability to express in their model or scale to realistic-sized and scope naval problems, (2) the extent to which they can currently be automated sufficiently to be used routinely in practice (i.e., don't require the user to hand tailor their own proofs for each new application), (3) the degree to which they might overprescribe or constrain the design or implementation in overly conservative ways. Thus, there is a strong need for the creation of user friendly software toolboxes that make these methods more broadly accessible to a wide range of practicing engineers and computer scientists working on different naval intelligent autonomous systems problems.

PHASE I: Determine a planned set of methods and their functionalities that will be in the toolbox and develop an initial version with an initial limited set of methods with sufficient functionality to demonstrate feasibility and allow some limited experimentation and demonstration. Experiments with methods may be done with low-fidelity simulation elements to show their value on particular use cases. Simulation may include some limited-complexity environmental models, vehicle models, sensor models, and communications models, depending on what would be most suitable to examine the particular approach. Develop metrics to evaluate the system in Phase II.

PHASE II: Further refine the toolbox design and develop aversion with a broad set of methods that can extend to a greater range of autonomous control algorithm, mission, and environmental situations and system types in a more complex dynamic and unstructured environment. Experiment on naval use cases with a medium-fidelity simulation and sufficient autonomy components to conduct and report on experiments and comparison with benchmarks. If feasible, experiments may also be conducted with the use of inexpensive unmanned vehicles or other hardware. Experiments should include a focus on determining the sensitivity of the tool to a variety of factors. Revise evaluation metrics as necessary.

PHASE III DUAL USE APPLICATIONS: Develop more user-friendly version of the toolbox with expanded functionality and sufficient support to be usable by a broad range of engineers and computer scientists in support of areas such as Unmanned Air Systems (UAS), Autonomous Undersea Vehicles (AUV), Unmanned Sea Surface Vehicles, (USSV), autonomous cars, and ground and industrial robotics.

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KEYWORDS: Neural Networks, Computer Vision, Verification, Autonomous Control, Intelligent Autonomy, Verification and Validation

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N231-062 TITLE: High Power Microwave (HPM) Solid State Amplifier Topologies

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

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

OBJECTIVE: Develop a radio frequency (RF) Solid State Power Amplifier (SSPA) topology specific to high power microwave (HPM) applications for use either as a stand-alone source or in an array, capable of generating a variety of waveforms while exploring the trade-off between power and bandwidth. Proposed solutions could cover pulse widths ranging from nanosecond to microseconds. Frequency interests span L, S, C, and X band SSPA topologies.

DESCRIPTION: Commercially available solid state RF power amplifiers (PAs) are designed to meet the widest breadth of application and primary market needs. This involves a tradeoff between power, duty factor, efficiency, cooling requirements, lifetime, and band width. Potential consequences of this tradeoff are connector loss, higher than necessary parasitics, poor volumetric power density, and very low or high instantaneous bandwidth.

A PA topology optimized for HPM applications would first optimize power coupled to a radiated antenna while maintaining the best possible values for other characteristic parameters. Thus, the goal of this SBIR topic is to consider design tradeoffs associated with maximizing power. A possible approach might be to sacrifice linearity to maximize power. Harmonic generation is of less importance as long as the total energy consumed by harmonics is less than 10% of the total output power. Noise figure is not important as long as total noise power is not a significant fraction of power out. What are the tradeoffs involved with PA input/output and source/ load impedances (determined by stability and power/efficiency requirements) on maximizing power out? While efficiency, duty factor, and lifetime are ultimately important for HPM applications, it is likely that they are not as severe as the requirements levied by most Commercial-off-the-Shelf (COTS) applications. The goal of this SBIR topic is to develop a new amplifier topology, suitable for HPM applications, that will be built and tested, informed by all the tradeoffs discussed above.

Since this SBIR topic is examining solid state amplifier for both stand alone and array concepts, the tradeoff between maximizing power out and minimizing jitter and phase noise is also of interest. Instantaneous bandwidth is at the discretion of the proposer. Two possible realizations are of interest: First, a very narrow but tunable instantaneous bandwidth for single or swept frequency applications. Second a very wide instantaneous bandwidth for extremely short pulses or multiple simultaneous frequencies. Both may be applicable to frequency hopping applications. The tuning time for the center frequency of the narrow instantaneous bandwidth systems should be at or better than state-of-the-art. The wide instantaneous bandwidth system should have a minimum bandwidth of 1 GHz. It is also desirable to be able to tune the center frequency of the wide band system.

While modifications of existing power amplifier class types are acceptable, new amplifier class types and/or die level design, specific to HPM amplifier needs, are also acceptable for consideration.

Key Performance Metrics/Goals:
The performance goals listed below define the outer edge of the desired outcome and are shown as an example specific to a nominal 2GHz center frequency; however, areas of interest span L, S, C, and X band SSPA topologies, which are encouraged. It is not expected that the topologies will meet all the design criteria. The topology's ability to meet the performance characteristics should be shown on a radar chart, and will be judged based on how many of the performance parameters are met and what/how tradeoffs are made to achieve those parameters.

1. Saturated power out: 5 kw at 2 GHz
2. Volumetric power density: should be at least 2x better than the COTS equivalent
3. Narrow instantaneous bandwidth tuning: at or better than state-of-the-art for both speed and frequency span
4. Wideband bandwidth: greater than 1 GHz
5. Harmonic generation: less than 10% of total output power
6. Duty cycle: greater than 50%
7. Power Added Efficiency: greater than 70%
8. Output impedance: 45 to 55 ohms

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DCSA and ONR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

PHASE I: Conduct a feasibility study via simulation to assess the art-of-the-possible that balances the tradeoffs specified in the Description section. The feasibility study should investigate all known options that meet or exceed the minimum performance parameters suggested in the Description. The study should also address the tradeoffs and risks, in accordance with the level of innovation. Prepare a report to ONR on designs, simulations, and a Phase II testing plan.

PHASE II: Develop scaled operational prototypes that demonstrate the concept(s) determined to be most feasible from the Phase I study. Provide an amplifier prototype; a report containing designs and testing results; and a Phase III plan for prototype evaluation.

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

PHASE III DUAL USE APPLICATIONS: The prototype amplifiers will be incorporated into stand-alone HPM systems. Demonstrate amplifier lifetime operating into a matched load. Deliver an amplifier prototype and report containing designs and testing data. Detailed mission descriptions and effectiveness requirements will be addressed at a higher level of classification.

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KEYWORDS: High Power Microwaves, solid state, amplifiers, High Power Microwave, HPM, Solid State Power Amplifier, SSPA, radio frequency, RF

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N231-063 TITLE: Additive Manufacturing for Graded-Index Lens Apertures

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): 5G; Networked C3

OBJECTIVE: Develop methods for additive manufacturing (AM) of dielectric materials with structurally varying densities, using a wider variety of materials to achieve a larger range of effective dielectric constants. Methods may include AM source materials with a higher natural dielectric constant, multiple different source materials, heterogeneous integration with planar printed circuit board or other antenna structures, or selective metallization patterning on AM dielectric structures, with the goal of higher performance, more compact lens and filtering components.

DESCRIPTION: AM of dielectrics and metals is a promising area for novel microwave and millimeter-wave components. As with other AM areas, it enables rapid iteration of antenna designs and components that would otherwise require significant time-consuming manufacturing steps. In some cases, such as graded-index (GRIN) lens structures, AM is the only way to achieve a particular design that subtractive methods cannot.

GRIN lens structures require a spatially varying index of refraction. A classic example is the Luneburg lens, which is ideally a sphere with a continuously increasing dielectric constant toward the center. This causes incident plane waves to focus down on the opposite side of the lens, which is often used to implement a high-gain antenna or a retrodirective radar cross-section (RCS) enhancement. Previous methods of producing a Luneburg lens relied on creating multiple concentric shells, each with a discrete dielectric constant. This produces a step-wise approximation of the ideal gradient index profile, and while a Luneburg lens with fewer shells is easier to produce, the beam sidelobes and aperture efficiency suffer when used as an antenna. A sliced Luneburg lens structure using punctured dielectrics to tailor the effective dielectric can more closely emulate the desired Luneburg lens profile [Ref 1].

Another downside of Luneburg lens structures is that they are bulky and protrude from the surface where they are installed. Planar GRIN lenses are better suited to conformal antenna applications and can still provide some degree of focusing. These designs are created using transformation optics to morph a Luneburg lens dielectric gradient into a planar design [Ref 2]. This requires significantly higher peak dielectric constant values to achieve focusing over a thinner, planar volume.

To reach these higher peak dielectric constants, planar GRIN lens structures can be fabricated using multiple slices of different circuit board laminate materials typically available for planar microwave circuits, similar to Rondineau et. al. [Ref 1]. These materials are available with adequate peak dielectric constants for planar GRIN designs. To achieve an effective dielectric constant, sheets are drilled out with specific hole patterns to remove material, such that certain frequencies see a lower effective dielectric constant if the wavelength is somewhat larger than the feature size.

Planar GRIN designs using punctured printed circuit layers have a few drawbacks, which include the significant number of drill holes required per layer and the number of layers. This increases the cost of a planar GRIN aperture designed using traditional planar printed circuit board (PCB) methods. Additionally, improving the operating frequency range requires additional layers to ensure good impedance matching. The planar design itself results in non-ideal focusing over the outer edges, leading to reduced aperture efficiency without additional corrective elements [Ref 3].

To produce novel lens designs quickly, new materials are becoming available that allow for the creation via AM of low-loss dielectric structures using photoresins. These allow for smaller feature sizes compared to other AM methods and potentially faster build speeds when batch printing. The Navy is seeking methods of designing and producing planar GRIN lenses that leverage these new materials, or a hybrid combination of these materials with other methods for developing microwave/mm-wave lensing and antenna structures, that can operate over large bandwidths and challenging environmental conditions.

PHASE I: Design and test GRIN lens structures that can conform to a flat outer profile, using a heterogeneous combination of ceramic photopolymer resins, other photopolymer dielectrics, and planar laminate dielectrics if needed to cover higher peak dielectric constants. Test apertures should cover all of K-band, with a scan loss exponent less than 4, peak sidelobes no more than 20-dB down from peak gain when steered at boresight, and no more than 15 dB when scanned to 50° off boresight. Other design objectives should focus on: minimizing weight of the lens, preferably below one pound or otherwise suitable for a large Group 1 or small Group 2 Unmanned Aerial System (UAS); maximizing aperture efficiency with a desired efficiency greater than 50%; increasing the bandwidth and highest frequency; and reducing the overall thickness of the lens between the outer conformal profile and the feed layer.

PHASE II: Design and test GRIN lens structures that can conform to a curving profile such as the fuselage of a small Group 2 UAS using a heterogeneous combination of ceramic photopolymer resins, other photopolymer dielectrics, planar laminate dielectrics if needed to cover higher peak dielectric constants, and metalized structures that aid in tailoring the operating frequency or required thickness of the aperture. Test apertures shall cover at least a 10-to-1 bandwidth with an objective of covering 2-40 GHz. Test apertures shall exhibit a scan loss exponent less than 2.5, peak sidelobes no more than 20-dB down from peak gain when steered at boresight, and no more than 15 dB when scanned to 50° off boresight. Other design objectives should focus on: minimizing weight of the lens; minimizing dielectric and other efficiency losses; improving thermal properties of the structure when supporting microwave power up to 10 kW; reducing the overall thickness of the lens between the outer conformal profile and the feed layer; minimizing production costs; and any potential performance or material issues that might arise in Naval maritime environments.

PHASE III DUAL USE APPLICATIONS: Design, build, and assist the Navy with integrating a set of broadband planar GRIN-lens apertures for a Naval communications, radar, or electronic surveillance application, which has similar specifications as the test components built up in Phase II. The effort will also focus on translating the design principles of these apertures to beamforming for terrestrial 5/6G or space-based communications.

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KEYWORDS: Antennas; graded-index lens; GRIN; additive manufacturing

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N231-064 TITLE: Reversible Replenishment Air Conditioning System

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR)

OBJECTIVE: Develop compact and energy efficient technologies to reduce the latent loads of outside air entering the ship during the summer while providing heat during the winter.

DESCRIPTION: The heating, ventilation, and air conditioning (HVAC) system is critical to the functionality of the ship's combat and damage control systems, in addition to ensuring the comfort and health of the crew. Navy ships operate in salt-latent humid environments. Latent loads from outside air, or replenishment air, entering the ship typically represents 10 to 20% of the total cooling load during the summer, while sensible heating from heaters during the winter season creates a significant electrical demand. Evolving battle-space doctrine, emphasizing operations in both the littoral and arctic, as well as changing climate conditions, are further increasing these loads. Technologies are sought to condition the outside air entering the ship to reduce the air conditioning latent load and improve system efficiency. Compact, non-hazardous, and efficient solutions are desired which minimize airside pressure loss while reducing size, weight, and electrical power consumption of the shipboard HVAC systems.

In a typical system, weather air enters the ship through a wire-mesh screen prior to entering a moisture separator or a vertical lift in ductwork, followed by a preheater directly upstream of a vane axial fan, which supplies the various shipboard spaces with fresh air. Typical air velocities through this ventilation system ranges from 1500 to 2500 feet per minute. The weather air is supplied to various recirculation systems, where it mixes with return air, prior to entering a filter directly upstream of the chilled water cooling coils, which provides sensible and latent cooling when applicable. Exhaust systems balance replenishment air but typically exhaust warm and often very humid air from spaces like laundry, scullery, showers, toilet areas, electronic cabinets, and flammable storage lockers. Design temperature for outside weather air during the summer is 90 degrees Fahrenheit (°F) and 10°F during the winter. The design relative humidity during the summer condition is 69%. Preheaters typical heat the air during winter conditions from 10°F to between 45°F and 55°F. Moisture entrainment within the airstream is not desirable and moisture should be disposed of by an appropriate drainage systems.

PHASE I: Develop an innovative, compact, and energy efficient approach to reduce air conditioning latent loads and power consumption associated with bringing outside air into the ship. The air-side pressure drop should be minimized and not exceed 1 inch of water gauge. Validate design performance through analytical modeling or subscale demonstration of components as appropriate.

PHASE II: Demonstrate a working prototype of the system sized for an airflow of 2000 cubic feet per minute device sized for 10-tons of cooling when exposed to design summer conditions and 30 kilowatts of heat when exposed to design winter conditions. Experimentally validate the unit's performance over a variety of flow rates and inlet dry-bulb and wet-bulb temperatures at and between design routines. Complete a cost analysis of concepts established to ensure the selected technology is competitive with current approaches.

PHASE III DUAL USE APPLICATIONS: Optimize the concept design for manufacturability, performance and military requirements using the knowledge gained during Phases I and II. Improve the effectiveness of the shipboard HVAC system to reduce size, weight, and power of military and commercial HVAC systems as well as other specialized thermal management systems.

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KEYWORDS: thermal management; air-conditioning; dehumidification; heating; energy efficiency

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N231-065 TITLE: Metamaterial Enhanced Micromirror Surfaces (MEMMS) for Enhanced Infrared Beam Control

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

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

OBJECTIVE: Develop, optimize, and demonstrate fast, frequency-agile, stimuli-responsive, and tunable micromirror surfaces that autonomously protect sensors from damaging optical beams, while allowing unobstructed transmission of non-damaging wavelengths and intensities in the 3-5 μm band.

DESCRIPTION: Digital micromirrors (DMDs, like those from Texas Instruments) are a well-established commercial technology that is routinely used in projection systems and could be incorporated into an adaptive imaging system to detect and steer harmful light or heat sources away from sensitive imaging equipment. While their high switching speeds (up to 12.5 kHz) and wavelength agnostic deflection are advantages, many enhancements could be made. Creating an enhanced surface that outperforms current micromirrors (e.g., faster, more compact, higher reflection, tunable open/close) through new processing techniques, new shape memory alloys [Ref 15] or incorporation of metamaterials. Showing how cooperative approaches can enhance micromirrors is the goal of this SBIR topic.

The ability to control strong light-matter interaction in liquid crystals [Ref 1], metamaterials [Refs 2-5], epsilon-near-zero (ENZ) materials [Refs 6,7], phase change materials (PCMs) [Refs 8,9], micro-electromechanical systems (MEMS) [Ref 10], and soft materials [Refs 11-14] suggest that these state-of-the-art materials systems can be leveraged to create smart surfaces that autonomously respond to bright sources in a scene. For example, spatial light modulation (SLM) by metamaterials, holography, and liquid crystals enables selective-area light attenuation [Refs 1,2]. Digital metamaterials offer lenses and phase modulators capable of light redirection and beam steering [Refs 3,4]. Non-linear optical responses in Bragg reflector stacks and ENZ materials provide another potential route to autonomous light attenuation [Refs 5-7]. Integrating these concepts with PCMs, MEMS, and micro-mirrors may reveal new opportunities and platforms for programmable SLM and beam steering [Refs 8-10]. Finally, soft materials like liquid crystal elastomers and photo-responsive hydrogels have recently emerged as new platforms for autonomous manipulation of light [Refs 11-14], offering new abilities to create nano/microstructures that move in response to light and platforms for trapping and guiding laser beams. New capabilities in nano-/microfabrication may enable new, hierarchical approaches that combine multiple stimuli-responsive materials and architectures to further enhance adaptability.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DCSA and ONR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

PHASE I: Design a surface utilizing a micromirror array capable of autonomously deflecting mid-wave infrared light. Surface can utilize other materials to enhance the micromirror or overall performance. Model performance enhancement over existing mid-wave infrared (MWIR) deflecting surfaces through:

- Novel micromirror designs(e.g., NiTi bimorphs) (Objective/Threshold: include at least 1 cooperative approach)- Faster actuation speeds (Threshold> 1 ms response time; Objective: >1 ns response time)
- Higher transmission across 3-5 µm (Threshold
- Higher blocking across 3-5 µm waveband (Threshold: > OD 4; Objective: > OD6)

Discuss tradeoffs of design in meeting these requirements and discuss implementation into a MWIR imaging system and any limitations. Demonstrate key component validation of the overall model design.

PHASE II: Based on Phase I modeling and proofs of concept, fabricate, test, and demonstrate at least one operational MEMMS filter prototype that is appropriate for implementation into existing and/or future Navy imaging systems. The prototype should be capable of autonomous optical responses with sub-ns response times. The MEMMS filters should reversibly cycle over 10^5 times without suffering more than 2% degradation in response time, OD change, reflection, transmission, dormant state/position, etc. Using a detailed analysis of system trades and input from appropriate stakeholders, propose a pathway to refine and integrate the MEMMS filter prototype with a candidate imaging system of interest to or used by the Navy or the Army. Depending on the target imaging system, the MEMMS filters should increase the total size, weight, power and cost (SWaP-C) burden by 0.1% or less, should not adversely impact imaging performance, and should allow normal imaging modality over typical ranges of brightness/lighting conditions; more specifically, MEMMS filters under normal imaging conditions should not change the system's modulation transfer function by more than 10%.

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

PHASE III DUAL USE APPLICATIONS: Transition the newly developed MEMMS filter technology to commercial availability through the prime contractors that build these imaging systems, the original equipment manufacturers that manufacture sensing components, other relevant optical and photonic suppliers, and/or other partnering agreement(s), as appropriate. Commercialization of this technology may occur via the incorporation of one or more MEMMS filters anywhere in an imaging system (e.g., windows, lenses, shutters, FPA pixels, etc.).

Ideally, deliver a capability upgrade for a relevant Navy Program of Record at the end of Phase III in the form of an imaging system that autonomously responds with no added cognitive burden to the user, and a minimum added SWaP-C burden.

Expected dual-use applications include autonomous vehicles, LiDAR, border security, astronomy telescopes (protecting radiation damage during imaging) and protecting civilian optical imaging systems (e.g., thermal imaging of the sun).

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KEYWORDS: Micromirror; micro-electromechanical systems; MEMS; Metamaterials; phase-change materials; dynamic filters; mid-wave infrared; MWIR; spatial light modulation; focal plane array; FPA

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N231-066 TITLE: Radiative Transfer Software Suite for Targeted Remote Sensing

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Artificial Intelligence (AI)/Machine Learning (ML); General Warfighting Requirements (GWR); Space

OBJECTIVE: Develop and demonstrate a software system that unifies high resolution radiative transfer modeling from the UV, optical, infrared, microwave, and radio wavelengths with a database of physical earth system radiative spectra properties (including emission, absorption, transmission, reflection, and scattering) to inform a software package that supports purpose-driven remote sensing sensor selection and algorithmic development.

DESCRIPTION: With expanded proliferation of remote sensing tools, especially from satellite orbit, there is a greater variation of wavelengths observed with differing physical signals that result in non-uniform interpretation of phenomena. Specifically for sensing of the earth system environment, properties of all the constituents of the land, water, atmosphere, and space environment have unique properties in the EM spectrum. There are currently no consolidated capabilities to interrogate multiple/mixed physical environments and their characteristics toward developing and optimizing remote sensing observation. This SBIR topic aims to provide that holistic capability to understand comparative observing characteristics of environmental signals, focusing on two specific use cases: (1) developing new hardware capability to optimally and generically observe desired environmental features (for example, determining the top three frequencies to maximally differentiate cloud water, snow over land, and glaciated ice); and (2) given legacy algorithms that leverage specific observing frequencies and bandwidths, optimally re-deriving those algorithms using the spectral characteristics of a new set of observing frequencies (e.g., porting products developed from one satellite constellation to another). While radiative transfer technology is relatively mature, much of the focus of this effort will be the identification, compilation, and characterization of the physical spectra database and the software implementation for straightforward model and simulation for a purpose-driven target enhancement and background minimization.

PHASE I: Demonstrate the technical capability to leverage a radiative transfer model (such as RRTMG, CRTM, or other related tool suite) and a set of selected physical radiative spectra characteristics in a software suite to model multiple use case scenarios. Clearly scope the full range of possible environmental characteristics in a possible physical database (including, but not limited to, oceanic states, atmospheric water/particles/chemistry/thermodynamics from troposphere through thermosphere and ionosphere, land surface characteristics, and sea ice). Identify methodological details needed to run radiative transfer modeling and calculate different use scenarios (such as algorithmic porting, new sensor development, model and simulation for extrapolated new frequencies, etc.), highlighting automated steps from user-defined entries in a man-in-the-loop system. Develop a final summary report, including literature review and overall conclusions and recommendations, to be presented at the end of this Phase. Develop a Phase II plan.

PHASE II: Conduct expanded technical development and validation of a robust prototype system for end-to-end modeling and simulation of radiative transfer characteristics of the earth system. Largely focus on the development and validation of the database on physical radiative characteristics and the software maturation, focusing on two specific use cases: (1) developing new hardware capability to optimally observe desired environmental features (for example, determining the top three frequencies to maximally differentiate cloud water, snow over land, and glaciated ice. This is only a display example, not a requested solution.); and (2) given legacy algorithms that leverage specific observing frequencies and bandwidths, optimally re-deriving those algorithms using the spectral characteristics of a new set of observing frequencies (for example, porting the “dynamic enhancement with background reduction algorithm (DEBRA)" from MeteoSat to Himawari. This is only a display example, not a requested solution.). The demonstration software package will include a fully connected radiative transfer model, complete physical radiative spectra database as outlined in Phase I, and will be compatible with running from open source python data analysis libraries. Delivery of the prototype software package and final verification report is expected at the end of this Phase.

PHASE III DUAL USE APPLICATIONS: A prototype software suite that provides generic capability to interrogate radiation spectra characteristics for different phenomena has potentially wide use cases, both within the earth science community and beyond. In addition to a more robust validation and verification of the software capabilities, Phase III efforts include expansion of frequency spectra for the radiative transfer, developing an expanded emissivity database for broader use case and material scenarios (potentially for higher resolution surface characteristics), and refinement/optimization of software usage. Developers of remote sensing tools and software engineers refining algorithmic uses, especially for the earth system environment in this instantiation, will have immediate ability to leverage this work for their efforts. More broadly, satellite, aircraft, ship-based, and land-based remote sensing all need information on observed physical phenomena to properly calibrate their sensor and develop downstream applications. Use cases span DoD, civil, and private sectors. Should this demonstration provide comprehensive capability for the meteorological use case, this methodology could be ported to use cases beyond the environment where radiative spectra database development would be useful.

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KEYWORDS: Radiative Transfer; Background; Emission; Atmospheric Science; satellite; satellite based environmental monitoring; remote sensing; spectral analysis

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N231-067 TITLE: Cognitive Tactics, Techniques and Procedures (TTP) Synthesis

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Artificial Intelligence (AI)/Machine Learning (ML); Autonomy

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

OBJECTIVE: Synthesize Artificial Intelligent (AI)-generated Electronic Support (ES) and Electronic Attack (EA) Tactics, Techniques and Procedures (TTPs) in near real-time against known legacy or unknown/complex sensor waveforms using online and unsupervised Machine Learning Algorithms (MLAs) based on real-time collaborative Tactical Situational Awareness and mission objectives for Size, Weight, and Power (SWaP)-constrained unmanned and/or manned naval platforms.

DESCRIPTION: Research will develop AI-generated, machine actionable ES and EA TTPs in near real-time using online and unsupervised MLAs based on all-available information and multi-modality data present in the Electromagnetic (EM) Spectrum for a single platform & across multiple collaborative Manned/Unmanned naval platforms. Capabilities being developed include:

- Self and collaborative real-time tactical situational assessment and predicted TTP needs against current and anticipated (near and far-term) adversary Intelligence, Surveillance, Reconnaissance and Targeting (ISRT) systems and associated kill chains to achieve mission objectives using game theoretic algorithms and machine learning enhanced micro-simulations.
- Multi-dimensional stochastic analysis for rapid AI-decision making for supporting near-term tactical objectives and long-term strategic goals.
- Autonomously-generated and machine deployable TTP source-code, testing and implementation that is reacting within an adversary's sensor Coherent Processing Interval (CPI), and continues adapting and refining the newly formed TTP based on subsequent observations.
- Automated deployment of AI-derived and tested TTPs between collaborative platforms to support current and future engagements that permits continued adaptation and refinement of the TTP from a collaboration perspective.

This approach extends beyond traditional library look-up solutions that are typically pre-loaded in an on-board Mission Data File (MDF). This research and development activity is envisioned to initially augment , and eventually replace, traditional Electronic Support Measures (ESM) techniques libraries/databases while reducing offline human-derived TTP development, analysis, and testing timeline by orders of magnitude.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, to perform on advanced phases of this contract as set forth by DCSA and ONR to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

PHASE I: Define, develop, and deliver algorithm designs, architectures, flow diagrams, and processes that clearly articulates how the program's objectives and capabilities will be achieved and implemented into research-level or prototype code during Phase II activities.

PHASE II: Develop, document, demonstrate, and deliver research-level or prototype code, libraries, executables, and necessary software artifacts that successfully achieves the program's objectives and capabilities as defined in Phase I. A Subsequent Phase II award would further mature, demonstrate, validate, and deliver research-level or prototype code, libraries, executables, and necessary software artifacts to support accelerated transition to the Program-of-Record.

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

PHASE III DUAL USE APPLICATIONS: Integrate the Phase II developed software with an on-board flight computer and Electronic Warfare systems, flight test the completed prototype system in a tactically-relevant environment, and integrate into a future FNC program for transition to a naval unmanned, and/or manned airborne platform.

Work products and deliverables are expected to be classified.

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KEYWORDS: Autonomous Tactical TTP Generation; Tactics, Techniques and Procedures; Online, Unsupervised Machine Learning; Automated Model Generation; Compressed Model Representation; Real-Time Analytics; SWaP-Constrained Platform Processing; Data Compression; Automa

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N231-068 TITLE: Cryogenic Solid-State Thermal Energy Storage

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR)

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

OBJECTIVE: Develop a cryogenic temperature retaining material that can maintain its cryogenic temperature for a time period of 2-4 hours without substantially increasing the final system weight.

DESCRIPTION: The U.S. Navy has been investigating the use of high-temperature superconductors for nearly four decades. A key aspect of the superconducting system is the need to keep the conductor at a cryogenic temperature. Typically a cryocooler is a major component of the overall superconducting system; however, certain applications may limit the use of an active cryocooler. There may also be times when a cryocooler may not have power, such as when the ship pulls into port and generators are powered down when switching to shore power. This SBIR topic seeks a material that can retain the cryogenic temperature in the superconducting system for a given time to either; operate without active cooling once the operational temperature is achieved; or if there is a loss of power to the cryocooler and the system still needs to remain operational for a given amount of time.

One solution to this problem is to increase the overall thermal mass by adding large amounts of conventional solid materials, such as copper. While doing so guarantees the system will take longer to warm up, the entire system quickly becomes too heavy to effectively deploy. Additionally, materials exist which can maintain a particular temperature for a short amount of time by utilizing latent heat during phase change; however, they are not tuned for such extreme temperatures and typically transition at least one phase of matter. Such technologies have given rise to freezer packs used to keep food frozen while not in a freezer.

Previous research attempts utilized a block of solid nitrogen capitalizing on the latent heat of vaporization. The expansion and sealing at gas phase were problematic. The large expansion ratio between nitrogen gas and solid resulted in a nitrogen supply of several hundred times the volume of the desired solid. Given the asphyxiation hazard associated with gaseous nitrogen in an enclosed environment, liquid and solid nitrogen are not currently used on naval platforms as cryogens, and such a solution is not desirable for this topic.

Alternatively, water has also been discussed as potential thermal phase change material. Unlike nitrogen, it does not expand as it heats up, but instead expands upon freezing by approximately 9%. Given the vacuum sealed nature of superconducting system, this expansion, coupled with the non-compressible nature of water, can potentially result in system damage if the expansion is not properly accounted for. Certain materials undergo solid-solid phase change, and others have such low expansion ratios upon phase change that they can be encapsulated without concern of system damage. This makes such technologies a more attractive alternate for naval use.

The topic seeks to develop a fully encapsulated material with negligible expansion, or a solid material that can retain the operational temperature of 30 K on the order of 2-4 hours, without increasing the total system weight by more than 10%; (i.e., if the superconducting system mass is 5000 kg, the total mass of the thermal energy system (including auxiliary hardware) must remain below 500 kg). The volume of the system must also be balanced with the weight restrictions. The solution must retain 30 K with a 100 W heat load for at least 2 hrs. Longer timelines or higher heat loads are more desirable. The solution must be stable not only at 30 K but also at 313.7 K (elevated room temperature), and it must withstand the thermal shock of cooling down from 313.7 K to 30 K. The solution must remain viable for over 10,000 cool-down/warm-up duty cycles. Lastly, the solution must be affordable to the Navy for implementation into a superconducting system and should be as low-cost as possible.

PHASE I: Conduct a feasibility analysis of the technological ability to meet desired performance specifications. Demonstrate the design and manufacturing concepts through modeling, analysis, and benchtop testing. Identification of size, weight, nominal performance, performance at cryogenic temperatures, and warm-up times shall be documented. Upon a feasible solution the awardee, shall perform a cost estimate, for both prototype development and full-scale production. The Phase I Option, if exercised, includes a detailed design and specifications to build a prototype during a Phase II effort.

PHASE II: Develop, design, and fabricate a functional prototype of a cryogenic phase change material for temperature retention. Commence with characterization of key performance metrics at the awardee's facility or other suitable test center identified by the offeror. Provide a warm-up time of the solution under various heat loads that may be experienced by a cryogenic system. Deliver the Phase II prototype to the Navy for further testing. Submit all maintenance and integration relevant designs and drawings of tested solution in addition to any updated designs, design changes, and related drawings that result from lessons learned discovered during prototyping. For material based solutions full Safety Data Sheets shall be required.

PHASE III DUAL USE APPLICATIONS: If successful demonstration of the technology is achieved, the transition of the development will lead to the sustainability of a superconducting system if there is a failure of the cryogenic refrigerator, or if there is no cryogenic refrigeration system available for a short time. This will enhance Fleet readiness when deploying superconducting systems in the Fleet. There are several superconducting systems that are currently being transitioned to the Fleet and this technology may be implemented in future upgrades to those systems, or in superconducting systems currently in development.

Additional use of this technology in the commercial sector may be implemented in superconducting systems being developed for the wind power generation market, resilient power grid, superconducting propulsion for aviation, and/or existing medical devices such as MRIs.

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KEYWORDS: Cryogenic Temperature Retention; Phase Change Material; Superconducting Systems; Energy Storage

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N231-069 TITLE: High-Rate, Reduced Life Cycle Cost Airframe

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Autonomy;General Warfighting Requirements (GWR)

OBJECTIVE: Develop technologies in the areas of 1) structural concepts, 2) design and analysis methods, 3) materials and processes (M&P), and 4) manufacturing that enable lightweight airframes with reduced total life cycles cost while being compatible with high-rate production.

DESCRIPTION: To enable successful manned-unmanned teaming (MUM-T)-based Concept of Operations (CONOPS), a sufficient number of Unmanned Aerial Vehicles (UAVs) must operate with manned assets. This requires that the total life cycle cost of UAVs must be much lower than that of the manned assets such that enough quantities can be acquired and operated. Here, the total life cycle cost is defined as the non-recurring development cost (engineering, tooling, capital equipment, etc.), recurring production cost, and sustainment cost. As important, those quantities of UAVs must be acquired in a relevant time period—i.e., a higher production rate than current state of the art must be achieved. Moreover, both goals—reduced life cycle cost and high production rate—must be achieved without excessive loss in structural efficiency (i.e., weight) and aerodynamic efficiency (i.e., geometric/assembly tolerances).

In order to address these three constraints—i.e., reduced life cycle cost, high production rate, and maintenance of relevant efficiencies—this SBIR topic seeks solutions in the following areas. The proposal should address both approaches but may emphasize one over the other:

DESIGN AND ANALYSIS METHODS:
The cost and time of engineering development of a new airframe is dependent on the chosen structural concepts and the methods and tools to design and optimally size them. However, in meeting the cost and schedule goals, the structural efficiency must be maintained to some level. Hence, cost, schedule, and performance goals can be met with automation in design, analysis, and optimization methods. Examples include:

- Tools and methods to reduce the nonrecurring cost of development of air vehicle external and internal loads models
- Tools and methods to reduce the nonrecurring cost of structural sizing and analysis for chosen structural concepts for multiple failure modes, including the ability to define user-based failure criteria and associated allowables
- Reliability-based structural sizing methods and implementation of the methods in above tools for sizing. Goal is to be able to size the airframe to meet a Single Flight Probability of Failure (SFPoF) requirement
- Tools and methods for 1) automated conversion of analytical laminate distribution in finite element model (FEM) from above to CAD/manufacturable laminate design distribution, and inversely 2) automated mapping/conversion of CAD laminate design distribution to FEM

M&P AND MANTECH:
High-rate production of low cost airframe will require novel M&P solutions and manufacturing methods. The focus of these methods should be on reducing the recurring cost of production with consideration for economic viability of investment in non-recurring cost items. Desire is to reduce touch labor and not the labor rate. Note that the M&P and ManTech solutions must be integrated and proposed together. Examples include:

• Malleable composites (e.g., thermoplastics, vitrimer), associated parts fabrication methods and joining/assembly methods. Advancement of malleable composite M&P and manufacturing methods must be in the context of compatible structural concepts (acreage and joints) for maximum structural efficiency and include the assessment of degraded material properties on structural weight at component- or vehicle-level. Field-repair methods should be considered.
• High tolerance, responsive, high-rate composite structures assembly methods. Two tolerances must be addressed: 1) tolerance within build of an assembly (such as wing or fuselage sections) and 2) tolerance between assembly-to-assembly mating (such as outboard wing to center wing, wing-to-fuselage, etc.).

KEY AIRFRAME PARAMETERS:

• Structural assembly size of at least 15 ft x 6 ft x 6 ft with final component/assembly size that is at least 40 ft x 6 ft x 6 ft. This is to provide context for the size of assemblies that parts fabrication and manufacturing methods must address.
• 50% reduction in non-recurring engineering design development and recurring production cost for air vehicle structures
• Production rate of 20 shipsets per month with surge capability.

PHASE I: Develop concepts for technical solutions in design/analysis engineering and M&P/manufacturing solutions and demonstrate key aspects of those solutions. For example, for design/analysis methods solution, develop a workflow/architecture and demonstrate key parts of or the entire workflow/architecture on a representative structural component. For new integrated M&P/ManTech solution, subscale structural component (e.g., flat stiffened skin, single cell closed box with joining concepts) should be designed and manufactured and preferably tested. For new materials solution, coupon-level and/or element-level tests should be performed to assess basic mechanical properties such as unnotched and notched compression strengths, interlaminar shear and tension strengths, preferably to include moisture/temperature effect. For all proposed solutions, cost benefits should be estimated.

PHASE II: Mature solutions using one or two representative but subscale component(s)—e.g., wing, empennage, or fuselage. Multiple replicates should be designed, built, and tested., Measure/demonstrate time to completion of engineering design and analysis, time to build detailed parts, time to assemble parts to component, tolerances achieved, quality achieved, learning curve achieved, and structural strength achieved. If responsive/flexible assembly approach is being developed, ability to reconfigure the approach for different assemblies must be shown, either physically or virtually, with estimation of time to complete reconfiguration. In the maturations of the solutions, additional constraints such as subsystems/systems integration should be considered. Prepare a final report and Phase III plan.

PHASE III DUAL USE APPLICATIONS: Demonstrate integrated design, M&P, and manufacturing solutions at full scale component level with additional constraints such as subsystems/systems integration. Show reduction in cost/schedule with relevant structural efficiency and aerodynamic cleanliness in a repeatable manner. Potential use of the lessons learned in commercial UAV market should also be explored.

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KEYWORDS: Life Cycle Cost, High-Rate Manufacturing, Unmanned Air Vehicles

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N231-070 TITLE: Ultraviolet Solar Blind Sensors for Microsatellites and Small Satellites

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

OBJECTIVE: Develop innovative manufacturing methods to produce high quality ultraviolet (UV) and Vacuum UV (VUV) photodetectors for use in space on microsatellites (microsats) and small satellites (SmallSats) with strong visible wavelengths rejection.

DESCRIPTION: Improvements in the manufacturing of UV and VUV sensors are needed by the Navy to meet sensitivity and stray light rejection demands of compact optical systems designed for operation in space on the next generation of microsats being designed to study the ionosphere,1,2,3 and thermosphere4, and for use in other Navy applications. Availability of high-quality photodetectors will allow for future mission growth. The Navy is seeking to foster the development of affordable optical components and systems with broad application to space-based remote sensing systems. Current detector technology involves either fragile glass phototubes or photodiodes, both of which have unwanted visible light sensitivity. Typical CubeSat UV sensors used in SmallSats have been commercial off-the-shelf (COTS) or custom photomultipliers with fragile components and require high voltages for operation. Innovative detectors are sought with the ruggedness, mass, and material properties necessary to produce high-quality spaceflight optical elements. Innovative techniques are sought to develop solar blind detectors needed for the new class of remote sensing instruments.

UV and VUV detectors used for remote sensing of the ionosphere, including PMTs and solid-state sensors, typically feature an unwanted sensitivity to visible light. These sensitivities are normally attributed to impurities in the sensor materials. Goals are a ratio of 10^5 improvement in the UV/visible sensitivity. Solidstate devices are preferred since they do not require high voltages and require less power. High purity, wide bandgap materials can be considered as well as innovative light filtering schemes. Devices should be composed of compatible spacecraft materials, be low outgassing, survive at temperatures of -50ºC to +60ºC, and have the ability to survive a NASA GEVS5 vibration specification and thermal test environment, all typical of the requirements imposed for flight on small spacecraft. Technologies proposed should not contain hazardous or high outgassing materials and should be capable of being integrated into typical optical systems. It is desired that their containers be moderately electrically and thermally conductive to avoid developing static charge and thermal gradients in space. They should be durable and able to withstand normal optical component handling procedures. They should be delivered in an optically clean state and be robust enough to withstand precision cleaning and vacuum baking as part of normal spacecraft processing.

PHASE I: Develop and demonstrate concept feasibility for an innovative UV and VUV sensor technology meeting Navy needs for microsat optical systems. Demonstrate performance advantages over current technology by producing sample devices that can be tested to Navy requirements. GSE circuits will be provided that allow the Navy to test the devices in Navy facilities. While exact sensor responsivities are not specified for Phase I, the awardee will establish that the device can be used in the UVC range with windows and that it is capable of operating windowless or with MfF2 windows for the VUV region. Focus research on visible light rejection and materials. The path to using this technology to produce VUV detectors should be defined.

Proposed sensor concepts should meet the following thresholds:
Deliverable Design Characteristics:
Maximum sensor mass = 35g
Sensor area: = 1mm^2

UVC sensitivity: 100 mA/W
UVC/Vis: > 10^5
Dark current < 10 nA
Survival Temp range: -50 - +60°C
Full sensitivity (windowless): for UV and VUV
Vibration, Shock, and Thermal: NASA GEVS5

PHASE II: Develop a Phase II prototype sensor of the > 1mm^2 size class for evaluation in the VUV. The prototype will be evaluated to determine its capability in meeting the performance goals defined in Phase II Statement of Work (SoW) and the Navy need for solar blind UV and VUV sensors. The prototype design should provide collecting areas no less than 1mm^2 (objective), and should show applicability to be utilized with various electronics and spacecraft architectures. Deliver a minimum of five of these prototypes to the Navy for evaluation. Perform detailed analysis to ensure materials are rugged and appropriate for Navy application. Environmental, shock, and vibration analysis will be performed. Optical checks will include UV & VUV sensitivity, dark current, signal to noise (S/N), and UV/Vis rejection ratio. Prototype windowless VUV sensors will be produced and tested.

PHASE III DUAL USE APPLICATIONS: Apply the knowledge gained in Phase II to build an advanced sensor, suitably configured for a smallsat application, including flight spares and interface electronics, and characterize its performance in the UV & VUV as defined by Navy requirements. Working with the Navy and applicable Industry partners, demonstrate application to a DoD Space Test Program (STP) flight test. Support the Navy for test and validation to certify and qualify the system for Navy use. Explore the potential to transfer the UV/VUV sensor system to other military and commercial systems (NASA, University, Optics Industry). Market research and analysis shall identify the most promising technology areas and the company shall develop manufacturing plans to facilitate a smooth transition to the Navy.

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KEYWORDS: Ultraviolet; UV; UV sensors; vacuum ultraviolet; VUV sensors, detector technology, detector fabrication, spaceflight optics, spaceflight structures

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N231-071 TITLE: Compact Aerial Inspection System for Elevated and Small Spaces

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): General Warfighting Requirements (GWR)

OBJECTIVE: Develop and test a compact, stable aerial inspection system with sufficient endurance (e.g., > 15 minutes on station) capable of visually inspecting ship surfaces in tight, confined, and elevated spaces, with easy-to-use pilot/visualization/inspection software tools at the ground station.

DESCRIPTION: Ship construction and sustainment requires that a multitude of tanks and internal spaces, plus external surfaces, are prepped/remediated, coated, and inspected for quality. Currently, these surfaces are manually inspected at every step in the process, typically in difficult to access spaces, requiring personal protection and support equipment. Overall, there is a desire to remove or reduce the number of dark, dirty, and dangerous jobs in the interests of worker safety and production efficiency.

The objective is to develop and test an aerial inspection system capable of visually inspecting ship surfaces in tight, confined, and elevated spaces, with easy-to-use pilot/visualization/inspection software tools at the ground terminal complementing a compact, long-endurance, stable airborne platform. Currently available airborne systems capable of carrying the required sensor payload and command and control electronics have insufficient endurance to be able to perform much usable inspection.

The aerial inspection system consists of an airborne segment (the aerial platform), a ground segment (the ground control station) and the communications link between them. The air platform itself will need to be compact, long-endurance, and stable while supporting visual inspection requiring a high resolution color camera with gimbal and illumination. The ground segment will need to support pilot controls, as well as inspection-supporting software. The communications link will need to be robust to ship environments, accommodating metal tanks and indirect lines-of-site, while the entire system must be secure from an encryption and cybersecurity perspective.

While drone and unmanned aircraft vehicles/systems (UAV/UAS) are available within the inspection community, no commercial-off-the-shelf (COTS) drone capability has been able to meet the specific requirements of naval inspectors. Some of these challenges have included size, stability, endurance, cybersecurity, and compliance with the National Defense Authorization Act (NDAA) guidance on certain covered UAS systems and parts. The endurance is a particular challenge when coupled with the small size (width) requirement; COTS inspection drones have offered tethers to overcome endurance challenges, however, while tethers can provide extended endurance, a tether may not be consistent with operating in extended/tight spaces. The cybersecurity aspect is an area that is not generally considered when designing a ‘drone,’ however, cybersecurity can have significant impact on whether a drone can be used within the Naval enterprise where collection of Controlled Unclassified Information (CUI) is likely.

General Requirements and Specifications:
Endurance: 15 minutes or greater (without any tether and outside of sight of the ground station); longer is desirable
Surface illumination: 50 foot candles; lighting system tolerant; able to compensate for reflective surfaces; field of regard for the lighting and camera should include up/down/left/right
High-resolution, color camera: capable of human eye resolution
Size: No wider than 14.75 inches nor taller than 13 inches; 24” or less preferred

General System Requirements:
Easily portable in a ship environment
Capable of operating stably in confined spaces and operate in a GPS denied environment (e.g., inside a ship hull)
Compliant with NDAA and Executive Order 13981
Communications link: certified to FIPS 140-2 Encryption or viable path thereto (i.e., any added hardware included in the endurance budget)
Required pilot interfaces for control; provided by ground station
User output from sensor package needed to perform its inspection mission: provided by ground station • Hardening: capable of eventually being hardened to survive Naval test equipment requirements (e.g., MIL-STD-28800) • Desirable ground station requirements: UAS battery life indicator; capable of saving video/imagery • Capable of operating in 20mph winds • Capable of carrying 1 pound of addition payload without reducing endurance (although endurance is the highest priority) (Objective)

PHASE I: Develop concepts for an aerial inspection system meeting the requirements in the Description. Demonstrate the feasibility of the concepts in meeting Navy and Naval Enterprise needs; and establish the concepts for development into a useful product. Establish feasibility through material testing and analytical modeling, as appropriate. Provide a Phase II development plan with performance goals and key technical milestones that address technical risk reduction.

PHASE II: Develop a prototype for evaluation to determine its capability in meeting the performance goals defined in the Phase II development plan and the Navy requirements for the aerial inspection system. Support Navy requirements for any flight operations, such as submittal of Navy Cybersecurity Waiver Board interaction, submissions and approvals, and development of a system security plan. Demonstrate system performance through prototype evaluation and modeling or analytical methods over the required range of parameters. Use evaluation results to refine the prototype into an initial design that will meet the Naval Enterprise requirements. Prepare a Phase III development plan to transition the technology to Naval Enterprise use.

PHASE III DUAL USE APPLICATIONS: During Phase III it is expected that this product could go into useful service in government and industry shipyards as well as assist with naval sustainment activities. This product could be leveraged in commercial shipyards, industrial plant inspection, and any application requiring visual inspection in tight or confined spaces.

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KEYWORDS: Inspection, Drone; Unmanned Airborne Vehicle; UAV; Unmanned Airborne System; UAS; Aerial inspection system; Ground station; Confined spaces

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N231-072 TITLE: High Temperature Ceramic Yarn from Discontinuous Silicon Carbide (SiC) Fibers

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

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

OBJECTIVE: Develop a process in which short silicon carbide (SiC) fibers are fabricated into a yarn capable of integration into traditional weaving or braiding systems used to produce high strength, high temperature ceramic matrix composites (CMCs).

DESCRIPTION: Advanced aerospace vehicles and munitions, including hypersonics, rely on CMCs in order to operate under harsh aerothermal environments. Carbon-carbon (C/C) composites are most frequently employed, but CMCs incorporating higher temperatures materials, such as Silicon Carbide (SiC), Hafnium Diboride (HfB2), Zirconium Diboride (ZrB), Hafnium Carbide (HfC), are being investigated and are important for improved performance. One of the greatest challenges associated with the production of high performance CMCs is the sourcing of needed materials, notably fibers. The majority of carbon fiber manufacturers are foreign companies, and even procuring carbon fiber, which has been a mature technology for more than 50 years, has its challenges. Additionally, much of the world production of higher temperature SiC fibers is controlled by foreign companies.

While most fiber processes utilize continuous fiber filaments, short fibers offer the potential for alternative manufacturing methods and material. Short fibers in yarn form can increase the drapeability of textiles, improve the processability of CMCs, and allow tuning of the thermal conductivity of the resulting composite. It is anticipated that developing this technology will result in an expanded domestic fiber supply for high temperature CMC components. To reduce supply chain risk and open up additional sources of fiber for the Navy's future needs, this SBIR topic aims to develop a manufacturing process to produce high temperature yarn from short SiC fibers.

The yarn will initially be constructed from SiC fibers, but it is desired that the process is material independent in order to accommodate other high temperature materials. In order to have broad application, the yarn must be of sufficient strength to interface with current weaving and braiding processes used in the construction of CMC preforms and textiles. For the yarn to yield high quality CMC components, the fibers must have good mechanical and thermal properties and be sufficiently aligned (target values to be provided upon contract award). Additionally, fibers must be of sufficient length in order to approach the properties of CMC yarns constructed from carbon fibers (properties include tensile strength, thermal shock, creep resistance, high temperature resistance). Required ranges to be provided upon contract award.

The Phase II effort will likely require secure access, and SSP will process the DD254 to support the contractor for personnel and facility certification for secure access. The Phase I effort will not require access to classified information. If need be, data of the same level of complexity as secured data will be provided to support Phase I work.

It is probable that the work under this effort will be classified under Phase II. The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DSS and SSP in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

PHASE I: In Phase I, companies are expected to complete the following:

- Design and demonstrate feasibility of a manufacturing process which is capable of producing yarn from discontinuous SiC fibers.
- Identify a source for superior SiC fibers, ensure their high strength and temperature properties, and develop plans to obtain a sufficient supply of these fibers for Phase II and Phase III of this project.
- Produce sample yarn from short ceramic fiber, and characterize it in order to ensure that it could meet the needs given in the description.

Although initial solutions may be at the benchtop scale, the Phase I effort will include plans to moderately scale up the solution under Phase II.

The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype system in Phase II.

PHASE II: In Phase II, companies are expected to complete the following:

- Produce a prototype system for manufacturing SiC yarn by improving upon and developing the approach from Phase I.
- Iterate on the manufacturing process in order to improve efficiency and yarn quality.
- Understand the impact of fiber characteristics on the manufacturing process and the resulting yarn through mechanical testing, imaging, and analysis.
- Provide SiC yarn to the Navy for testing and evaluation in processes which normally rely on fiber tows.

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

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use. Finalize development, based on Phase II results, and aid in supplying the Navy with material needed to manufacture and test CMC components under representative flight conditions. The need for additional domestic sources of fiber exist within other branches of the DoD, and potential uses for this technology exist in the commercial and aftermarket composite industry as well. Currently, short fibers are milled for filler material or used to manufacture non-woven isotropic composites. The compositing process often generates significant scrap fiber. Additionally, ceramic fiber can be extracted from recycled composites. Instead of processing these fibers in low performance and value composites, they could be converted to a yarn and used in high quality components, similar to continuous fiber.

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KEYWORDS: Hypersonics; silicon carbide; ceramic matrix composites; manufacturing; yarn; weaving; thermal protection system

Communication with SSP TPOCs will be coordinated through the SSP SBIR Program Manager.

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N231-073 TITLE: Radiation Hardened FPGAs for Strategic Systems

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

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

OBJECTIVE: Develop a cost-effective approach to field a radiation-hardened field programmable gate array (FPGA) that can be used in strategic weapons systems.

DESCRIPTION: Strategic Systems Programs (SSP) needs a cost-effective approach to field an FPGA that both address hardware assurance concerns and can meet the objective radiation requirements detailed in request for proposal (RFP) CS-22-1301 to be used in strategic weapons systems [Ref 1]. The current approach to upgrade digital flight hardware electronics for strategic weapon systems involves the redesign of application specific integrated circuits (ASICs) in radiation hardened manufacturing foundries. The full custom nature of the ASIC design addresses assurance concerns by allowing for comprehensive verification to detect bugs and potential hardware Trojans. However, the ASIC design process and requalification of the fabricated ASIC is costly, requires multi-year design and verification cycles and is resource consuming. FPGAs have the ability to shorten the design cycle and provide rapid digital flight hardware electronics upgrade solutions. Unfortunately, no FPGA device currently exists that meets the radiation and assurance requirements to fly in a strategic weapon system.

Currently available FPGA devices and enabling FPGA technology do not meet one or more of the RFP CS-22-1301 objective requirements, such as 300 krad(si) total ionizing dose (TID), single event latchup (SEL) thresholds > 100 MeV-cm2/mg, and device circumvention and recovery (C&R) < 1ms [Ref 1]. These examples are meant to be representative only, and not to be taken as requirements or limits/thresholds. Additionally, hardware assurance concerns exist when using commercial FPGAs in strategic systems as the complete FPGA physical design information has potentially not undergone an independent verification and validation activity by United State Government (USG) to search for bugs and potential hardware Trojans.

The following potential methods may be used to develop solutions to address the above-stated radiation and assurance concerns that currently prohibit the use of FPGAs in strategic weapons systems. This SBIR topic seeks research to further one or more ideas below to address these concerns. Additional solutions provided by the proposers not listed below are welcome as well.

(1) One approach could develop and qualify radiation hardened volatile or non-volatile configuration memory options with transition potential to an FPGA product. Transition paths may include a commercial FPGA vendor or an industrial partner leveraging embedded FPGA (eFPGA) intellectual property (IP) to field an FPGA that meet the objective specifications in RFP# CS-22-1301. These configuration memory options would target an on-shore manufacturing process available from vendors such as Honeywell, Skywater, Intel, and GlobalFoundries.

(2) Another method could involve leveraging existing commercial FPGA physical die. Examples may include upscreening through radiation lot acceptance testing or by developing multi-chip modules with bare commercial FPGA vendor die to meet C&R requirements.

(3) Another acceptable approach could involve a prototype FPGA integrated circuit (IC) design and FPGA software toolchain targeting an onshore manufacturing process that integrates commercially available IP and radiation hardened by design (RHBD) processes. Examples of potential eFPGA IP solutions such as Flexlogic, Avago, and OpenFPGA.

(4) Another acceptable topic could involve developing assurance methods applicable to commercial and open source FPGA devices. These assurance methods would provide a quantitative measure of assurance that the physical FPGA circuitry and FPGA software does not either contain Trojan or bug that could be exploited to cause loss or subversion during operation of the configured FPGA.
The commercial FPGA community categorizes FPGAs in accordance with their configuration memory options. Static random access memory (SRAM)-based configuration memory solutions that enable high performance, but require an off-FPGA configuration file resulting in C&R times > 1ms [2]. FPGAs with embedded non-volatile configuration memory options such as Flash and SONOS meet the objective C&R times but do not meet either TID or SEL objectives [Refs 3, 4].

The proposed R/D effort will develop enabling technology toward fielding an FPGA for a strategic weapon system.

PHASE I: Define and develop the concept(s) and method(s) to further the one of the research areas defined in the Description. Provide description(s) of the approach(es), along with corresponding preliminary evidence supporting each approach. Validate the method selected. Identify technical challenges as well as risks and opportunities for the selected method that will be addressed during Phase II. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype and/or a process/tool solution in Phase II. Prepare a Phase II plan.

PHASE II: Develop a physical prototype and/or a process/tool of the proposed concept or method that meets the capabilities listed in the Description. Demonstrate and validate the concept or method. Demonstrate the ability of the prototype and/or a process/tool to meet or exceed the specifications located in the Description. Identify and document any opportunities for improvements for future iterations.

PHASE III DUAL USE APPLICATIONS: Support in transitioning the technology for Navy use in SSP. Support the Navy with transitioning the technology developed within this SBIR topic into a fieldable FPGA that meets the threshold objectives in RFP# CS-22-1301. The RFP# CS-22-1301 government purpose rights (GPR) deliverables will be provided as available materials to realize a fieldable FPGA. Example CS-22-1301 GPR deliverables include pre-silicon IP design files, fabrication-ready GDSII files, and software modules.

The technology developed can also be commercialized into products with space radiation effects requirements. The threshold objectives for space radiation systems is often a subset of the threshold objectives for Strategic Radiation Hard (SRH) systems. Other markets such as automotive/medical with high-reliability and aggressive power-on-reset specifications are other potential candidates for this enabling FPGA technology.

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KEYWORDS: FPGA; SRH; strategic; Field Programmable Gate Array; eFPGA; radiation; programmable hardware; strategic system; MRAM; ReRAM; C&R

Communication with SSP TPOCs will be coordinated through the SSP SBIR Program Manager.

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N231-074 TITLE: Characterization of the Radiation Environment Capabilities of Exploding Foil Initiators (EFIs)

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

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

OBJECTIVE: Investigate and demonstrate the ability of a low energy exploding foil initiator (LEEFI or EFI) to function in the Strategic Systems Programs (SSP) D5 missile system.

DESCRIPTION: With a new ballistic missile submarine under development (Columbia class SSBN), the capability delivered by the current generation of Submarine Launched Ballistic Missile (SLBM), the Trident II (D5) Missile, will continue to be required throughout the majority of the 21st century. As SSP maintains and modernizes the Trident II (D5) Missile through manufacturer consolidation and material obsolescence, a strong emphasis will be placed on improving manufacturability, sustainability, life-cycle costs, and safety, reliability and performance of the system.

The ability of a low energy exploding foil initiator (LEEFI or EFI) to function in the SSP D5 missile system is to be investigated and demonstrated. Specifically, since the missile is subject to various strategic radiation environment environments; any electrical system must be robust enough to reliably operate during exposure to the elevated radiation environment. Many EFI designs exist in industry and their viability must be understood prior to use in systems which experience radiation environments. To provide potential users with a wider selection for their application and to promote new designs, characterization of the performance of bridge foils of varying materials and sizes will be conducted when subjected to various radiation environments, comprised of neutrons, gammas, X-rays, electrons, and ElectroMagnetic Pulse (EMP).

The baseline application is for EFIs, which conform to MIL-STD-1316 [Ref 1] and/or MIL-STD-1901 [Ref 2], design and safety requirements for use in systems. Of particular interest is the effects of radiation on the narrowed bridge area (metal, e.g., aluminum, copper, gold, silver) and flyer (dielectric, e.g., polyimide, polyethylene terephthalate (PET)) aspects of the bridge foil such that the EFI would not fire or would prematurely fire. The EFIs will need to withstand radiation environments analogous to natural space and man-made hostile conditions for a prompt high dose rate range of 1E11 to 1E13 rad(Si)/s, a Total Ionizing Dose range of 1E5 to 5E5 rad(Si), Neutron Displacement Damage maximum of 5E12 to 1E14 n/cm2, and X ray fluence range of 0.1 to 10 cal/cm2.

The Phase I deliverables would include an analysis-based “handbook” and recommended processes to evaluate typical common EFI bridge foil materials (cf. preceding paragraph) and how they react in various radiation environments for use when determining EFI viability in a system and/or narrow down design parameters for a custom EFI in a strategic system.

PHASE I: Develop a concept for characterizing the EFI bridge foil parameters and environments. Determine EFI parameter trade space from industry availability and literature. Determine pass/fail criteria. Conduct a RAD transport simulation feasibility assessment for the proposed approaches and documentation design guideline advancements in contrast to existing devices/Foils. Address, at a minimum, the capabilities listed in the Description. Document findings in an analysis-based handbook. 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: Formulate validation plan, including analysis, test approaches, and locations. Develop test plans to monitor the radiation response. Propose a conceptual design or improvements that can be performed on commercially available EFIs that will meet or exceed the environments described above. Develop a Phase III technology hostile environment validation and verification plan. Address, at a minimum, the capabilities listed in the description.

PHASE III DUAL USE APPLICATIONS: Validation of Phase II test (not necessarily hardware) in a hostile environment. Show MIL-STD-2169 compliance data from testing to exercise the designs in relevant environments and collect performance data, which may be used to characterize the capabilities of the design. This design concept will be leveraged for the Strategic Weapon System Trident II D5 and D5 Life Extension Programs. This technology has the potential to be used commercially in the aerospace and energetic industries that require low energy exploding foil initiators such as safer non-military application of deep well Wireline Perforating.

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KEYWORDS: Low energy exploding foil initiator; LEEFI; high voltage; ordnance; initiation; strategic radiation; battlespace environments; survivability; characterization study; Strategic Missiles; Materials Development; Electronics Enclosures; Shielding; Attenuation

Communication with SSP TPOCs will be coordinated through the SSP SBIR Program Manager.

TPOC-1: SSP SBIR POC
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N231-075 TITLE: Reduced Integrated Optical Circuits (IOC) Half-wave Voltage (Vpi) for improved Size Weight and Power (SWaP) in Interferometric Fiber-Optic Gyroscopes (IFOG)

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

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

OBJECTIVE: Reduce half-wave voltage (Vpi) in current state-of-the-art Y-branch dual phase modulator integrated optical circuits (IOC) so that they can be packaged in smaller instruments

DESCRIPTION: The performance requirements for strategic-grade inertial sensors based on optical interferometry continue to become more stringent, necessitating continued innovation for optical component technologies that require unprecedented precision and characterization of long-term bias stability, scale factor linearity, angle random walk performance, etc. [Ref 1]. One of these key components is the IOC. The IOC is typically comprised of Y-branch dual phase modulators based on waveguides and electrodes formed on the surface of a crystal, such as lithium niobate, and assembled (pigtailed) to optical fiber (one input and two output fiber ports) [Ref 2]. Current devices are limited in size by the length of the crystal required to produce a PI phase shift. Improvements to Vpi should allow the same phase shift with a shorter length and enable more tightly packaged and integrated fiber optic gyroscopes. The objective of this SBIR topic relates to advanced lithium niobate IOCs for strategic-grade inertial sensors with 1550 nm operating wavelength. The reduced Vpi shall have negligible impact on other IOC design and performance criteria resulting in a reduced overall size, overall optical insertion loss, polarization extinction ratio, and flat frequency response behavior.

PHASE I: Perform a design and materials study aimed at reducing the Vpi and Size, Weight and Power (SWaP) of the lithium niobate IOC. Target Vpi should be significantly below current annealed proton exchange (APE) and reverse proton exchange (RPE) standards which easily achieve < 10V in a 25mm long package. The study must demonstrate that Vpi reduction to an equivalent of 5 V (or lower) in a 25mm long package is feasible. The technique should be compatible with IOCs having either APE or RPE waveguides with 1550 nm operating wavelength. The study must assess performance criteria and consider all aspects of device fabrication. The study shall include a preliminary assessment of long-term environmental stability assuming a design life of 30 years at 50 °C based on a materials physics analysis, including Mean Time Between Failure (MTBF), Mean Time to Failure (MTTF) and Failure In Time (FIT) values, along with identification of the assumptions, methods, activation energy, and confidence levels associated with these values. The study shall justify the feasibility/practicality of the approach for achieving reduced Vpi and SWaP with negligible impact on other IOC design and performance criteria, including overall optical insertion loss and polarization extinction ratio (PER). The study shall estimate the effects of the change to Vpi on IOC design and performance criteria relative to a control prototype design that does not include the new feature. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build prototype solutions in Phase II, as well as a test plan for an accelerated aging study (minimum 5 year real-time equivalent) to be conducted in Phase II.

PHASE II: Based on the Phase I results, design, fabricate, and characterize six (6) prototype IOCs, complete with fiber-optic pigtails and electrical connections suitable for incorporation into test beds for interferometric inertial sensors. Characterization must comprise evaluation electrical measurements including Vpi frequency response and residual intensity modulation (RIM), and optical measurements including optical insertion loss, chip PER, optical return loss (ORL) or coherent backscatter, and wavelength dependent loss (WDL). An accelerated aging study involving IOCs at elevated temperatures under vacuum must be performed to develop a predictive model of long-term environmental stability. The prototypes should be delivered by the end of Phase II.

PHASE III DUAL USE APPLICATIONS: Based on the prototypes developed in Phase II, continuing development must lead to productization of IOCs suitable for interferometric inertial sensors. While this technology is aimed at military/strategic applications, phase modulators are heavily used in many optical circuit applications, including in telecom industry hardware. A phase modulator with significantly reduced SWaP is likely to bring value to many existing commercial applications including LIDAR, satellite free space communications and other radar applications. Also, this technology could be leveraged to bring IFOG technology toward a price point that could make it more attractive to the commercial markets.

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KEYWORDS: Integrated Optical Circuit; Phase Modulator; Lithium Niobate; Waveguides; Inertial Sensor; Fiber-optic Gyroscope

Communication with SSP TPOCs will be coordinated through the SSP SBIR Program Manager.

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N231-076 TITLE: Electrically Conductive Self-Assembled Monolayer (SAM) Anti-Stiction Coating for Micro-Electromechanical Systems (MEMS)

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

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

OBJECTIVE: Develop an anti-stiction self-assembled monolayer (SAM) coating that is electrically conductive along the molecule chain, but not conductive between molecules.

DESCRIPTION: SAM coatings have been shown to reduce stiction-related failures for Micro-Electromechanical Systems (MEMS) devices during fabrication and in operation. Although industry has incorporated this technology into commercial products such as accelerometers and gyroscopes, the requirements for strategic sensors necessitate special considerations, including minimizing induced stresses from mismatches of coefficients of thermal expansion (CTE), designing the sensor to be robust through strategic radiation environments, preventing parasitic charges from creating erroneous signals, and ensuring that the sensor will be stable over several decades. Examples of existing research for SAM coatings can be found in the referenced articles [Refs 1-3].

MEMS sensors are more frequently being considered as alternatives to conventionally machined sensors in order to meet stringent performance requirements. This SAM coating is likely to bring value to multiple industries as the need for stability and reliability become more important.

PHASE I: Design a SAM coating for wafer-level processing with the desired goals of 1) reducing stiction in a silicon MEMS device; 2) allowing electrical conduction along the molecule chain (goal of < 100 Ohm resistance between the coating and silicon substrate), but not across molecules (goal of > 1 MOhm resistance laterally across the coating); 3) selectively coating only exposed silicon surfaces, and not oxide or metal surfaces 4) ensuring stability of the coating for up to 30 years. Material space is not constrained and unique designs are encouraged. The Phase I study shall assess all aspects of fabrication and justify the feasibility and practicality of the designed approach. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Based on the Phase I design and execution plan, fabricate and characterize a small lot (up to Qty: 5 wafers) of silicon articles with the sample coatings. This characterization may include coating selectivity, coating conductivity, stiction reduction for sample MEMS devices, and thermal sensitivity for sample MEMS devices. These articles do not need to incorporate etched features – however, the prototypes must address the desired goals specified during Phase I. The prototypes, test samples, and characterization results should be delivered by the end of Phase II.

PHASE III DUAL USE APPLICATIONS: Based on the prototypes developed in Phase II, continuing development must lead to productization of the SAM coating. While this technology is aimed at military/strategic applications, SAM coatings are used more broadly in the MEMS industry. Perform final qualification by inserting and demonstrating the SAM coating into a known microfabrication process for a MEMS design. (Note: The devices incorporating the SAM coating may be subject to several common test environments for strategic sensors, including radiation and vibration environments.)

A stable SAM coating carefully designed to reduce parasitic effects (such as charging in the coating) is likely to bring value to existing commercial applications such as space and autonomous vehicle navigation to improve both the reliability and performance of high-end MEMS sensors.

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KEYWORDS: Self-assembled monolayers; coatings; micro-electromechanical systems; microfabrication; anti-stiction; wafers

Communication with SSP TPOCs will be coordinated through the SSP SBIR Program Manager.

TPOC-1: SSP SBIR POC
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N231-077 TITLE: Ultra Low-Profile Hermetic Fiber Optic Interconnect

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

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

OBJECTIVE: Reduce the size of state-of-the-art optical fiber hermetic interconnects so that they can be packaged into small form factor fiber optic gyroscopes.

DESCRIPTION: Delivering optical fibers into and out of hermetically sealed systems is a common problem in optical experiments and applications. While there are numerous commercially available options and even MIL-Spec options such as MIL-DTL-38999 hermetic fiber interconnects [Ref 1], these solutions are often bulky and limited to specific fiber types.

While much work has been done to improve the fiber feedthrough seals, which can now achieve helium diffusion rates of < 10-12 mbarr/sec, shrinking the footprint of fiber optic interconnects has not been effectively achieved.

The smallest custom hermetic fiber optic interconnect solutions are on the order of 40mm in length and ¼" in diameter [Ref 2]. In order to continue to miniaturize optical sensors it is necessary to greatly reduce the size of the currently available hermetic fiber optic interconnections. This SBIR topic proposes to design, prototype, and test an 80µm fiber hermetic interconnect that is 3.155mm in length with a stretch goal of achieving 0.1mm in length.

PHASE I: Perform a design and materials study aimed at reducing the length of currently available hermetic optical fiber interconnects. The technique should be compatible with 80 micron polarization maintaining (PM) fiber. The study must assess performance criteria and consider all aspects of device fabrication. The study shall include a preliminary assessment of long-term environmental stability assuming a design life of 30 years at 50°C based on a materials physics analysis, including Mean Time Between Failure (MTBF), Mean Time to Failure (MTTF) and Failure In Time (FIT) values, along with identification of the assumptions, methods, activation energy, and confidence levels associated with these values. The study shall justify the feasibility/practicality of the approach for achieving reduced hermetic optical fiber interconnect with negligible impact on PM fiber performance including, overall optical loss, polarization extinction ratio, and polarization cross-talk. For the performance impact to be deemed negligible, the impact must be consistent with that of a fiber splice, index matching joint, or other high-performance interconnect. The Phase I Option if exercised, will include the initial design specifications and capabilities description to build prototype solutions in Phase II, as well as a test plan for an accelerated aging study (minimum 5 year real-time equivalent) to be conducted in Phase II.

PHASE II: Based on the Phase I results, design, fabricate, and characterize six (6) prototype ultra low-profile optical fiber hermetic interconnects, that can be flush-mounted onto stainless steel cover suitable for incorporation into test beds for interferometric inertial sensors. Characterization must comprise evaluation of hermeticity over temperature with minimal-to-no impact on PM fiber performance. An accelerated aging study elevated temperatures must be performed to develop a predictive model of long-term environmental stability. The prototypes should be delivered by the end of Phase II.

PHASE III DUAL USE APPLICATIONS: Based on the prototypes developed in Phase II, continuing development must lead to productization of ultra low-profile hermetic optical fiber interconnects suitable for interferometric inertial sensors. While this technology is aimed at military/strategic applications, optical fiber interconnects are heavily used in many optical circuit applications, including in telecom industry hardware. An optical interconnect with significantly reduced size could be employed to deliver light from a single light source into multiple fiber optic Sagnac interferometers and is likely to bring value to many existing commercial applications. Also, technology meeting the needs of this topic could be leveraged to bring IFOG technology toward a price point that could make it more attractive to the commercial markets.

REFERENCES:

1. MIL-DTL-38999M, Connectors, Electrical, Circular, Miniature, High Density, Quick Disconnect (Bayonet, Threaded, or Breech Coupling), Environment Resistant with Crimp Removable Contacts or Hermetically Sealed with Fixed, Solderable Contacts, General Specification for. 08-SEP-2017. https://assistca.dla.mil/online/doc_analysis/doc_info_general.cfm?ident_number=22497
2. “KTRAV-M10: Hermetic Fiber Optic Feedthroughs for Vacuum and Pressure up to 600 bars.” Laser Components. September 2020. https://www.lasercomponents.com/fileadmin/user_upload/home/Datasheets/sedi/hermetic-feedthrough-up-to-600-bars.pdf

KEYWORDS: Ultra low-profile, hermetic, optical fiber, interconnect, optical fiber feedthrough, polarization maintaining fiber

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N231-078 TITLE: Phase Trimming for Integrated Photonics

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

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

OBJECTIVE: Development of simultaneously low power, low optical loss, and small die area technologies that combat integrated photonics device phase errors at visible and near-infrared wavelengths.

DESCRIPTION: Integrated photonic devices suffer from phase errors introduced by fabrication and material deposition variations across reticles, across individual wafers, and between wafers. Mitigation of phase errors through optical phase trimming will enable larger devices, which will greatly improve photonic system performance in light-starved applications: shorter integration times, resolution, longer ranges, and higher signal-to-noise ratio for applications such as optical communications and LiDAR [Ref 1]. The most mature phase control technologies typically have one or more of the following drawbacks: 1) large size, 2) active phase control devices often have high power consumption, and 3) high optical loss, especially at visible and near infrared wavelengths. Addressing these challenges will advance photonics. Over the past decade, work has gone into some of the following areas, among others: liquid crystal technology [Ref 2], focused-ion-beam (FIB), laser writing, and micro/nano-electromechanical systems (M/NEMS) switches [Ref 3]. Both static and active phase error correction solutions are encouraged to respond to this SBIR topic. Similarly, both the evolution of academic techniques as well as the adaptation and maturation of known techniques to this problem are of interest. Zero-power-hold solutions are of particular interest.

One novel area of interest is phase change materials [Refs 4, 5] – a reliable and repeatable supply is crucial for use by academia, foundries, and government research laboratories. A full solution is not required for answering this SBIR topic. This work could include improving uniformity of material targets, improving repeatability of material properties, and formulating new materials for low optical loss, particularly at shorter wavelengths.

This technology should focus on visible and near-infrared (NIR) wavelengths, particularly between 700-900 nm, and be compatible with silicon (Si) and silicon-nitride (SiN) processes. A path toward integration with densely-packed waveguide arrays is necessary. As the technology is matured, performers will collaborate with SSP and government contractors to integrate the technology into relevant platforms. This collaboration will also seek to develop a technology transfer plan for commercial-scale photonics foundry fabrication.

PHASE I: Perform a design and fabrication analysis to assess the feasibility of the proposed technique or material development for producing phase trimming capability in the near-infrared (across 700-900 nm) for use in integrated photonic devices. Include the expected dynamic range for the technique (up to 2pi optical phase shift is preferred), expected die area required (< 100 μm2 or capable of individual addressability within waveguide arrays with < 5 µm center-to-center spacing is preferred), optical loss introduced (< 1 dB insertion loss preferred), and energy required for switching. For materials development efforts, report optical properties (refractive index and extinction coefficient) for amorphous, crystalline, and attainable intermediate phases, expected conditions (temperature, electric field, etc.) and energy required for switching, and comparison to current materials. Identify risks and risk mitigation strategies. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build prototype solutions in Phase II.

PHASE II: Fabricate and characterize five (5) prototypes that demonstrate the phase trimming capability or material system. Variability of key metrics (optical phase shift, refractive index change) > 3% and optical insertion loss > 1 dB should be addressed with a mitigation plan to enable highly reliable performance as the system matures.

The final report will include a discussion of potential near-term and long-term development efforts that would improve the technology's performance, ease of fabrication, and integration in the required small die area. It will also include an evaluation of the cost of fabrication and how that might be reduced in the future. The prototypes should be delivered by the end of Phase II.

PHASE III DUAL USE APPLICATIONS: Based on the prototypes and continual advancement of photonics, a low SWaP phase trimming capability should lead to dramatic improvements in the scaling phase-sensitive photonic devices. Support the Navy in transitioning the technology to Navy use. The prototypes will be evaluated through optical characterization and testing with relevant adjacent devices. The end product technology could be leveraged to bring photonic imaging and sensing towards a more mature state with a lower SWaP profile that could make it more attractive for optical communication and Light Detecting and Ranging (LiDAR) as well as in the biomedical, navigation, and vehicle autonomy markets.

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1. Clevenson, Hannah A. et al. "Incoherent Light Imaging Using an Optical Phased Array.", Applied Physics Letters 116, 031105 (2020). https://doi.org/10.1063/1.5130697
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5. Delaney, Matthew et al. "A New Family of Ultralow Loss Reversible Phase-Change Materials for Photonic Integrated Circuits: Sb2S3 and Sb2Se3", Advanced Functional Materials 30, 2002447 (2020). 0.1002/adfm.202002447

KEYWORDS: Photonic integrated circuits, phase change materials, optical phase trimming, photonic imaging, optical phase shifters, visible and near infrared photonics

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