NAVY
STTR 14.A PROPOSAL SUBMISSION

INTRODUCTION:

The responsibility for the implementation, administration and management of the Navy STTR Program is with the Office of Naval Research (ONR). If you have questions of a general nature regarding the Navy's STTR Program, contact Ms. Lore-Anne Ponirakis (loreanne.ponirakis@navy.mil). For general questions regarding NAVAIR topics N14A-T001 through N14A-T008, please contact the NAVAIR STTR Program Administrator, Dusty Lang (navair.sbir@navy.mil). For inquiries or problems with electronic submission, contact the DoD Help Desk at 1-866-724-7457 (8:00 a.m. to 5:00 p.m. ET). For technical questions about a topic, you may contact the Topic Authors listed under each topic before **5 March 2014**. Beginning **5 March 2014** for technical questions you must use the SITIS system at **www.dodsbir.net/sitis**, or go to the DoD Web site at http://www.acq.osd.mil/osbp/sbir/solicitations/sttr2014A/index.shtml for more information.

The Navy's STTR Program is a mission-oriented program that integrates the needs and requirements of the Navy's Fleet through R&D topics that have dual-use potential, but primarily address the needs of the Navy. Companies are encouraged to address the manufacturing needs of the Defense Sector in their proposals. Information on the Navy STTR Program can be found on the Navy STTR Web site at **http://www.onr.navy.mil/sbir.** Additional information pertaining to the Department of the Navy's mission can be obtained by viewing the Web site at **http://www.navy.mil.**

PHASE I PROPOSAL SUBMISSION:

Read the DoD front section of this solicitation for detailed instructions on proposal format, submission instructions and program requirements. When you prepare your proposal, keep in mind that Phase I should address the feasibility of a solution to the topic. The Navy only accepts Phase I proposals with a base effort not exceeding $80,000 and with the option not exceeding $70,000. The technical period of performance for the Phase I base should be 7 months. The Phase I option should be 6 months and address the transition into the Phase II effort. Phase I options are typically only funded after the decision to fund the Phase II has been made. The Phase I technical volume, including the option, has a 20-page limit. Please use the proposal template located at http://www.navysbir.com/submission.htm. Technical Volumes that exceed the 20 page limit will be reviewed only to the last word on the 20th page. Information beyond the 20th page will not be reviewed or considered in evaluating the Offeror's proposal. To the extent that mandatory technical content is not contained in the first 20 pages of the proposal, the evaluator may deem the proposal as non-responsive and score it accordingly. The Navy will evaluate and select Phase I proposals using scientific review criteria based upon technical merit and other criteria as discussed in this solicitation document.

Due to limited funding, the Navy reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded. The Navy typically provides a firm fixed price contract or awards a small purchase agreement as a Phase I award.

All proposal submissions to the Navy STTR Program must be submitted electronically. It is mandatory that the **entire** technical volume, DoD Proposal Cover Sheet, Cost Volume, and the Company Commercialization Report are submitted electronically through the DoD SBIR/STTR Submission Web site at **http://www.dodsbir.net/submission**. This site will lead you through the process for submitting your technical proposal and all of the sections electronically. To verify that your technical volume has been received, click on the "Check Upload" icon to view your uploaded technical volume. If you have any questions or problems with the electronic submission, contact the DoD SBIR Helpdesk at 1-866-724-7457

(8:00 a.m. to 5:00 p.m. EST). Your proposal **must** be submitted via the submission site before **6:00 a.m. ET, Wednesday, 9 April 2014**.

Within one week of the Solicitation closing, you will receive notification via e-mail that your proposal has been received and processed for evaluation by the Navy. Please make sure that your e-mail address is entered correctly on your proposal coversheet or you will not receive a notification.

In accordance with section 4.10 of the DoD Instructions, your request for a debrief must be made within 30 days of non-award notification.

PHASE II PROPOSAL SUBMISSION:

All Phase I awardees will be allowed to submit an initial Phase II proposal for evaluation and selection. The details on the due date, content, and submission requirements of the initial Phase II proposal will be provided by the awarding SYSCOM either in the Phase I award or by subsequent notification. **Note: All SBIR/STTR Phase II awards made on topics from solicitations prior to FY13 will be conducted in accordance with the procedures specified in those solicitations (for all Department of Navy topics this means by invitation only).**

Section 4(b)(1)(ii) of the SBIR Policy Directive permits the Department of Defense and by extension the Department of the Navy (DON), during fiscal years 2012 through 2017, to issue a Phase II award to a small business concern that did not receive a Phase I award for that R/R&D. The DON will NOT be exercising this authority for SBIR or STTR Phase II awards. **In order for any small business firm to receive a Phase II award, the firm must be a recipient of a Phase I award under that topic and submit an initial phase II proposal.**

The Navy will evaluate, and select Phase II proposals using the evaluation criteria in Section 6.0 of the DoD Program Solicitation with technical merit being most important, followed by qualifications and commercialization potential of equal importance. Due to limited funding, the Navy reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded.

The Navy STTR Program structures Phase II contracts in a way that allows for increased funding levels based on the project's transition potential. This is called the Phase II.5 and is accomplished through either multiple options that may range from $250,000 to $1,000,000 each, substantial expansions to the existing contract, or a second Phase II award. For existing Phase II contracts, the goals of Phase II.5 can be attained through contract expansions, some of which may exceed the $1,000,000 recommended limits for Phase II awards.

DISCRETIONARY TECHNICAL ASSISTANCE:

The SBIR Policy Directive section 9(b), allows the DoN to provide discretionary technical assistance to its awardees to assist in minimizing the technical risks associated with SBIR projects and commercializing into products and processes. Firms may request, in their application for Phase I and Phase II proposals, to contract these services themselves in an amount not to exceed $5,000 per year. This amount is in addition to the award amount for the Phase I or Phase II project.

Approval of direct funding for this discretionary technical assistance will be approved by the DON SBIR office if the firm's proposal clearly identifies the need for assistance, provides details on the provider of the assistance and why they are uniquely skilled to carry out this work, and the cost of the required assistance. If the firm requests discretionary technical assistance in a Phase II proposal, they will be eliminated from participating in Navy Transition Assistance Program (TAP) and Navy Opportunity Forum or any other assistance the Navy provides directly to firms.

Phase I awardees that propose more than $150,000 in total funding (Base, Option and discretionary technical assistance) cannot receive a purchase order. The need to issue a Firm Fixed Price (FFP) contract may result in contract delays if the SYSCOM normally issues Phase I awards as purchase orders.

All Phase II awardees not receiving funds for discretionary technical assistance in their award must attend a one-day Transition Assistance Program (TAP) meeting during the second year of the Phase II. This meeting is typically held in the summer in the Washington, D.C. area. Information can be obtained at: **http://www.dawnbreaker.com/navytap**. Awardees will be contacted separately regarding this program. It is recommended that Phase II cost estimates include travel to Washington, D.C. for this event.

PHASE III:

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

TOPIC AWARD BY OTHER THAN THE SPONSORING AGENCY:

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

AWARD AND FUNDING LIMITATIONS:

In accordance with STTR Policy Directive section 4(b)(5), there is a limit of one sequential Phase II award per firm per topic. Additionally in accordance with STTR Policy Directive section 7(i)(1), each award may not exceed the award guidelines (currently $150,000 for Phase I and $1 million for Phase II) by more than 50% (SBIR/STTR program funds only) without a specific waiver granted by the SBA.

TOPIC AWARD BY OTHER THAN THE SPONSORING AGENCY:

Due to specific limitations on the amount of funding and number of awards that may be awarded to a particular firm per topic using SBIR/STTR program funds (see above), Head of Agency Determinations are now required before a different agency may make an award using another agency's topic. This limitation does not apply to Phase III funding. Please contact your original sponsoring agency before submitting a

Phase II proposal to an agency other than the one who sponsored the original topic. (For DON awardees, this includes other SYSCOMs.)

TRANSFER BETWEEN SBIR AND STTR PROGRAMS:

Section 4(b)(1)(i) of the STTR Policy Directive provide that, at the agency's discretion, projects awarded a Phase I under a solicitation for SBIR may transition in Phase II to SBIR and vice versa. A firm wishing to transfer from one program to another must contact their designated technical monitor to discuss the reasons for the request and the agency's ability to support the request. The transition may be proposed prior to award or during the performance of the Phase II effort. Agency disapproval of a request to change programs shall not be grounds for granting relief from any contractual performance requirement. All approved transitions between programs must be noted in the Phase II award or award modification signed by the contracting officer that indicates the removal or addition of the research institution and the revised percentage of work requirements.

ADDITIONAL NOTES:

1. The Naval Academy, the Naval Postgraduate School and other military academies are government organizations but now qualify as partnering research institutions. However, Navy laboratories DO NOT qualify as a research partner. Navy laboratories may be proposed only IN ADDITION TO the partnering research institution.

2. Due to the short time frame associated with Phase I of the STTR process, the Navy does not recommend the submission of Phase I proposals that require the use of Human Subjects, Animal Testing, or Recombinant DNA. For example, the ability to obtain Institutional Review Board (IRB) approval for proposals that involve human subjects can take 6-12 months, and that lengthy process can be at odds with the Phase I time to award goals. Before the Navy makes any award that involves an IRB or similar approval requirement, the proposer must demonstrate compliance with relevant regulatory approval requirements that pertain to proposals involving human, animal or recombinant DNA protocols. It will not impact our evaluation, but requiring IRB approval may delay the start time of the Phase I award and if approvals are not obtained within 6 months of notification of selection, the award may be terminated. If you are proposing human, animal and recombinant DNA use under a phase I or phase II proposal, you should view the requirements at **http://www.onr.navy.mil/About-ONR/compliance-protections/Research-Protections.aspx.** This website provides guidance and notes approvals that may be required before contract/work can begin.

PHASE I PROPOSAL SUBMISSION CHECKLIST:

All of the following criteria must be met or your proposal will be REJECTED.

1. **Include a header with company name, proposal number and topic number on each page of your technical volume.**

2. **Include tasks to be completed during the option period in the 20 page technical volume and include the costs as a separate section in the Cost Volume. The costs for the base and option are clearly separate, and identified on the Proposal Cover Sheet, in the Cost Volume, and in the work plan section of the proposal.**

3. **Break out subcontractor, material, and travel costs in detail. Use the "Explanatory Material Field" in the DoD cost proposal worksheet for this information, if necessary.**

4. **If Discretionary Technical Assistance (DTA) is proposed, add information required to support DTA in the "Explanatory Material Field" in the DoD Cost Volume worksheet.**

5. **The Phase I proposed cost for the base effort does not exceed $80,000 with a period of performance of seven months. The Phase I Option proposed cost does not exceed $70,000 and have a period of performance of six months. The costs for the base and option are clearly separate, and identified on the Proposal Cover Sheet, in the cost volume, and in the technical volume. If proposing direct DTA, a total of up to $5,000 may be added to the Base and Option periods combined**

6. **Upload your Technical Volume and the DoD Proposal Cover Sheet, the DoD Company Commercialization Report, and Cost Volume electronically through the DoD submission site by 6:00 a.m. ET, 9 April 2014.**

7. **After uploading your file on the DoD submission site, review it to ensure that it appears correctly. Contact the DoD SBIR/STTR Help Desk immediately with any problems.**

NAVY STTR 14.A Topic Index

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NAVY STTR 14.A Topic Descriptions

N14A-T001 Topic removed from solicitation.

N14A-T002 TITLE: Innovative Unified Damage Mechanisms-Based Model to Predict Remaining Useful Life for Rotorcraft Structures

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop an innovative damage accumulative model that quantifies structural damage on rotorcraft structures and predicts remaining useful life.

DESCRIPTION: Naval rotorcraft operate in environments that include harsh loading conditions and corrosive elements, both of which factor into the accumulation of structural damage on rotorcraft components. Due to the limited amount of procurement options for new naval rotorcraft, legacy platforms are required to operate beyond their original design life, incurring costs for fleet maintenance, operation, and support. Maintainers are faced with getting the most usage out of rotorcraft components but in many cases are required to retire components early because the calculated usage life has been expended. Presently, a safe-life approach is utilized to manage structural component life and is determined using S-N curves, flight regime loads from the mission spectrum, and the rate of occurrence for each flight regime. Therefore an innovative solution is required to accurately characterize the actual fatigue damage which has accumulated on rotorcraft components in order to ensure optimum use of structural components while assuring safety. Of particular interest is determining high cycle, low amplitude fatigue damage commonly encountered in rotorcraft operating environments and not easily captured by current rotorcraft damage modeling methods. The factors examined would be the predicted number of cycles before the onset (initiation) of a crack (for metals) or delamination (for composites) would be the metrics. Then the factors would be the predicted number of cycles for the propagation of the crack/delamination. These numbers will be validated through test.

Current work to move away from maintenance based on flight time to conditional maintenance such as the Integrated Hybrid Structural Monitoring System (IHSMS) require load tracking while in flight, which require sensors to be located on specific components or areas. Recent developments in fatigue damage prognosis reveal an intimate connection between accumulated fatigue damage and measured changes in surface temperature and acoustic emission signature. Temperature sensors and piezoelectric acoustic sensors may be leveraged to measure these changes, and it could alleviate the need to track loads for each component. Magnetic properties, electrical resistivity, and thermal conductivity have also been shown to change with the accumulation of fatigue damage. New analysis techniques offer the potential to bridge thermodynamic and mechanical principles for damage accumulation at the micro scale to macro scale crack formation.

An innovative unified damage model is therefore desired that can be used to predict remaining useful life. In the long term, the model should be able to take into account progressive damage, multiple damage mechanisms, modes of failure and multiple loadings including mechanical, electro-chemical and thermal. The model should be physics based vs. phenomenological and rely on measureable and quantifiable parameters. The model should measure one or a combination of these parameters such as temperature changes of acoustic emission readings, and relate them to accumulated damage and remaining useful life through sound analytical methods without requiring prior usage history or data.

PHASE I: Develop an innovative unified damage accumulation model with sound physical basis for estimating remaining useful life. Demonstrate the application of this model to constant amplitude loading for an aircraft structural material. Constant amplitude is an input. It is a fixed interval of loading that is pre-determined by the tester.

PHASE II: Demonstrate the application of the unified damage accumulation model to variable amplitude loading. Compare the model predictions with experimental measurements.

PHASE III: Develop a prototype model for field applications. Conduct field studies to improve sensitivity of the model, and develop user-friendly software using the proposed model for remaining life predictions. Then transition software to the Naval platforms.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: All aircraft have dynamic components which are subject to fatigue damage although the rate of damage may differ depending on the loading. The model can be used on any aircraft, whether it be military or commercial, to determine the remaining life of a specific component to have it serviced before a failure occurs.

REFERENCES:
1. Amiri M, et al., 2011, January. “An experimental approach to evaluate the critical damage”, International Journal of Damage Mechanics, Vol. 20. http://ijd.sagepub.com/content/20/1/89.abstract.

2. Amiri M, et al., 2010, “Rapid determination of fatigue failure based on temperature evolution: fully reversed bending load”, International Journal of Fatigue 32, pp. 382–389. http://www.researchgate.net/publication/228453827_On_the_Role_of_Entropy_Generation_in_Processes_Involving_Fatigue.

3. Bourchak M, et al., 2007, “Acoustic emission energy as a fatigue damage parameter for CFRP composites”, International Journal of Fatigue 29, pp. 457-470. http://scholar.google.com/citations?user=G09SkVgAAAAJ&hl=en.

4. Fatigue Mechanisms: “Advances in quantitative measurement of physical damage”, 1983, ASTM Spec. Tech. Publication # 811. http://www.astm.org/DIGITAL_LIBRARY/STP/SOURCE_PAGES/STP811.htm.

5. Naderi M, et.al., 2010, “On the thermodynamic entropy of fatigue fracture”, Proceeding of the Royal Society, A, p. 466, pp. 423–438. http://rspa.royalsocietypublishing.org/content/466/2114/423.full.

6. Yong Z, et al., 1993, “Slowing down metal fatigue damage with a magnetic field”, Engineering Fracture Mechanics” Vol. 46, No. 2, pp. 347-352.http://www.sciencedirect.com/science/article/pii/0013794493902954

7. DoD NAVAIR INSTRUCTION, Public Release Authorization Request Form, 2 pages, uploaded in SITIS 03/10/2014.

8. DoD NAVAIR INSTRUCTION 5720.10, Public Release Authorization Process for Clearing Unclassified Information, 18 pages, uploaded in SITIS 03/10/2014.

9. DoD NAVAIR SYSTEMS, Guidelines for Obtaining Public Release Authorization, 2 pages, uploaded in SITIS 03/10/2014.

KEYWORDS: Prognostics, Acoustic Emission, Fatigue Damage, Failure Mechanism, Physics Based, Life Monitoring

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

N14A-T003 TITLE: Light-Weight, Solar Cells with High Specific Power and Conversion Efficiency

TECHNOLOGY AREAS: Air Platform, Battlespace

OBJECTIVE: Develop a light-weight, high-performance solar cell with specific power (>1.2 kW/kg) and high conversion efficiency (>37%).

DESCRIPTION: There is an ever growing Navy interest in the development of Small Unmanned Aerial Vehicles (SUAVs) to provide persistent Intelligence, Surveillance, Reconnaissance and Communication (ISRC) capabilities in extended and uninterrupted flight missions. To achieve the goals of persistent surveillance, it is highly desirable and usually necessary to have the SUAVs stay deployed at operating altitude in a continuous, long-endurance 24-hour, 7-day-a-week (24/7) operation.

The long-endurance mission requirements pose a very difficult challenge to large and small UAVs with either internal combustion engine-based or electrical motor-based propulsions. SUAVs with combustion engines typically cannot carry enough fuel to meet long endurance requirements without refueling. Likewise, SUAVs with electrical motors also need recharging as the energy density of on-board batteries is lower than that of chemical or fossil fuels. That requires the SUAVs returning to the base every few hours for recharging and hence drastically limits their field ISRC capabilities.

Current state-of-the-art solar power and energy systems for SUAVs are far from being adequate for any continuous, persistent ISRC applications. In spite of the recent advances for efficient electrical propulsion systems and light-weight composite materials for air frames, there is still a critical need for efficient, light-weight, deployable and renewable energy source, in the form of solar cells that can be integrated with the UAVs' exterior surfaces, to meet the SUAVs' 24/7 operational challenges. While it is intuitive that the performance of a solar cell scales with the light-to-electric conversion efficiency, another lesser known but even a more important performance figure of merit of solar cells that are critical for integration with SUAVs is their specific power in terms of the amount of power generated per unit weight of the cells.

State-of-the-art multi-junction solar cells grown on single crystal have been demonstrated with efficiencies approaching 37%, but with the specific power of crystalline-based solar arrays limited to no more than 0.2 kW/kg due to the single-crystal cells' requirement of stiff and heavy support structures. On the other hand, thin-film photovoltaic solar cells on light-weight flexible substrates have been demonstrated with specific power close to 1kW/kg. However, the thin-film solar cells typically have low conversion efficiencies that are less than 10%. Therefore, the Navy is seeking the innovative technology development of solar cells that have the combined characteristics of high conversion efficiency (>37%) and specific power (>1.2 kW/kg) to power SUAVs for future Naval 24/7 persistent ISRC, and autonomous operations.

PHASE I: Develop innovative technological design approach for solar cells with the combined performance characteristics of over 37% conversion efficiency and over 1.2 kW/kg specific power. Identify technological and reliability challenges, propose viable risk mitigation strategies, and demonstrate proof-of-concept for the proposed technology. A viable design path forward for scaling up the output power of the solar cell array should be proposed and included as part of the deliverable for Phase I.

PHASE II: Design, fabricate, characterize and deliver a solar cell array prototype that produces over 1.2kW/kg specific power at over 37% conversion efficiency. It is also critical to incorporate manufacturing cost reduction as part of the design criteria for the scalable solar cell array throughout all the phases of this program.

PHASE III: Commercialize the solar cell technology and leverage the advantages of scalable manufacturing process to develop a very cost-effective manufacturing process for technology transition to various system integrations for both DoD and civilian applications.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: This high-performance, light-weight solar cell technology has a very vast private sector commercial potential. The private sector can significantly benefit from this technology development in any commercial areas that can utilize highly efficient, portable, renewable energy source that has virtually zero carbon foot-print.

REFERENCES:
1. King, R. R. et al., 2009, Proceeding of 24th European photovoltaic solar energy conference, p. 55. http://www.spectrolab.com/pv/support/Band-Gap-Engineered_Architectures_for_High-Efficiency_Multijunction_Concentrator_Solar_Cells-Presentation.pdf.

2. Takamoto, T., Agui T., Washio H., Takahashi N., Nakamura K., Anzawa O., Kaneiwa M., Kamimura K., Okamoto K., & Yamaguchi M., 2005, January, "Future development of InGaP/(In)GaAs based multijunction solar cells," 31th IEEE PVSC, p. 519, Orlando, FL.http://www.dodtechmatch.com/DOD/Opportunities/PrintSBIR.aspx?id=AF073-098.

3. Wanlass, M., Geisz J., Kurtz S., Wehrer R., Wernsman B., Ahrenkiel S., Ahrenkiel R., Albin D., Carapella J., Duba A., & Moriaty T., "Lattice-mismatched approaches for high performance III-V photovoltaic energy," 2005, January. 31th IEEE PVSC, p. 530, Orlando, FL. http://www.researchgate.net/publication/4154101_Lattice-mismatched_approaches_for_high-performance_IIIV_photovoltaic_energy_converters/file/72e7e52cb418b3a554.pdf

KEYWORDS: Reconnaissance; UAV; Surveillance; Solar Cell; Information; Conversion Efficiency

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

N14A-T004 TITLE: Active Combustion Control (ACC) of Augmentor Dynamics

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Advance the innovation in active combustion control (ACC) technologies to develop active screech suppression system for thrust augmentors in high-performance gas turbine engines.

DESCRIPTION: Combustion instability, or screech, occurs in many combustion systems. Combustion instability is due to the complex physical coupling of the acoustic resonances in the combustion chamber with fluctuations in the heat release of the combustion process. In modern gas turbine afterburners, instability or screech modes typically occur in the range of frequencies from hundreds to thousands of hertz. Coupling can produce large pressure fluctuations that can be severe enough to damage engine hardware. Three stream engines and the integration of the augmentor, exhaust ducts, and nozzle for next-generation gas turbines will increase the desired range of operability for the augmentor and further challenge the ability to manage instabilities.

Historically, screech has been mitigated by two very different approaches; (1) passive combustion control, such as damping, and (2) altering the screech coupling or driving. In the damping approach, acoustic liners and resonators have been fashioned to absorb acoustic energy; liners, by their nature, are most effective on modes with frequencies greater than 1 kHz, whereby resonators can be tuned to suppress much lower frequency modes, less than 1 kHz. However, resonators are physically large (approximately 3 feet in diameter and 5 feet in length) and have a significant system weight penalty (approximately 30-40 pounds). Integration of screech liners or resonators with multi-stream engines also presents significant integration challenges for future systems.

Altering the coupling or driving for screech involves changing the aerodynamics or at least the fuel delivery to change the spatial or temporal characteristics of the heat release. This is often accomplished empirically since reliable analytical tools do not exist for this complex process. If such changes are needed late in the engine development program, this can be very costly to implement and difficult to retrofit. Another method of altering the heat release is to implement an active control system which will modulate the fuel or air sources depending on the operating condition and instability presence to alter the heat release.

ACC is an emerging art of regulating combustion performance using a dynamic hardware component that rapidly modifies combustion input. ACC relies on proper timing of software-controlled actuation rather than spatial changes to the combustor hardware as practiced currently in combustion instability problems. Since timing adjustment is simpler than the potential geometry modifications associated with conventional passive control, ACC could provide potential flexibility in performance while eliminating costly retrofit for combustor design modification. With continuing advances in electronics, ACC could be developed into a next-generation, paradigm-shifting technology for controlling unwanted combustion dynamics.

One of the main active control approaches is high bandwidth active control using the fuel, whereby fuel is modulated at the frequency of the instability using an actuator valve. The phase of the modulation is varied actively until sufficient heat release is out of phase with the instability which results in suppression of the instability. Active control methods have demonstrated excellent control of combustion instability in ground-based gas turbine systems, where weight and actuator power consumption are not significant factors. Development of actuators with sufficient driving capability is still an open research area.

Combustion in the augmentor is governed by many unsteady physical processes. Desired are new active control screech suppression technologies that target the physical processes in the afterburner. These new active control technologies should be developed such that they could easily be implemented in current gas turbine augmentors with little weight (less than 30-40 lbs) or cost consequence. These technologies should also address exhaust integration issues for next-generation systems without adversely impacting the proper functioning of the exhaust or the engine as a whole.

PHASE I: Identify, develop, and demonstrate the feasibility of an innovative concept using the proposed ACC for suppression of instabilities in a laboratory environment. Identify the experimental methodology to evaluate the influence of the technology on the magnitude and bandwidth of the instabilities observed in modern augmentors and address the feasibility for full-scale implementation.

PHASE II: Further develop the proposed concept and conduct extensive experimental evaluation of the active control technologies identified in Phase I. Assess the ability of the candidate technology to reduce the magnitude and bandwidth of screech instabilities that occur in modern augmentors. Perform a prototype demonstration of the active control suppression concept.

PHASE III: Collaboration with an original equipment manufacturer (OEM) of high-performance afterburners is recommended to ensure successful transition of technology concepts. Demonstrate a fully-functional, active control system for screech suppression and transition the approach to Naval Aviation platforms.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The technology has the true potential for dual-use applications by suppressing combustion instabilities in both military and civil gas turbine engines because the methodology should be applicable to main-burner combustion instabilities.

REFERENCES:
1. DeLaat, J.C., Kopasakis, G., Saus, J.R., Chang, C.T., and Wey, C. (2013). “Combustion Control for a Low-Emissions Aircraft Engine Combustor Prototype: Experimental Results,” Journal of Propulsion & Power, Vol. 29 (4), pp. 991-1000.

2. Schadow, K.C., Gutmark, E. and Wilson, K. J. (1992). “Active Combustion Control in a Coaxial Dump Combustor,” Combustion Science and Technology, Vol. 81, No 4-6, pp. 285-300.

3. Candel, S. (2002). “Combustion Dynamics and Control: Progress and Challenges,” Proceedings of Combustion Institutes, Vol. 29, pp. 1-28.

KEYWORDS: Active Combustion Control; Screech; Combustion Instability; Active Flow Control; Active Instability Suppression; Augmentor Instability

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

N14A-T005 TITLE: <u>Design Optimization and Analysis of Advanced Exhaust Systems</u>

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop methodologies to resolve and optimize the multi-physics environment of high-performance engines’ exhausts.

DESCRIPTION: It is recognized that new exhaust systems may include features such as compact, sinuous ducts featuring complex 3-D non-axisymmetric shapes, fixed exit areas, thrust vectoring etc., constructed with a minimum number of moving parts. The current capability in the aerospace industry is to conduct the aerodynamic and structural analyses in an uncoupled fashion, which is a cumbersome, time consuming, and therefore expensive, practice. For that reason it typically results in less than optimal final exhaust configurations under tight time and budget constraints.

Significant recent advances in Computational Fluid Dynamics (CFD), particularly employing the Large Eddy Simulation (LES) method, have revealed the underlying physics of non-ideally expanded hot, transient supersonic exhaust plumes in never before seen detail. The exhaust plumes from non-axisymmetric serpentine exhausts are currently not well understood. However, it is possible that employing LES to analyze the exhaust system interior aerodynamics, together with the plume, will improve the state-of-the-art.

This solicitation seeks the development of an analysis tool that predicts both the steady and unsteady stresses in propulsion system exhaust components and also employs optimization methodologies to minimize component weight and maximize system performance. In addition, these structural analyses should be coupled to advanced aerodynamics analyses of the interior of the gas turbine engine exhaust duct and nozzle and the exterior of the air vehicle aft-deck and engine plume.

PHASE I: Determine feasibility of proposed methodology for the design or optimization of round engine exhausts transitioning to non-axisymmetric exhausts including aircraft aft-decks and Single-Expansion Ramp Nozzle (SERN) type non-axisymmetric nozzles employing state-of-the-art numerical methodologies. The methodology should be capable of accurately resolving the multi-physics environment of high-performance engines exhaust systems, including steady state and acoustic wall pressures, unsteady heat transfer coefficients and exhaust plumes.

PHASE II: Develop prototype software analysis tools and perform an aerodynamic and structural evaluation of a conceptual exhaust system or available nozzle design and verify it against experimental test data. Demonstrate proposed methodology for the design or optimization of advanced exhaust ducts with advanced exhaust nozzles, thrust vectoring and aft decks employing state-of-the-art experimental or numerical methodologies capable of accurately resolving the multi-physics environment of high-performance engines' exhausts. Validate the obtained analytical results with experimental data.

PHASE III: Transition the developed jet shear layer pressure measurement technology to NAVAIR Propulsion & Power and possibly to original equipment manufacturers (OEMs) responsible for propulsion systems, to analyze the design and implementation of "second generation" nozzles hardware for current/future aircraft programs.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Civil applications of the developed tools/methodologies would benefit from the design of commercial aircraft nozzles employing coupled multi-physics (structural-aerodynamic) and design optimization capabilities, currently not available to industry.

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KEYWORDS: non-axisymmetric nozzles; SERN Exhaust Systems; Aft Decks; Serpentine Exhaust Ducts; Multi-Physics Modeling; Design Optimization

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

N14A-T006 TITLE: Development of a Safer Lithium-ion (Li-ion) Battery for Naval Aircraft Applications Through Thermal Management Design

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop and demonstrate a safe Lithium-ion (Li-ion) battery that is capable of preventing thermal runaway conditions between cells or group of cells by integrating novel thermal management technologies.

DESCRIPTION: Lithium batteries are composed of multiple individual cells connected in parallel and/or series depending on the specific application. If the desired outcome is to increase overall voltage or overall capacity, they are connected in series or parallel, respectively. If both increased power and capacity are required, the conformation of the cells becomes more complicated. In large aircraft batteries, there are a large number of risks in battery engineering, especially due to the power requirements aircrafts demand. Catastrophic failure by aircraft damage, fire damage, and battery explosion is one risk that has turned into an issue for aircraft Li-ion batteries. In addition, aircraft Li-ion batteries are operated in extreme environmental conditions. Adverse operating conditions can result in thermal runaway conditions due to failed cells and thereby limit the life expectancy of aircraft Li-ion batteries. Conventional thermal management technologies for dealing with safety and battery life may increase the overall size and weight of the battery which can ultimately eliminate the energy and power benefits derived from the use of Li-ion batteries on aircrafts. The key to avoiding these kinds of failures is to develop novel thermal management technologies such as passive techniques (advanced insulation), active techniques (heat pipes, working fluids), and light-weight structured materials.

The goal is to design an integrated battery pack system concept to develop a fully functional battery product. The integrated battery pack system should be designed in such a way that the proposed advanced thermal management technologies can support individual cell temperature monitoring and help prevent single cell thermal runaway conditions as well as limit/eliminate thermal failure propagation leading to cell/battery fratricide. The design should be capable of insulating cell-level thermal events to prevent thermal transfer, propagation between cells as well as the ability to dissipate heat faster to prevent failure. Single cells, depending on the electrode materials and design, may undergo high energetic release. The overall thermal management system must be designed so that in the event of thermal runaway conditions the propagation will be limited to the cell pack (threshold) or single cell (objective), thereby ensuring maximum safety for the battery in case of failure. The Li-ion product should be thermally stable over a wide temperature range (negative 18 degrees Celsius to 71 degrees Celsius operational and exposure to 85 degrees Celsius [4]), as well as meeting electrical needs of aircraft in relevant environment (shock test, vibration test, humidity test, transient drop test, etc.[4]).

PHASE I: Develop the proof of concept for a battery pack system ensuring maximum safety in case of thermal event leading to cell fratricide. Use state-of-the art modeling and simulation (M&S) tools for thermal management design and verify by demonstrating at cell/module level.

PHASE II: Develop a safer Li-ion battery prototype by integrating innovative thermal management technologies to demonstrate the response to failure mode in a lab environment.

PHASE III: Demonstrate the battery pack system that is thermally stable over a wide temperature range as well as meet the electrical needs of aircraft in operational environment, and transition the technology to the appropriate navy platforms (Ex. F/A-18E/F, H-60, and F-35).

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Li-ion batteries are one of the most prevalent commercial types of rechargeable batteries due to their superior properties such as very high energy and power density. Because of this they are gaining popularity in commercial aircraft applications.
Improvements made under this topic would be directly marketable to the commercial aviation fleet.

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KEYWORDS: Li-ion Batteries, Electrical Power, Directed Energy Weapons, Thermal Management Technologies, Safety, Extreme Environmental Conditions

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

N14A-T007 TITLE: More Efficient GaN - SiGe based MMICs for Communication and Radar Systems

TECHNOLOGY AREAS: Electronics

OBJECTIVE: Develop a high-efficiency and low-cost Gallium Nitride (GaN) Low Noise Amplifier (LNA) Monolithic Microwave Integrated Circuits (MMIC) with integrated Silicon-Germanium (SiGe) control approach for Active Electronically Scanned Arrays (AESAs) to supports pulse mode interleaving.

DESCRIPTION: In order to fulfill future demands on power, bandwidth, robustness, weight, overall cost and multi-functionality future AESAs will need to utilize highly efficient GaN based LNAs in combination with integrated digital signal processing (DSP) and control functions (including phase control) using SiGe multifunction chips. A key attribute of these next generation AESAs will require the capability to interleave multiple modes at the pulse level in order to meet stressing mission objectives. The inclusion of SiGe core-chip as an integral part of the solution is necessary to support pulse mode interleaving and is a major milestone leading to digital front-end solutions. The inclusion of SiGe based control also lowers overall system power requirements and increases reliability since discrete device interconnects are a major source of failures.

The goal of this technology development is to design, develop and fabricate a prototype GaN and SiGe based receive module approach. While the ultimate goal is to address the needs of both radar and communications systems, here the focus shall be limited to C-band AESA radar applications with separated transmit and receive elements.

PHASE I: Develop and analyze preliminary design of high efficiency, low power consumption, GaN SiGe based MMIC receiver. Prove feasibility of preliminary design and expected performance of the low noise MMIC receive module capable of pulse mode interleaving.

PHASE II: Fabricate, test and evaluate a prototype receiver MMIC. Demonstrate prototype to highlight the low power consumption, power dissipation, gain, noise temperature and digital control functions to include pulse mode interleaving. The prototype may utilize commercially available GaN amplifiers in order to allow focus on the SiGe functionality and module integration.

PHASE III: Further mature receiver MMIC and integrate into a demonstration AESA and address manufacturing issues in preparation for transition to Triton and Fire Scout Unmanned Air Systems (UAS).

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Commercial applications include AESA based mobile communications and sensing systems.In particular the devices developed as part of this investigation can be used in IEEE-802.11a Unlicensed National Information Infrastructure (U-NII) systems expected to be utilized in the near future by many wireless internet service providers. The U-NII systems operate at C-band.

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KEYWORDS: SiGe; GaN; Monolithic Microwave Integrated Circuits (MMICs); Noise Temperature; Low Power Consumption; Low Noise Amplifier

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

N14A-T008 TITLE: Object Cueing Using Biomimetic Approaches to Visual Information Processing

TECHNOLOGY AREAS: Air Platform, Battlespace, Human Systems

ACQUISITION PROGRAM: PMA 281

OBJECTIVE: Develop object recognition capabilities based upon biomimetic sensory, perceptual, and cognitive processes, which can effectively and efficiently process imagery data.

DESCRIPTION: In the data-rich operational world of our military forces, it is increasingly difficult to sift through the vast amount of information to determine that which is mission relevant. Efforts to develop automated object recognition, cueing, and assorted automated/semi-automated decision aids have been ongoing for many decades, but have yet to produce viable technologies able to reliably and accurately distinguish objects of interest from varieties of imagery data. As such, the burden of processing such data falls to laborious and expensive manual human processing. The complexity of such visual search and pattern recognition is certainly at the heart of the difficulties in attaining this capability, but some have argued that there may be a fundamental flaw in the 'brute force' algorithm approach that is traditionally used to discern patterns and identify objects. The simplest organism's ability to identify objects remains vastly superior to even the most sophisticated software, so efforts to model biological sensory, perceptual and cognitive processes have been underway in an effort to replicate the powerful functionality of simple biology.

It has been noted (e.g., Shoujue & Jianliang, 2005) that traditional pattern recognition methods of statistical modeling points in a high-dimensional space are generally inferior to biomimetic pattern recognition approaches; biomimetic approaches have proven successful in applied domains, such as with electro-optical (EO)/infra-red (IIR) imagery processing with high object classification (Pace & Sutherland, 2001). These biomimetic approaches have successfully modeled fundamental animal information processing (Lang et al., 2011) and general frameworks (Chikkerur and Poggio, 2011), as well as increasingly detailed biological representations (c.f., Hay et al., 2011) and present an opportunity for application in assorted remote sensing domains. These applications have been both highly specific (e.g., modeling highly specific areas of the brain such as retina, Tadross et al., 2000) as well as larger scale to include subcortical (Cecchi, Kozloski,Peck, and Rao, 2005) and cortical (e.g., see Lebiere & Anderson, 1993) structures.

PHASE I: Identify and research candidate biomimetic modeling approaches, functions, integrations, and concepts to support object identification and recognition, and demonstrate proof-of-concept.

PHASE II: Develop a prototype system capable of reliably and accurately discriminating land and sea objects from imagery data of quality comparable to typical imagery-type data that includes, but is not limited to full motion video (FMV), EO/IR data on moderate entity count scenarios.

PHASE III: Transition a final system capable of reliably and accurately discriminating land and sea objects from imagery-type data that includes, but is not limited to full motion video (FMV) and EO/IR data in high-entity count scenarios, to an appropriate Navy Unmanned Air System (UAS).

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Effective automated object recognition from imagery data for vehicles would be useful for the United States Coast Guard (USCG), Department of Homeland Security (DHS), Department of Energy (DOE), and other federal agencies for which protection from vehicle based threats is important. Commercial security entities could likewise benefit from automated processing of imagery data. Federal, state and commercial rescue organizations could also benefit from the ability to track objects. All organizations for which remote imagery is valuable could potentially benefit from this technology.

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KEYWORDS: Image Processing; Biomimetics; Pattern Recognition; Automatic Object Recognition; Automatic Object Classification, Autonomous Systems

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

N14A-T009 TITLE: <u>Precise Positioning with Local Signal Carrier Phase Measurements and Global Positioning System (GPS) Fusion</u>

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PMA 213

OBJECTIVE: Develop precise positioning techniques based on a local radio system and fusion algorithms combining Global Positioning System (GPS), which are suitable for shipboard landing systems.

DESCRIPTION: Carrier phase measurements in GPS are well known to enable precision performance at centimeter level. In consideration of GPS possibly degraded or unavailable, however, carrier phase measurements in a local radio system of transmitters and receivers are proposed here for precise positioning within Line Of Sight (LOS) distances. Local transmitters and receivers may be found in legacy military communications e.g. LINK16 and/or commercial pseudo-lite products. Also, they may be newly built in the future for dual purpose of positioning and communications.

In maximally re-utilizing GPS technologies (not necessarily GPS-original), it is important to thoroughly understand differences between the local radio system and GPS. First of all, local signals can be much stronger due to the proximity, and result in higher Signal to Noise Ratio (SNR) for receiver tracking circuitries such as Phase Lock Loops (PLLs), Frequency Lock Loops (FLLs) and Delay Lock Loops (DLLs). Consequently, local receivers can produce better carrier phase measurements even in higher dynamics, see Chapter 12 of Reference 1. The measurement update rate can reach 100 Hertz or higher with less cycle slips. On the other hand, local receivers may experience non-planar such as spherical or paraxial wave fronts due to the proximity and directivity from/to transmitters. The proximity is as close as 100 feet or less for landing aircrafts on the ship. The directivity is likely imposed to avoid multi-paths caused by reflection on aircraft, ship structures and sea surfaces. Thus, it remains as a concern that receiver tracking circuitries may experience less optimal or even ill-functional from non-planar wave fronts, even if they are designed optimal for planar wave fronts. Proposals should include clear understanding of fundamental differences, if any, of the local and GPS receiver tracking performances.

In Differential or Relative GPS (DGPS/RGPS), processing carrier phase measurements can be said to resolve integer ambiguities in a larger context of complementary (Kalman) filtering, which is a particular sensor fusion theory itself. The classical processing method is documented in Reference 2, whereas a new approach is published in Reference 4. In either case, GPS is not a sole source of measurements but the aiding sensor to IMU (Inertial Measurement Unit) in achieving precise positioning. In general, any qualified system other than GPS can be an aiding sensor to IMU. Reference 3 explains an optical system as the aiding sensor to IMU. Here, the proposed local radio system is now intended as the aiding sensor to IMU for precise positioning. Proposers should describe how they will approach precise positioning algorithms in the context of complementary filtering or another sensor fusion framework through theoretical analysis, simulations and/or physical experiments. (GPS and IMU are complementary in that GPS and IMU provide measurements at low and high update rates, respectively. The proposed local radio system and IMU are not complementary in the same sense when the local system produces measurements at the rate as high as IMU.) If possible, proposals should describe how to accomplish precise positioning solely based on the proposed local radio system without IMU.

When properly implemented, the proposed local radio system should have multiple advantages over GPS: less sensitivity to multi-paths, less cycle slips, faster complementary (Kalman) filter convergence and higher receiver dynamics. While, the local radio system would have short-comings. A typical case is Dilution of Precision (DOP) due to a limited geometry as the local radio system is installed shipboard.

As the project becomes mature in later stages, the proposed local radio system should be fused with GPS. The contenders should consider successful reports later on that analyze merits from combining the locality and globalism. It is very desirable to eventually embed the developed technologies inside GPS receivers of the next generation.

PHASE I: Determine feasibility of precise positioning techniques based on carrier phase measurements from a local radio system of transmitters and receivers. Assess maximal reuse of GPS receiver tracking circuitries in the local radio system. Develop and simulate basic complementary (Kalman) filtering with the local radio system and IMU.

Clearly present fundamental differences, if any, of the local and GPS receiver tracking performances through theoretical analysis, simulations and/or physical experiments.

PHASE II: Refine the basic complementary filtering, or devise a broader fusion algorithm for the local radio system and IMU. Simulate them to be suitable to real-time aircraft control in shipboard landing environments. In comparison to GPS counterparts, evaluate filtering performances in multi-paths, cycle slips, filter convergence, receiver dynamics, DOP and others. Devise fusion architecture/algorithms with existing RGPS algorithms for shipboard landing systems. Verify and validate improvements from stand-alone algorithms to fusion algorithms for combined GPS and the local radio system that likely include IMUs. Through theoretical analysis, simulations and/or physical experiments, clearly present any advantages or short comings between standalone local radio systems and fused local radio systems with GPS.

PHASE III: Develop dual receivers for GPS and the local radio system. Test and evaluate dual receivers in shipboard landing operations. Develop airborne-to-airborne precise positioning and navigation. Explore applications such as for precision strike and electronic warfare.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The developed local signal carrier phase measurement techniques will result in LOS navigation applications in general that require high dynamics beyond what GPS can handle. Also, the developed duality with GPS in particular will enable more reliable automated unmanned vehicles such as in open field mining operations and airborne highway traffic surveillances.

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KEYWORDS: carrier phase measurement, local signal, GPS, RGPS, integer ambiguity, complementary filtering, fusion, IMU, multi-path, cycle slip

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

N14A-T010 TITLE: Innovative Materials for Microwave Tube Applications

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: PEO IWS 2, Above Water Sensors

OBJECTIVE: Research and development of high purity metal alternatives for microwave tube (MWT) production that meet or exceed the performance and reliability of existing materials.

DESCRIPTION: The Navy uses microwave tubes (MWT) in both radar and electronic warfare (EW) systems. Throughout the microwave tube industry, high purity metals are increasingly difficult and costly to procure. For example, vacuum-grade high purity copper and copper-nickel alloys such as Monel and cupronickel (ref 1, 2, 3) are highly desirable in MWT manufacturing processes because they are corrosion resistant, often stronger than steel, have a low coefficient of thermal expansion, and can be welded and brazed, both to other metals and to metallized ceramics. However, these alloys are considered “niche” market materials and are therefore expensive and increasingly only available from foreign suppliers

Replacement materials are needed that can significantly stabilize the (domestic) MWT material supply base while improving material and process reliability for improved vacuum integrity, manufacturing yield, corrosion resistance, and thermo-mechanical compatibility, resulting in longer life microwave tubes and hence, decreased life-cycle cost. The main difficulty with many otherwise attractive alloys is the fact that metallic and non-metallic impurities infuse into the material and lead to undesirable consequences such as vacuum degradation and cathode poisoning. In some cases, the coefficient of expansion of the impurity is greatly different than the alloy, thus leading to weakness in the material. The weaknesses are often found during the microwave tube manufacturing process where brazing, welding and heat cycling are commonplace. Impurities often cause virtual leaks to occur where vacuum integrity breaks down and the microwave tube ceases to function properly. Presently, in order to mitigate this risk, microwave tube manufacturers often have to plate the material to seal in the potential weak spot which adds cost and time to the manufacturing process.

Alternatives are sought to improve existing manufacturing techniques for MWT relevant metal alloys and/or to develop new materials suitable to replace existing vacuum-grade materials while maintaining MWT compatible characteristics such as coefficients of expansion, manufacturability and thermal conductivity required by the industry. Innovative materials (or processes such as plating and brazing) are needed which mitigate the niche market supply problems which plague the microwave tube industry. Furthermore, proposed solutions should decrease the dependence on foreign supply and the resulting fluctuations in material cost. The solutions will also lead to significant reductions in life cycle costs.

PHASE I: The company will develop a concept for providing high purity materials for microwave tube applications that meet the requirements described above. The company will demonstrate the feasibility of the concept in meeting Navy needs and will establish that the concept can be feasibly developed into a useful product for the Navy. Feasibility will be established through material testing, and analytical modeling. The small business will provide a Phase II development plan that addresses technical risk reduction and provides performance goals and key technical milestones.

PHASE II: Based on the results of Phase I and the Phase II development plan, the small business will develop prototype materials and processes for evaluation. The prototype will be evaluated to determine its capability in meeting the performance goals defined in Phase II development plan and the Navy requirements for high purity materials for microwave tube applications. Microwave tube compatibility and performance will be demonstrated through prototype evaluation and modeling or analytical methods over the required range of parameters including thermal stress cycling. Evaluation results will be used to refine the prototype into an initial material/process that will meet Navy requirements. The company will prepare a Phase III development plan to transition the technology to industry for the production of microwave tubes for Navy use.

PHASE III: The company will be expected to support the Navy in transitioning the technology for Navy use. The company will develop innovative materials for microwave tube applications in accordance with the Phase III development plan for evaluation in order to determine suitability of the material(s) in the MWT industry and the effectiveness of microwave tubes incorporating these new materials in an operationally relevant environment. The company will support the Navy for test and validation to certify and qualify the material(s) for Navy use.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Innovative materials developed for Navy MWT application have equal applicability to commercial microwave tubes. Other Government agencies and commercial customers use microwave tubes for a wide variety of radar, telecommunications, medical therapy, food and materials processing application. In addition, various scientific applications (such as plasma fusion and materials research) exist which also rely on microwave tube technology.

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KEYWORDS: Microwave Tubes, High Purity Metals, Copper-Nickel Alloys, Monel, Cupronickel, Vacuum-Grade Materials.

N14A-T011 TITLE: Development of Characterization of Failure Modes for Mechanical Components

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PMS397, OHIO Replacement program.

RESTRICTION ON PERFORMANCE BY FOREIGN CITIZENS (i.e., those holding non-U.S. Passports): This topic is "ITAR Restricted". The information and materials provided pursuant to or resulting from this topic are restricted under the International Traffic in Arms Regulations (ITAR), 22 CFR Parts 120 - 130, which control the export of defense-related material and services, including the export of sensitive technical data. Foreign Citizens may perform work under an award resulting from this topic only if they hold the "Permanent Resident Card", or are designated as "Protected Individuals" as defined by 8 U.S.C. 1324b(a)(3). If a proposal for this topic contains participation by a foreign citizen who is not in one of the above two categories, the proposal will be rejected.

OBJECTIVE: The research and development needed is to characterize the failure modes of the mechanical components of submarine systems under extreme loadings, create a database of failure modes and develop a viable multiple component shock qualification process for components with similar failure modes that is automated via the development of a novel software tool.

DESCRIPTION: The Navy's shock hardening (ref 1) program is a critical element of the commitment to ensuring the safety of its crew members and the mission capabilities of its war fighting vessels to extreme loadings (ref. 2-3), such as an underwater explosion (UNDEX) shock event. The Navy is also committed to reducing non-recurring engineering costs in the design of each new submarine class. Mission critical components are required to remain operable following a shock event. Demonstration that each component has met this requirement is currently accomplished through standard testing, applying validated analytical methods or demonstrating that a new component which is similar to a previously "qualified" component has equal or greater shock resistance as the previously "qualified" component. The latter method is known as an "extension". The extension process allows for the certification of shock worthiness of new components that are similar in physical aspect, shipboard installation and intended use (form, fit and function) to a previously "qualified" component. Components that do not meet the similarity criterion must be qualified by either a shock test or an extensive Transient Shock Analysis (TSA), which is also limited in its applicability, due to its inability to demonstrate the successful operation of mechanical components following a shock event. Both qualification via shock test and TSA incur more cost than qualification via the extension process. Thus, to meet both the Navy's shock hardening requirements and ship design for affordability goals, the applicability of the more cost effective extension process must be expanded. The expansion of the extension process will reduce the labor hours (designer and approval authority) required to obtain shock qualification of systems to the Navy's shock hardening program levels. Expanding the extension process requires the development of a novel criterion for component similarity that is based on component failure modes. The development of a failure mode similarity based extension process will establish the first ever database of component failure modes associated with a class of submarine components when responding to high intensity mechanical loading and a unique analytical tool (in the form of PC based software) for certifying the shock worthiness of submarine components via a comparison and assessment of component failure modes.

PHASE I: The company will develop a concept for establishing the submarine component failure mode database and an analytical methodology of certifying the shock worthiness of new submarine components that have similar failure modes. The company will demonstrate the feasibility of the concept in meeting Navy needs and will establish that the concept can be feasibly developed into a useful product for the Navy. Feasibility will be established by analytical modeling. A Phase I option, which is dependent upon results of Phase I Base, for conducting laboratory testing to verify analytical modeling efforts will be included. The company will provide a Phase II development plan which addresses technical risk reduction and provides performance goals and key technical milestones.

PHASE II: Based on the results of Phase I and the Phase II development plan, the company will populate submarine component failure mode database and develop the associated analytical method. The analytical method will be evaluated to determine its capability in meeting the performance goals defined in Phase II development plan and the Navy requirements for the analytical method. Validation of the analytical method will be demonstrated through a series of "building block" simplified testing and data analyses. Evaluation results will be used to refine the analytical method into a tool suitable for use by both design engineers and Navy survivability approval authorities according that will meet Navy requirements. The company will prepare a Phase III development plan to transition the technology to Navy use.

PHASE III: The company will be expected to support the Navy in transitioning the first ever database of component failure modes and the innovative analytical method of shock qualification for Navy use. The company will establish a component shock failure mode database that can be easily and continually updated by Navy engineers as more data is acquired. The company will also refine and finalize the tool developed. The company will support the Navy for test, validation and implementation of the tool for Navy use.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: An analytical method for assessing the resistance of multiple components with similar failure modes to high intensity loadings has potential commercial applications where high intensity loading are of concern, such as the automobile and aircraft industries.

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KEYWORDS: shock hardness; shock qualification; shipboard shock; failure modes; shock testing of mechanical components; analytical method for assessing resistance

N14A-T012 TITLE: Environmental Effects Radar Modeling For Training

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: PMS505, Littoral Combat Ship Fleet Introduction and Sustainment Program Off

RESTRICTION ON PERFORMANCE BY FOREIGN CITIZENS (i.e., those holding non-U.S. Passports): This topic is "ITAR Restricted". The information and materials provided pursuant to or resulting from this topic are restricted under the International Traffic in Arms Regulations (ITAR), 22 CFR Parts 120 - 130, which control the export of defense-related material and services, including the export of sensitive technical data. Foreign Citizens may perform work under an award resulting from this topic only if they hold the "Permanent Resident Card", or are designated as "Protected Individuals" as defined by 8 U.S.C. 1324b(a)(3). If a proposal for this topic contains participation by a foreign citizen who is not in one of the above two categories, the proposal will be rejected.

OBJECTIVE: The objective is to develop innovative real-time physics-based software that models environmental effects on shipboard radars for use in shore-based tactical trainers

DESCRIPTION: LCS Training includes a combination of classroom instruction, computer-based lessons, live and virtual simulations, and shipboard evolutions in port and, where appropriate, at sea. The goal is to bring the crew member as close as possible to final systems operator qualifications before operations, tasks, or missions aboard ship commence. Therefore, simulators take a prominent role in the LCS training construct and a high level of realism is essential. Simulated bridges can include all modern navigation technologies; simulate all types of navigation conditions, breakdowns, emergencies, maritime areas and maneuvering situations (Ref 1).

The LCS integrated bridge and combat systems tactical scenario training for sailors replicates the basic layout and design of the LCS command and control, propulsion control systems and a bridge that includes video screens. However the simulators are not capable of displaying radar clutter or other environmental effects. Moreover, a search has identified no existing simulators that provide that capability. Some examples of clutter are rainstorms, sea surface scatter, land, trees, mountains, and buildings. Clutter has a number of undesirable effects on radar's operation. It obscures targets by overpowering the target's signal and reduces the ability to detect targets of interest (Ref 2). Sailors must be able to step aboard the ship ready to stand the watch and carry out their duties with minimal onboard familiarization.

In order to increase the realism and effectiveness of training, an innovative software solution is required that models environmental effects into radar displays. This software shall; simulate the impact of environment effects (rain, snow, dust, sea state, etc.) on the radar display; simulate the impact of jamming on the radar display; simulate the impact of operator actions (adjustment of radar settings) on the radar display.

PHASE I: The company will develop a concept for modeling environmental effects that meet the requirements described above. The company will demonstrate the feasibility of the concept in meeting Navy needs and will establish that the concept can be feasibly developed into a useful product for the Navy. Feasibility will be established by material testing and analytical modeling. The small business will provide a Phase II development plan must address technical risk reduction and provides performance goals and key technical milestones.

PHASE II: Based on the results of Phase I and the Phase II development plan, the small business will develop a prototype for evaluation. The prototype will be evaluated to determine its capability in meeting the performance goals defined in Phase II development plan and the Navy requirements for modeling environmental effects. System performance will be demonstrated through prototype evaluation and modeling or analytical methods over the required range of parameters including numerous deployment cycles. Evaluation results will be used to refine the prototype into an initial design that will meet Navy requirements. The company will prepare a Phase III development plan to transition the technology to Navy use.

PHASE III: The company will be expected to support the Navy in transitioning the technology for Navy use. The company will develop software for modeling environmental effects according to the Phase II development plan for evaluation to determine its effectiveness in an operationally relevant environment. The company will support the Navy for test and validation to certify and qualify the system for Navy use.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Effective crew training is critical to successful operations in the Navy and Coast Guard. A radar model that includes environmental effects would ensure proper training of crews in shore based simulators without the need for costly at-sea time on operational assets.

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KEYWORDS: Environmental Effects Simulation; Tactical Maritime Simulator; Radar Clutter Modeling in an Open Ocean or Near Shore Environment; Predictive Radar Propagation Software; Full Spectrum Training Simulation; Shipboard Radar Operator Training

N14A-T013 TITLE: Durable Low Adhesion Anti-Icing and Ice-Phobic Surfaces

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PEO-Ships (R. Mitchell), PMS 400F (E. Macfarlane), NAVSEA 05T (M. Bosworth)

OBJECTIVE: Develop and demonstrate robust and affordable anti-icing surfaces (prevent ice formation) that are also ice-phobic (reduce ice adhesion to substrates) for superstructure ice protection of surface ships in Arctic operations with no unacceptable ship and environmental impacts.

DESCRIPTION: Ship superstructure icing decreases seaworthiness, reduces deck safety, and risks mission success by reducing electronics and machinery performance. Ice is currently removed manually with baseball bats, chemicals and shovels, a hazardous operation in Arctic cold in high seas with risk of damaging ship components. Novel passive ice protection technologies are needed that do not require personnel on deck and maintain high performance of ship components during and after icing conditions. Many anti-icing materials have been demonstrated in the laboratory, and some have had limited field tests, but there has been little rigorous testing in operational environments. Anti-icing, typically superhydrophobic, surfaces delay drop freezing allowing them to roll off of surfaces before freezing. However, they can be defeated by frost, snow, and high winds driving drops into the surface, making an additional ice-phobic capability also desirable.

In this program, novel passive, not requiring power, anti-icing materials that are also ice-phobic will be developed that will meet the following performance requirements:

(1) Ice adhesion strength less than 30 kPa that will be proven by an independent government laboratory through repeated tests.
(2) Operate effectively in temperatures down to -30°C in salt water and fresh water.
(3) Durable and abrasion resistant in simulated or actual operating environments, warm and cold. Vendor must demonstrate anti-icing and deicing capability and durability of the surface for the equivalent of one year of ship-board use (multi-season) in Beaufort Sea or Chukchi Sea conditions.
(4) Affordable manufacturing techniques for covering ship superstructures and hulls (cost effectiveness).
(5) Ease of application to ship superstructures and other deck equipment (cost effectiveness), including recoat over existing material, or material removal if necessary.

In addition, resistance to corrosion, mild acids, UV, organisms and organic phosphates; optical transparency (>80% in the visible regime); slipperiness on decks; compatibility with current low solar absorbing ship paints; RF transparency; and radiation and recoat frequency should be considered. The infrared and millimeter wave (MMW) signatures of coatings are also critical to ship survivability.

PHASE I: Develop and demonstrate theory and proof of concept for proposed material. Demonstrate capability of the proposed low adhesion anti-icing/ice-phobic surface and manufacturing processes for making the materials to meet the requirements specified above. Laboratory scale flat coupons with minimal size of 30cm x 30cm should be fabricated by the vendor and characterized for its performance in a relevant environment.

PHASE II: Based on Phase I development and demonstration, improve manufacturing processes considering affordability and ease of applications for large area coverage. Conduct systematic performance evaluation of larger scale prototype low adhesion anti-icing/ice-phobic surface with minimal size of 1m x 1m to assess the capability of meeting the requirements specified above in a relevant environment. Repeated and accelerated testing will be performed to assess durability of the specimens.

PHASE III: Produce large area anti-icing/ice-phobic surfaces and apply to a platform (either a ship or a stationary off-shore structure) and test in the real arctic operational environment.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Successful development of the low adhesion anti-icing/ice-phobic surfaces that are durable and easy to apply to a large area will benefit an enormous range of commercial applications including marine transportation in the Arctic regions, commercial airplanes before flight (deicing), and the power industry (prevent ice accumulation on power lines).

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KEYWORDS: Anti-Icing Surface, Ice-Phobic Surface, Ice-Releasing Surface, Superhydrophobic Surface, Arctic Operations, Cold Region Operations

N14A-T014 TITLE: Surface Modification Process to Limit Cathodic Current Density

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: F/A-18, T-45

OBJECTIVE: Develop a novel surface modification process, to limit or control high current densities on cathodic structural materials like fasteners, pins, attachment points, and interfaces; commonly constructed from materials like copper-beryllium, stainless (CRES) steel, or titanium, without reducing the mechanical properties or function of the fastener substrate.

DESCRIPTION: Open circuit potential (OCP) is used as a proxy for corrosion driving force; however, OCP is a steady-state, uncoupled bulk material property, and structural materials are not uncoupled. OCP is not accurate in assessing corrosion rates or cracking. Recent research has shown that surface chemistry, residual stress, and current density are key. Specifically, this work has shown the acceleration factor to be linked with cathodic current density. Bushings, fasteners, and other structural attachment materials are usually CRES, Ti, or Ni-based alloys, all cathodic to the standard airframe metals. Corrosion at holes and other interfaces drives crack initiation and propagation; since these areas are stress intensity risers, and therefore at a higher energy state. A surface modification process is required to suppress cathode current density without affecting the mechanical properties of the fastener/bushing materials.

PHASE I: Demonstrate the process and concept for modifying the chemical or physical structure of the alloy surface to effect electrical and ionic conductivity, polarization response and/or coupled current density.

PHASE II: Validate the process(es) for ability to modify surfaces or substrate alloy with respect to cathodic current density when coupled to anodic substrates such as aluminum, magnesium, or steel. Validate the mechanical properties, such as strength, toughness, stiffness, etc. are not negatively impacted by the changes to electrochemical properties. Demonstrate the mechanism(s) of limiting cathodic current, via insulation, conductivity, etc. Demonstrate the scalability to bulk, high rate fastener or bushing manufacturing process incorporation.

PHASE III: Scale up and transition the process to a validated commercial surface finishing product. Coordinate with the Naval Air Warfare Center Materials and Structures engineering competencies for approval and transition to FRC or approved OEM vendor applications.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Commercial aviation, automotive, maritime/ships, and facility/infrastructure applications are all viable transition of this technology into dual-DoD/private sector applications.

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KEYWORDS: Corrosion, Galvanic, Cathode, Current, Surface, Modification

N14A-T015 TITLE: Anesthesia Ventilator for Atlantic Bottlenose Dolphins and California Sea Lions

TECHNOLOGY AREAS: Biomedical

ACQUISITION PROGRAM: Explosive Ordnance Disposal Underwater Programs (SEA00 EOD/CREW-2)

OBJECTIVE: Develop an anesthesia ventilator for Atlantic bottlenose dolphins and California sea lions that can mimic the breathing patterns of these unique animals, and is functionally compatible with commercially available human and large animal veterinary gas anesthesia systems.

DESCRIPTION: The U.S. Navy uses Atlantic bottlenose dolphins (Tursiops truncatus) and California sea lions (Zalophus californianus) in the Fleet's operational Marine Mammal Systems to protect harbors and Navy assets, detect and/or mark underwater mines, and locate and attach recovery hardware to underwater objects. To contribute to the maintenance of the fitness of these marine mammals for duty and the readiness of the U.S. Navy Marine Mammal Systems, the U.S. Navy is interested in developing a ventilator for use when anesthetizing Atlantic bottlenose dolphins and California sea lions. Ensuring adequate ventilation of the marine mammal patient is one of the key challenges to the anesthetist. Marine mammal pulmonary anatomy, cardiovascular physiology, and central nervous system control over ventilation are often unique in comparison to terrestrial animals. Also challenging for the anesthetist is the effect of removing the patient from the water and its buoyant effects. This is primarily an issue with anesthetized dolphins. Add to this that most anesthetics cause mild to moderate respiratory depression and the need for reliable and effective ventilation becomes obvious in this group of animals. Most anesthesia ventilators are designed for humans and have some use with small mammals (<140 kg) (1). Most anesthesia ventilators do not include newer modes of ventilation and some cannot develop high enough inspiratory pressure, flow or positive end expiratory pressure to ventilate large mammals (2). Few ventilators are designed for large mammals, all of which fail to resolve ventilation perfusion mismatch and significantly reduce cardiac output, and none of which meet current anesthesia ventilator standards (3, 4).

PHASE I: Conceptualize and design an anesthesia ventilator for Atlantic bottlenose dolphins and California sea lions. The anesthesia ventilator should utilize commercially available components and operate in a manner that facilitates a normal physiologic state in these animals in the face of anesthesia and their unique pulmonary mechanics (5-14). The anticipated ventilator support time is 4-5 hours in a conventional ventilation mode (15-21). Respiratory rates should be adjustable from 0-16 breaths per minute. The target tidal volume is 3-15 liters. Inspiratory/expiratory volumes need to be adjustable to allow for variable rates of flow over time. Inspiratory volumes should be delivered in 0.5 – 4 seconds while expiratory volumes should be exchanged in 0.5 – 15 seconds. System requirements are that peak inspiratory pressures should range from 0 – 50 centimeters of water. The user interface should display the respiratory rate, inspiratory time, peak inspiratory/airway pressure, and the inspiratory to expiratory ratio. The ventilator should be functionally operable with commercially available human and large animal veterinary gas anesthesia systems. Apneustic plateau and airway pressure release ventilation (APRV) modes are desired capabilities in this ventilator. Magnetic resonance imaging (MRI) compatible/conditional system capability is also desired (22, 23). Collaboration with a Boarded Veterinary Anesthesiologist experienced with anesthetizing both California sea lions and Atlantic bottlenose dolphins is recommended.

PHASE II: Based on the Phase I design, build a prototype anesthesia ventilator for Atlantic bottlenose dolphins and California sea lions and demonstrate its functionality with commercially available human and large animal veterinary gas anesthesia systems using a mechanical model. Testing of the initial system on an animal model is also desired. Collaboration with a Boarded Veterinary Anesthesiologist experienced with anesthetizing both California sea lions and Atlantic bottlenose dolphins is recommended.

PHASE III: Build an operable gas anesthesia system incorporating the Atlantic bottlenose dolphin and California sea lion anesthesia ventilator prototype. Demonstrate the operability and safety of the complete system on marine mammals. Document and report the physiologic parameters of the animal while anesthetized to demonstrate and validate system efficacy. Demonstrate the system's capability and efficacy to ventilate in standard, apneustic plateau, and APRV modes. Components of the gas anesthesia and ventilator system will be constructed to meet MIL-STD-810G as it applies to use of deployable military medical equipment. Magnetic resonance imaging (MRI) compatible/conditional system capability is desired. Collaboration with a Boarded Veterinary Anesthesiologist experienced with anesthetizing both California sea lions and Atlantic bottlenose dolphins is recommended.

Efforts should lead to development of a product that meets appropriate standardization requirements or FDA approval, and focus on technology transition, preferably commercialization. The small business should have plans to secure funding from non–STTR government sources and/or the private sector to develop or transition the technology into a viable product for sale in the military and/or private sector markets. There are currently no standards for safety and functionality of veterinary medical equipment. Suppliers of anesthesia machines for human patients voluntarily agreed to comply with standards set by ASTM International (known until 2001 as the American Society for Testing and Materials (ASTM)) since 1988. Several other organizations have worked to assure a degree of safety and functionality of equipment, but are still somewhat limited in controlling for all applications. No single standardization has yet arisen, but the American National Standards Institute (ANSI), ASTM and CEN (the European Community for Standardization) are working together to promote interoperability and consumer protection, while the International Organization for Standardization (ISO) works toward a universal, internationally accepted set of standards.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: A ventilator developed with the above listed capabilities would have application in the care of captive and managed populations of these animals world-wide (e.g. aquariums, marine parks) and may have applications for alternative modes of ventilation in other mammalian species.

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KEYWORDS: Sedation; Marine mammal health; Dolphin; Sea Lion; Anesthesia; Ventilation; Anesthesia machine; Anesthesia system

N14A-T016 TITLE: Acoustic Counter Detection Tactical Decision Aid

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: PEO-IWS5 (Integrated Warfare Systems) and Submarine Development Squadron 12

OBJECTIVE: Develop a submarine acoustic counter detection Tactical Decision Aid (TDA) to assist crews' decision making in monitoring and maintaining acoustic stealth during rapidly changing, complex missions and tasks.

DESCRIPTION: Potential adversaries are challenging the United States military's assured access to the global commons. The Joint Force Commander will increasingly rely on low-signature undersea forces to open the door for large-capacity general-purpose surface and air forces. Undersea forces need to penetrate an adversary's anti-access/area denial (A2/AD) perimeter to deter, neutralize, or destroy submerged, surfaced, or airborne threats while maintaining tactical position and accomplishing mission. To achieve this goal, submarine crews need to stochastically evaluate local ocean environmental conditions to help detect, localize, and assess vulnerabilities (i.e. risk of counter detection) to A2/AD threats. A TDA should interface with currently fielded systems to provide acoustic risk in relation to historical and planned track and evolutions, contain platform specific and user configurable source levels for own ship noisy evolutions, determine the acoustic vulnerability of a given evolution for a given threat sensor, and use as an input existing noise monitoring systems to provide these assessments. The development community understands the physics of noise generation and propagation completely. The physical equations used to model both the generation and propagation of sound in the ocean have been validated through extensive measurements, and analysis over many decades. It is the temporal and spatial variation of the physical constants of the propagating medium and the acoustic characteristics of the adversary's sensor that defy our ability to accurately predict the nature of sound propagation and our vulnerability to counter-detection. An effective Vulnerability TDA should deal with uncertainty in the environment and the threat sensor; it should treat the environment and the threat sensor as random variables and evaluate vulnerability as Probability Density Functions. As a start, it should manage first order effects and not try to solve the problem absolutely.

PHASE I: Provide an initial development effort demonstrating an operator decision aid that simulates submarine noise monitoring systems to create an acoustic vulnerability assessment over time and space. The TDA tool output will overcome current assessments where the operator must manually draw overlays on top of a geographic plot with an operators' best guess for vulnerability. TDA calculations will compute and display noise, sound speed profile, bottom type, and topography over time to estimate acoustic vulnerability.

PHASE II: Prototype TDA using submarine acoustic data sets where the environment and the threat sensor are random variables and evaluate vulnerability as Probability Density Functions. The prototype and report will be submitted to PEO-IWS5A's Submarine Advanced Processor Build (APB) process integrates S&T solutions into a software build that can be transitioned to submarine production. The Submarine APB process is a well-defined and established process. It is a rigorous process comprised of four sequential 'steps'. In Step 1, PEO-IWS5A peer review group assesses the performance of the S&T products via PEO-IWS5A's APB Broad Agency Announcement. Step 2 consists of an independent performance testing and evaluation by PEO-IWS5A peer review groups, assuming that the S&T technologies showed promise in Step 1. Step 3, PEO-IWS5A funds independent end-to-end lab testing of the technology Products. Step 4 consists of at-sea testing. It is anticipated that the TDA software would be submitted in the APB-17 cycle.

PHASE III: Build and integrate TDA into the submarine mission planning application software located in AN/BYG-1 Submarine Combat and Weapon System.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Successful development of the TDA should transition to other warfighting platforms.

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KEYWORDS: Decision aid; Acoustic; Sonar; Counter detection; Display

N14A-T017 TITLE: Processing of High-strength Ultra-Conductive Wire

TECHNOLOGY AREAS: Materials/Processes, Electronics

ACQUISITION PROGRAM: none

OBJECTIVE: The objective of this topic is to develop processing capabilities of high-strength ultra-conductive wire to improve power-to-weight ratios and energy efficiency across military systems.

DESCRIPTION: Electrical wire is a vital component of any military system. The wiring harnesses carry electrical power and data to all parts of the vehicle/vessel. To date, copper is the choice of material for the wire conductor because of its balance of high electrical conductivity, good processability, good corrosion resistance, and moderate cost. As power and data requirements increase, the mass of the wiring harnesses have increased to become a considerable fraction of the vehicle weight. The conductivity and mechanical properties of copper limit the minimum conductor size in a wire one may use reliably in an application. Low cost composite wires, with high strength and ultra-high conductivity, become attractive alternatives to pure copper.

Several groups have succeeded in imbedding nanoscale graphitic carbon (for example carbon nanotubes, graphene nanoscrolls, etc.) into copper and aluminum matrices. They report very high electrical conductivities (as high as 1000% IACS) and strengths as high as 350% that of Oxygen Free High Conductivity (OFHC) copper. This could allow the reduction of the weight of the wiring harness of a Boeing 747 by 1300kg; or of a large communications satellite by as much as 3000kg.

The processes are laboratory-scale batch operations, however, and the yields are low and the repeatability is very poor. Some groups have attempted scale-up feasibility studies; but with such poor repeatability, they are unable to examine the real process control needs and have little confidence in the predictions. Proper assessment of the scale-up of the processes requires a detailed physical understanding of the phenomena that occur during the process, converted to a quantitative description suitable for engineering analysis. It also requires a thorough understanding of structure-property relationships in the material to provide target structures for the processes. This also provides the fundamental tools needed for optimization of unit processes to improve yields, uniformity, and reliability.

The first objective of this project is to develop quantitative structure-property models for the electrical and thermal conductivity of nano-scale carbon modified copper (and aluminum). The second objective is to develop quantitative models for the individual operations for the processes extant in the synthesis/processing of nano-scale carbon modified copper (and aluminum) that are suitable for the design of multi-step processing operations. The third objective is to demonstrate these tools in the design of an overall processing sequence to produce high conductivity nano-scale carbon modified copper (and aluminum). This project supports the goals of the Materials Genome Initiative (MGI) in the area of Integrated Computational Materials Engineering (ICME).

PHASE I: The successful Phase I project will perform characterizations of the microstructures of high-conductivity (successful) and low-conductivity (unsuccessful) materials, and the determination of a set of structure-property relationships (e.g. grain size, volume fraction, orientation distribution, porosity, etc.) that predict suitably for the conductivity of the system. The final activities of the successful Phase I effort will scope out the unit processes associated with the synthesis and processing of wire and plan time and the resources needed to model those operations.

PHASE II: The successful Phase II effort will begin with a determination of target microstructures for acceptable physical properties of a wire product. It will model the major processing unit-step operations associated with the laboratory-scale operations, and introduce structure evolution and process failure envelopes for the unit-step operations. By the end of the successful Phase II effort, the investigators should have models for the major processing steps that communicate sufficiently to allow them to perform preliminary designs for the wire production process.

PHASE III: In a Phase III effort, the investigators will (with partners) begin the design of the processing operations needed to produce reliable high conductivity composite metal wire, and begin to predict the costs of scale-up for a commercial operation. Future activities will refine the models and lead to process optimization and the support of production operations.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Wiring on automobiles, aircraft, consumer electronics, and other applications where high reliability and light weight are desirable.

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KEYWORDS: ICME; Processing; Ultra-conductive; Wire

N14A-T018 TITLE: Compact Megavolt Switch Utilizing Novel Switching Mediums

TECHNOLOGY AREAS: Materials/Processes, Electronics, Weapons

ACQUISITION PROGRAM: ONR Code 35: High Power Radio Frequency (HPRF) Basic Research

OBJECTIVE: Develop, design, and build a compact (<150 in3) high voltage switch for use in High Power Radio Frequency (HPRF) applications on naval platforms utilizing novel or innovative switching mediums/dielectrics capable of switching megavolts, in 750 ps or less, pulse lengths of < 300 ns, 20 to 100 ns switch charge times, at pulse repetition frequencies of 100 Hz - 1 kHz.

DESCRIPTION: Switches are a critical component for the pulsed power systems utilized to produce the high voltages/currents for HPRF generation. HPRF systems use a wide range of opening and closing switch technologies from traditional spark gap, gas insulated switches to solid state photoconductive switches. The commonality among these switches is the capability of the switch medium to transition from insulator to conductor, to act as the connection between the energy storage system and the load, all with precision timing to produce the desired output pulse. A very traditional switching medium, because of its intrinsic and extrinsic chemical properties is Sulfur Hexafluoride (SF6). However, the main motivation of this topic began with the desire to eliminate or reduce the use of SF6 as a switching medium in HPRF systems. SF6 is not only more costly than other insulating gases, but after subjected to electrical discharges, toxic and corrosive compounds are formed. These toxins present an environmental and personnel hazard for the maintainability and disposal of the system, increasing the overall system life-cycle costs. As the Navy endeavors to minimize the use of such materials and reduce system costs, alternative dielectric mediums that not only meet our current, but future technology needs, that can also be easily integrated into naval architectures and withstand the maritime environment must be found.

The electric power industry is the dominant commercial user of SF6, accounting for 80% of the world market alone, the majority of which is utilized for circuit breaker applications (Ref 10). However, SF6 is a greenhouse gas with an estimated lifetime of 3,000+ years in the atmosphere (Ref 17). One of the primary sources of SF6 emissions is leakage from power transmission and distribution equipment. Although the EPA has developed programs such as the SF6 Emission Reduction Partnership for Electric Power Systems, the main focus has been on reducing the use and leakage of SF6. Little to no effort by either the EPA or their commercial partners has gone into finding an alternative switching medium. Thus, the need for the development of switching mediums comparable in performance to SF6 is a capability gap for not only the military, but for industry as well.

A driving factor in the transition of HPRF systems is a focus on applicability to operational use. As these systems push the envelope of increased energy and power on-target, the more robust the subsystem components must become, while remaining in a compact form. The U.S. Navy is interested in further developing switch technology hold-off capabilities through the studying of innovative and novel dielectrics that will not only advance the current state-of-the-art, but also be safer and cheaper to utilize within HPRF systems. The switching mediums of interest include, but are not limited to, gases and gas mixtures (i.e. 40%SF6-60%N2), liquids (i.e. oil, water), and solid state materials (i.e. photoconductive switches utilizing GaAs, 4H-SiC, GaN, etc.). The challenge for switch technology development is improved performance, in the 1 MV to 10 MV range, with switching times of 750 ps or less, for pulse lengths of < 300 ns, and switch charge times between 20 ns to 100 ns. In addition, repetition rates in the 100 Hz to 1 kHz regime are required, all in a footprint of less than 150 in3 (0.002 m3). The current state-of-the-art for gas, water, and oil switches ranges from 1 to 6 MV, 170 in3 to 9100 in3 in size, with 1 to 100 Hz pulse repetition frequencies, and switch charge times of 10 to 30 ns. Photoconductive switches are reaching comparable specifications with 10's of picosecond switch times and 10's of kV hold-off voltage for single element handling capability, but in a much smaller package than gas or oil switches. A secondary goal of the overall switch development is to minimize the secondary support systems needed to support the dielectrics such as gas mixing, oil circulation, deionization water filtration, gas expansion chambers, laser triggering units, etc. A novel switch design should aim for reducing or removing the need for these types of secondary support systems.

PHASE I: Conceptualize and design a breadboard switch utilizing the chosen novel switching medium. Although not required, more than one switch may be developed and/or more than one switching medium evaluated. For the completion of Phase I, the switch prototype design(s) should be capable of the following performance characteristics in a single switching event (or pulse count):

Phase I Design Parameters:
• 500 kV switch voltage
• 1 ns or less switch time
• 100 ns pulse lengths
• 10 ns charge times
• 10 Hz pulse repetition frequency
• Volume of < 1200 in3

Electromagnetic and circuit modeling and simulation of the switch design should be conducted and results leading to the final design(s) should be documented and provided in the final report along with a data package on all proposed critical components in the breadboard system design. A design plan should also be submitted outlining the plans for scaling the switch and support systems for the Phase II requirements.

PHASE II: Construct and test a brassboard switch utilizing the Phase I design and the chosen novel switching medium. The use of actual hardware and empirical data collection is expected for the performance analysis of the switch and switching medium and should be provided in the final report along with a data package on all critical components in the brassboard system. At the completion of Phase II, the prototype switch should be capable of demonstrating the following performance characteristics in a single switching event (or pulse count):

Phase II Design Parameters:
• 500 kV to 1 MV switch voltage
• 1 ns or less switch time
• 100 ns pulse lengths
• = 10 ns charge times
• 10 to 100 Hz pulse repetition frequency
• Volume of < 300 in3

The Phase II switch prototype must demonstrate a clear path towards addressing the scalability challenges along with packaging the system into a relatively useful volume. At this point, the prototype should be able to demonstrate switch capabilities with minimal secondary system support, even if for a short test cycle. Furthermore, a plan should be developed clearing stating the methodology for future secondary system reduction and scalability for a fully developed switch. All data collected in the analysis of the switch and switching medium of the prototype system will be included in the final report along with a data package on all critical system components.

PHASE III: Phase III will consist of a demonstration of a fully capable, compact switch meeting the specified switch requirements (below) along with no immediate secondary system support. The final system will represent a complete solution and should be ruggedized for, at a minimum, testing in a dry, outdoor environment and be environmentally enclosed.

Phase III Parameters:
• 1 MV to 10 MV switch voltage
• 750 ps or less switch time
• < 300 ns pulse lengths
• 20 to 200 ns charge times
• 100 Hz to 1kHz pulse repetition frequency
• Volume of 150 in3

All data collected in the analysis of the switch and switching medium of the final system will be included in the final report along with a user's manual and a data package on all critical system components. The final system shall be developed with performance specifications satisfying the targeted acquisition program requirements coordinated with technical point of contact. A preliminary design package and plan outlining the use of the switch in commercial switching applications should also be submitted with the final report.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: HPRF sources, and consequently switches, are used in a wide variety of commercial applications including electric power industry, semiconductor processing, x-ray machines, pulsed power, and medical applications. The use of SF6 in the commercial power industry for insulating high voltage equipment and/or as an arc quenching medium is abundant. From circuit breakers to gas-insulated substations, it has been estimated that 80% of the SF6 produced worldwide is utilized by the electric power industry alone (Ref 10). In addition, SF6 has been identified as a greenhouse gas with a global warming potential of ~23,000 times greater than carbon dioxide. Although it has been a priority of the EPA to reduce the usage and emission of SF6, little has been done to develop an alternative switching medium that is comparable.

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KEYWORDS: High power radio frequency; high power microwave; dielectrics; closing switches; opening switches; spark gap; semiconductor solid state switches; photoconductive switches

N14A-T019 TITLE: Multi-Modal Biosensing

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: None in place

OBJECTIVE: A compact, low power dynamical system built on an integrated circuit (IC) serving as a common and scalable platform for multi-modal current detection sensing at the 1pA level for Electrocardiogram (ECG), Electroencephalogram (EEG), and Electrodermal Response (EDR) biosignal detection joined with non-contact wearable electrodes. The signal processing will be able to compensate for movement and be useful for medical monitoring to assess a subject's stress, fatigue and resilience.

DESCRIPTION: A set of odd-numbered nonlinear oscillators can work cooperatively to enhance the detection of minute signals that can serve as an ultra-sensitive electrical current detector on an IC with multi-channel capabilities. An array of these oscillators can detect electrical current changes on the order of 1 pA, which will be used as the common platform for simultaneously sensing different types of signals such as magnetic fields, electric fields, along with seismic, acoustic, infrared, and other signature modalities. Derived from this integrated common platform (backbone), a wearable biosensing system which is immune to motion artifacts and muscle noises is to be developed for medical applications and human performance assessments.

PHASE I: Develop a conceptual design of an IC-based dynamical oscillator array including transistor-level simulations to demonstrate electrical current detection with a high enough signal to noise ratio to provide a sensitivity level to allow operation against low-frequency current fluctuations with realistic system noise.

PHASE II: 1. Develop, demonstrate and validate a prototype chip-based system with multiple channels built onto an IC based on the Phase I work. 2. Demonstrate multi-modal signal detections (at least 2 different signal collections). 3. Integrate the IC with contactless electrodes for biosignal detections. 4. Package the biosignal detection system together with electrodes, a power management unit and wireless transceiver, all into a bandage-sized form factor of 2cmX4cm.

PHASE III: 1. Field a wearable biosensors device with the Marine Corps Warfighting Lab to test an integrated system for biosignal data fusion with sufficient precision, analytical capabilities, scalability, and energy efficiency to enable long-term monitoring and robust operation from limited energy supplies. Data will be obtained under a variety of situations, such as sleep deprivation, physically stressful activities, and during sleep. 2. Market the biosignal detections miniature wearable device for EEG, ECG, and Electro-dermal response and data connectivity to a common communication device such as a smart phone.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: A wearable medical data recorder for EEG, ECG, and EDR operable under daily activities.

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KEYWORDS: Multi-modality sensing; physiological signals; coupled oscillators; electric field sensor; wearable biosensors; non-contact electrodes

N14A-T020 TITLE: Development of a Micro-glider for Oceanographic Air-Sea Interaction Sampling

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors, Battlespace

ACQUISITION PROGRAM: PMW-120 (Battlespace Awareness and Information Operations Program); PMS 406

OBJECTIVE: To explore and develop a “micro glider” that addresses the rapid response needs for measuring in the boundary layers of the ocean and that dramatically reduces size and cost for production of fleets of small, disposable instruments. The design needs to incorporate scaling for fast turning radii and the instrumentation for fine-scale, fast response.

DESCRIPTION: The use of undersea gliders for battlespace characterization was accepted and formulated into a program of record in the Littoral Battlespace Sensing Fusing and Integration program of record. In this program, undersea gliders are used in key areas of interest to provide the ocean state assessment that is then telemetered via iridium satellite back to the Naval Oceanographic Office headquarters. Once there it is used to constrain ocean models and performance assessments for Anti-Submarine Warfare and Mine Warfare. These instruments cost over $150,000 per unit and while providing many years of service, they are expensive enough that ship time is devoted to their deployment and recovery. Because of the size of the instrument (roughly 6 feet, 120 lbs.) it has a long slow turning radius and although optimum for its present program of record purpose, it is not extensible to air-sea exchange measurements in the ocean atmosphere boundary layer.

The glider evolved from the ocean profiling float that populates the ARGO program and provides the world with ocean state estimations for climate assessment. The ARGO floats are a similar size, 4-6 feet and 120 lbs and profiles slowly, and only vertically. Recently, ocean technologists reduced the ARGO float size to 1.5 ft with an A size diameter and rate parachute for deployment from P3’s or P8’s. In reducing the size, complexity and cost was also reduced. The opportunity exists to harvest similar cost and size savings by creating the micro-glider. The research needs to address the first technical objective: (1) utilize scaling evaluations to determine the exact length, diameter, and center of gravity needed to achieve a rapid turning radius so that the very near surface of the ocean can be sampled. The present family of coupled models run by the navy requires detailed structure in this region to improve the representation of the fluxes of variable. The second technical objective is to find the low-cost rapid response sensor suite that can provide the appropriate turbulent flux data. Specialist now use additional velocimeters, accelerometers and fast response thermistors, strapped on awkwardly to generation 1 ocean gliders, in order to collect this data. The third technical objective is to reduce cost so that the new micro glider approaches the low cost of profiling floats – the objective cost is $20k. Both the Navy and other DOD agencies have accepted that cost point for deploying instruments without the need to retrieve them.

This STTR differs from previous SBIRs that sought to reduce complexity and cost and achieve air-deployability because the micro-glider, by its size, and pay-load, serves a different technical sampling need: rapidly profiled turbulent fluxes in the mixed layer.

The Navy will only fund proposals that are innovative, address Research and Development (R&D) and involve technical risk.

PHASE I: Provide an initial development effort, based on the three technical objectives identified in the description, which demonstrates scientific merit and capabilities of the proposed micro-glider; perform and document the scaling and sensor analysis and investigate the tradeoff matrix to identify a candidate size and possible manufactured cost. Determine the challenges in achieving communications and lifetime in the smaller packaging. Provide detailed documentation and references showing the technical feasibility and approaches that could achieve the desired goals as well as meeting the price point. This document should outline the research approach for the Phase II effort.

PHASE II: Using results of Phase I effort, fabricate and characterize prototype micro-glider; demonstrate rapid profiling, sensor response and the quality of the flux data that are achievable. Evaluate life-time and sea-state response and fidelity of communications. Produce multiple micro-gliders to assess production potential and manufacturability; document the process and costs and materials.

PHASE III: It is expected that this prototype will be of interest to the Littoral Battlespace Sensing Fusion and Integration (LBSF&I) program of record (POR) as well as to various programs that provide expeditionary sensing systems for U.S. Marines and other naval applications. The LBSF&I POR utilizes the Naval Oceanographic TAG ships for deployment and recovery but they have begun to explore partnerships with NOAA and US Coast Guard for additional deployment opportunities. To certify this prototype for deployment and recovery, detailed engineering drawings of the electronics, engineered structures, and energy systems will be required. All materials should be documented including MSDS references. The power source, type of batteries, safety systems, chemistries, providers and tertiary and secondary quality control procedures should be documented and provided together with the electrical schematics to aid examination and approval by the appropriate certifying agent (NOSCA).

It is anticipated that these devices will be used not only by Navy, NOAA and Coast Guard but also by the ocean and ocean engineering communities. To aid in commercialization, software should be written as open source and clear indications of patents and intellectual property should be indicated.

Deliverables from this Phase will include no less than 5 micro-gliders for evaluation by entities indicated by ONR- such as but not limited to the LBSF&I POR, complete engineering and electrical diagrams, software with documentation, a battery safety documentation package, and a description and or gear for launch and recovery.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: There are presently three manufacturing companies for full-sized gliders that provide a growing military and commercial market (Konigsberg, BlueFin, Teledyne Brown) and multiple small businesses that have worked on specialized gliders and glider packages including: MRV, Exocedus, ANT, iRobot, VCT, Rockwell). The market has growth potential for both the military and by National Oceanic and Atmospheric Administration (NOAA), Department of Energy (DOE), Homeland Security, United States Coast Guard, and other agencies to have an appropriately sized sensor-equipped-glider that fits within their operational and affordability projections.

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KEYWORDS: Oceanographic glider; Profiling floats; Buoyancy engines; Turbulent fluxes; Ocean/atmosphere boundary layer; Affordability; Sea state; Iridium communications

N14A-T021 TITLE: Affordable 3D Printed Phased Arrays

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Electronics

ACQUISITION PROGRAM: PMW-170, Integrated Topside INP (Innovative Naval Prototype), SATVUL FNC

OBJECTIVE: To develop a low cost phased array technology enabled by 3D direct digital fabrication.

DESCRIPTION: The potential promise of 3D printing to manufacture a phased array antenna can dramatically reduce cost and enhance the mechanical, electrical and radio frequency (RF) performance through high precision dense integration. Current ink-jet printed techniques have been used to produce 2-dimentional antenna structures applicable for conformal surfaces and notably supporting the radio frequency identification (RFID) revolution. The ability to move to 3D printing offers novel interconnections, packaging, and embedded circuits supporting phase shifters, delay lines, filters and shaped RF characteristics. The intent is to build a multifunction 3D layer composed of low power functions such as phase shifting or true time delay, gain control, switching, low power amplification, filtering, interconnectivity, thermal management, and mechanical packaging.

The Navy will only fund proposals that are innovative, address R&D and involve a level of technical risk commensurate with desired cost/performance.

PHASE I: Develop initial concept design with tradeoffs, and model key elements. Include the 3D printing technology approach. Part of the design concept identifies instantiations of a single module, at the simplest level Rx-only, Tx-only, and Tx/Rx. Address inclusion method for non-printable large signal gain high power components. Identify critical design parameters associated with: S-parameter estimation, thermal performance estimation, packaging, losses and testability. Provide design for a single array element, a fabrication strategy and estimated cost/element, and testing approach of a steerable multi-element array.

PHASE II: Fabricate and characterize a prototype single element. Include design and simulated performance. Compare measured results to design goals and objectives. Define interfaces and integration to other components such as high power Monolithic Microwave Integrated Circuits MMICs. Demonstrate a baseline performance and compare against simulated performance to assure repeatable quality control in both design and process. An objective is to develop a 2x2 array with beam forming demonstrated (C-, X-, or the Ku- band).

PHASE III: Produce a steerable array. Identify interfaces between 3D printed array and MMIC components. Address potential for integrating high power MMICs. Test and measure array performance under a variety of environmental conditions such as temperature, humidity, salt water spray, shock and vibration. Identify a strategy for scaling the array size and conformal instantiation. Address mounting, tuning and calibration to allow a possible limited operational demonstration on a platform. An objective is to develop a 4x4 array with both beam forming and steering demonstrated (C-, X- or the Ku- band).

Phase III outcome must also include a clear way-ahead approach and strategy to scale up manufacturing, which enables larger array sizes, varying shapes, and potentially conformal topologies for the Integrated Topside Innovative Naval Prototype program or the SATVUL Future Naval Capability. This could include tradeoffs of sub-array size with combining to achieve total array size/shape flexibility while maintaining low cost affordability.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Successful development of 3-D printing RF devices directly benefits commercial wireless industry. Unforeseen benefits include micro-controllers, robotics, healthcare, smart devices, and transportation.

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KEYWORDS: Antenna; Phased Array; 3-D printing; Beam forming, Beam steering; 3D direct digital fabrication

N14A-T022 TITLE: Expendable Direct Sensing for AUV Based Geotechnical Survey Operations

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: Littoral Battlespace Sensing - Unmanned Undersea Vehicles ACAT IV

OBJECTIVE: Develop a direct measure seabed characterization system that is low cost, either AUV mountable or self-contained, and has the potential to operate at depths down to 100 meters.

DESCRIPTION: Increasingly, autonomous vehicles equipped with acoustic systems are employed to carry out missions in littoral waters. In many cases, mission success depends on predictions of how well the acoustic system will perform in the operational environment. A weak link in performance prediction is often due to a lack of knowledge of the operational environment used in the system models. This limitation is particularly acute in the area of environmentally-adaptive automated target recognition (ATR) for Mine Counter-Measures (MCM), which requires training data. These training data are often either fully, or augmented by, simulated data due to the expense of collecting real data. The requirements increase as environmental complexity increases when moving between areas characterized by different features (e.g. sand, sea grass, rock). Currently, the existing seabed characteristic databases do not have sufficient resolution and/or accuracy to support the new adaptive approaches. However, the proliferation of more autonomous platforms offers a potentially efficient means to field sensors and fill this gap.

At present, there exist approaches based on the use of acoustics for use in determining bottom sediment classification necessary for planning and executing MCM or littoral surveillance missions. These approaches rely on post-processing to extract wide-area seabed characteristics, are often time consuming, and provide no ground-truth. In this call, we seek a complimentary approach that is more direct and capable of operating near/on/or in the seabed to provide near immediate initial local classification of the seabed in terms of composition (sand, mud, sea grass) as well as roughness. Segmentation of seabed types would be provided by accumulation of measurements over a spatial domain and/or combining measurements from many sensors. With little or no post-processing, the measurements could be exported to sediment databases or used in-situ for environmentally adaptive algorithms running on a vehicle. These measurements could be used to constrain and/or ground truth other wide area remote sensing approaches and have applications in MCM and mine burial prediction. Advances in commercial products aimed at gaming and action sports suggest the potential for small form factor, possibly expendable, sensing capabilities for this application. The system may be self-contained or delivered by Autonomous Underwater Vehicle (AUV).

PHASE I: Develop the initial concept design for a direct measure seabed characterization system that is low cost, either AUV mountable or self-contained, and can operate at depths down to 100 meters. The concept design should identify the most promising sensing technologies and the envisioned packaging or platform. It should also address expected area coverage rates, geospatial registration and segmentation, data storage, and if applicable concepts for in-situ use of and/or exfiltration of data.

PHASE II: Develop a prototype system and demonstrate its capabilities for data collection and seabed classification in a realistic undersea environment. Phase II will include development of hardware but a completely functional prototype is not required; however, the feasibility and the expected performance of a final design should be clearly evident within the demonstration.

PHASE III: Contractors shall work with the Navy and their contractors to implement the system developed in this program for integration with the Littoral Battlespace Sensing –Unmanned Undersea Vehicles (LBS-UUV) Program of Record.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: A dual use application will be basic and applied research related to Geoacoustic and Geotechnical Inversion and Survey technique development, as well as a potential tool for offshore construction projects (e.g. wind farms).

REFERENCES:
1. Lyons, A.P., et al., “Characterization of the two-dimensional roughness of wave-rippled sea floors using digital photogrammetry,” IEEE J. Ocean. Eng., vol. 27 (2002).

2. Khoshelham, K. and Elberink, S.O.,”Accuracy and resolution of Kinect depth data for indoor mapping applications,” Sensors, vol. 12 (2012).

3. Maffione, R.A., "Evolution and revolution in measuring ocean optical properties," Oceanography, vol. 14 (2001).

KEYWORDS: Unmanned undersea vehicles; littoral; sensor; inversion; survey

N14A-T023 TITLE: Wideband RF Photonic Link with Real-time Digital Post Processing

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: FY15 Scalable, Integrated RF System for Undersea Platforms (SIRFSUP)

OBJECTIVE: Develop an integrated real-time electronic backend processor providing digitization and linearization of an analog photonic link. The analog photonic link and real-time backend processor shall provide an instantaneous bandwidth of at least 2 GHz and achieve spurious free dynamic range >120 dB Hz^2/3.

DESCRIPTION: Complex military communications, sensing and surveillance systems require distribution of high fidelity analog signals. Due to their wide bandwidth, low weight, and immunity against electromagnetic interference, analog fiber optic links have attracted ample attention. However, meeting the dynamic range requirements of communication and radar systems has proven to be challenging. In particular, nonlinearities of the electro-optic modulator, photodiodes, and electronic amplifiers have prevented the true potential of analog photonic links to be realized. In addition for wideband links the dynamic range of the analog-to-digital converter (ADC) poses another bottleneck. While significant research has been conducted on improving the components and on analog linearization, a wideband analog optical link that meets the stringent performance metrics of a military system has remained elusive.

In recent years, there has been unprecedented progress in commercial programmable devices in terms of both logic density and processing speed. Especially Field Programmable Gate Arrays (FPGAs) and Graphics Processor Units (GPU) offer a combination of high performance processing and programming flexibility without the high cost of complex application-specific integrated circuit (ASIC) development. Terabit real time processors may now be constructed using commercial off the shelf (COTS) FPGAs and GPUs. However, the challenges posed by handling the massive amount of high speed data at the board level in real time is a formidable barrier that has held back the use of COTS processors' tremendous computational power in many applications. This program aims to leverage the progress in digital electronics to improve the dynamic range of analog optical links.

The envisioned RF to digitized data system would consist of a wideband (RF) photonic link covering from very high frequency (VHF) up to at least the K super high frequency (SHF) band for transport of the signal from a remote antenna over several hundred meters to the receiver system consisting of photo-detection, electronic interface to an ADC, and real time digital signal processing (DSP) for linearization of the system. In addition to linearization of the electro-optic modulator response, linearization of the photo-detector and ADC may be considered as well in order to meet/exceed the stated goals. It is well known that the ADC in such a wideband system represents a bottleneck because of its decreasing dynamic range as a function of analog bandwidth. Approaches to circumvent the ADC bottleneck and achieve wideband high-effective number of bits (ENOB) performance beyond the performance attainable with available electronic digitizers have been investigated—e.g., approaches employing front end optical pre-processing and backend signal reconstruction. While these approaches offer to achieve unprecedented bandwidth and dynamic range, they also suffer from a high level of complexity. A down-converting photonic link approach has been demonstrated whereby an intermediate frequency (IF) sub-band from the wideband RF signal is digitized and linearized in digital post processing. The goal of this STTR is real-time digitization and linearization of a ~2 GHz IF sub-band from the wide bandwidth of interest; therefore, down-converting link approaches are appropriate. As the focus of the STTR is the development of the real time DSP linearization algorithms and hardware, proof of concept demonstrations using a 2 GHz photonic link without down-conversion may be acceptable if the DSP linearization approach would be applicable to the ultimately envisioned design. Proposals should discuss the DSP linearization in terms of the proposed photonic link design and applicable link component non-linearities. ADC linearization techniques to aid in meeting/exceeding the 120 dB Hz^2/3 project goal are also within the scope of the STTR. Approaches should minimize the size, weight and power (SWaP) required by the electronic back end subsystem. SWaP requirements should be detailed in the proposal.

Development of new photonic devices, electro optic devices, and electronic ADC devices are not contemplated under this project.

In addition to extending the dynamic range of analog links, real-time digital processing of wideband RF spectrum is critical in achieving efficient utilization and dominance of the electromagnetic spectrum in C4ISR systems. For example, systems must be able to perform Fourier transform, beam forming and Doppler processing in real time. They must be able to capture elusive transients, trigger on them, capture them into memory without loss of information and analyze them in the frequency, time, modulation, statistical and code domains. It is anticipated that the real-time processors contemplated under this STTR will become one component of digital backend in C4ISR systems.

PHASE I: Photonic link and electronic backend design concept shall be developed addressing the goals in the description. Approach to linearization of the system shall be detailed. Detailed electronic backend designs to provide real-time linearization shall be developed. Modeling and simulation of the system and analysis of required power for DSP approach shall be performed. Proof-of-concept demonstrations are encouraged.

PHASE II: Build and test prototype packaged digitally enhanced analog optical link with 300 meter length, >120 dB Hz^2/3 dynamic range and ~2 GHz IF instantaneous analog bandwidth incorporating real-time DSP.

PHASE III: Transition the demonstrated wideband RF transmission technology into military systems and platforms that benefit from high dynamic range RF signal distribution and remoting via optical fiber. Pre-production engineering prototypes shall be developed with performance specifications satisfying targeted acquisition program requirements.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Wideband real-time processing is a ubiquitous dual-use technology that is needed in a variety of commercial applications. The technology plays an important role in applications such as test and measurement instruments, optical and wireless communications, imaging for security and surveillance, environmental monitoring, and biomedical diagnostics such as high throughput screening of biological fluids. The volume of these potential commercial markets is extremely large compared to the defense market this technology enables.

REFERENCES:
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KEYWORDS: Wideband Photonic Links; Analog Transmission; High Dynamic Range; RF Signal Distribution; Microwave Photonics; Digital Signal Processing

N14A-T024 TITLE: Information and Decision Recommender

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: PMW150, SPAWAR, MC3 MARCORSYSCOM, PMMI MARCORSYSCOM, PMW 120

OBJECTIVE: The objective of this topic is to develop an effective and continuous operations and intelligence picture that supports decision making. To this end, an information and decision recommender system will be matured.

DESCRIPTION: Due to the large quantities of data now available to the warfighter it has become more difficult for the warfighter to find data that is most relevant to a course of action (COA) decision. Additionally, the development of COA recommendation tools has lagged the development of predictive tools related to enemy actions even though the two classes of tools may be able to leverage a common technology base. The objective of this topic is to address these two capability gaps by developing a recommender system for information delivery and COAs. For the purposes of this topic, proposers may assume that detailed COA can be represented by a simpler taxonomy consisting of “attack”, “hold”, “reinforce” and “retreat”.

The challenge can be broken down into four parts. The first challenge lies in the development of an ability to map human entered COA to a machine understandable taxonomy (e.g. attack, hold, reinforce, and retreat). The second challenge is to map COA decision models to possible relevant features. Work related to feature selection that leverages modeling techniques for feature reduction can be leveraged [1]. The third challenge is development of an information recommender system to personalize information delivery to specific warfighters making specific COA decisions based on past behavior. Such systems have been developed by the social networking community to optimize information delivery. Within those efforts, advances have been made in understanding the strengths and weaknesses of specific algorithms. Based on that understanding, recommender systems based on a fusion of recommendations have now been demonstrated [2]. The fourth challenge is development of a system to incorporate a predictive capability that can suggest COA recommendations to an overtaxed commander based on the content of the information set identified as most relevant to a particular decision. The challenge of mapping observable or latent features to a COA recommendation accurately may require a layered modeling approach [3]. The COA recommender must update recommendations whenever new and relevant data is received.

During Phase I, performers may select unclassified use cases from open source that have both rich reporting and a correct COA that became apparent after a period of time. Examples of this include political scandals (e.g. San Diego’s mayor’s eventual decision to retreat) or well documented military battles (e.g. Gettysburg).

The key technical challenges inherent to the topic include the development of 1) machine understanding of human entered COA, 2) automated feature selection and reduction, 3) algorithms that can tailor information selection and delivery, and 4) learning based decision recommendation tools.

PHASE I: Develop techniques to implement some or all of the component pieces of the described system; identify key technical risks associated with the development of a prototype; implement a design strategy to measure algorithm performance over time. Technical approach should address the challenges of 1) machine understanding of human entered courses of action, 2) automated feature selection and reduction, 3) algorithms that can tailor information selection and delivery, and 4) learning based decision recommendation tools. The Phase I effort should also identify a specific application and use case for a customer (military and commercial) and outline a plan for going forward with research. The final Phase I brief should include a proof of concept demonstration and show plans for a Phase II.

PHASE II: Produce an information and decision recommender prototype system that is capable of supporting a diverse set of COA. The prototype system should allow human entered COA to be entered for a specific mission and return COA recommendations. The recommended COA needs to be dynamically adjusted as new data becomes available during mission execution. The prototype should present pedigree information on recommendations with traceability back to key data features. During the Phase II effort, the transition path should be strengthened by focusing on data and COA trade spaces of interest.

PHASE III: Produce an application or set of applications that are capable being generalized to all Naval mission areas. The Phase III product(s) should be capable of running on program of record command and control systems while supporting data discovery on program of record intelligence systems within the Department of the Navy. The developed system must have relevance to tactical amphibious warfare and anti-access/area denial mission areas. During this phase the performer should concentrate on operational relevance and transition.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The information and decision recommender system to be developed could be used by the private sector to develop decision support products related to employment and business decisions in a very similar manner.

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1. Volker Tresp, Markus Bundschus, Achim Rettinger, and Yi Huang. "Towards machine learning on the Semantic Web", Uncertainty Reasoning for the Semantic Web I Lecture Notes in AI, 282-314, Springer, 2008. (http://www.dbs.ifi.lmu.de/~huang/papers/LearningRDF23.pdf).

2. Seok Jong Yu, "The Dynamic Competitive Recommendation Algorithm in Social Network Services", Information Sciences, 187 (2012) 1-14.

3. Yoshue Bengio, Learning Deep Architectures for AI, Foundations and trends in Machine Learning, Vol. 2, No. 1 (2009) 1-127.

4. Accumulo, http://accumulo.apache.org/.

KEYWORDS: Decision support, feature selection, predictive analysis, courses of action, fusion, recommender

N14A-T025 TITLE: Improving the Life Expectancy of High Voltage Components Using Nanocomposite Surface Solutions

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: Fixed Submarine Broadcast System

OBJECTIVE: Develop surface coatings to improve the high voltage, wet-limit performance and longevity of dielectric and conducting materials used in VLF/LF (Very Low and Low Frequency) antenna components for the Fixed Submarine Broadcast System (FSBS).

DESCRIPTION: Transmission power ranges for VLF/LF (Very Low and Low Frequency) antennas used in the FSBS radiate from hundreds of kilowatts to megawatts. The high voltage operation at these sites and their exposure to the elements (e.g., rain) can quickly age and cause failure in the materials used in the VLF antenna components. The three major components that are affected by external environmental conditions are the insulating materials of the feed-through bushings, the dielectric supports for the tuning coils and the structural members of the insulators. Failure modes for the materials vary, but generally result in burning or fire due to high voltage arcing and surface tracking. Improved surface coatings will prevent the premature failure of these materials preventing downtime and costly replacement of damaged parts. The long term goal is to have the components perform in all weather conditions as well as they perform in dry weather.

The Navy is interested in proposals for new surface coating treatments that actively prevent surface damage to materials used in the VLF system for all weather conditions and during high voltage operation. The surface coatings should take into account the following requirements: 1) Compatible with existing VLF device materials, 2) Ease of application, 3) Sufficiently water repellant, 4) Highly-insulating and non-conductive so as to prevent arcing, 5) Relative small feature sizes to avoid "hot spotting," 6) Uniform coating quality, and 7) Long lasting requiring infrequent applications. Solutions of particular interest are superhydrophobic surfaces and other nanocomposite surfaces that can actively control water droplets. Development of such innovative surface treatments should demonstrate coatings that scale up to component size, resulting in significant reduction in failures and overall cost effectiveness.

PHASE I: Explore and define protective surface coating technologies that prevent the ingress of water into the internal layers of the materials. Demonstrate feasibility of the coating treatment for improved environmental conditioning. Demonstrate feasibility of the approach through limited testing on small sample pieces. Analyze the expected costs (non-recurring and recurring) and performance on a full size component and provide a plan for proof of performance.

PHASE II: Fully develop the concept demonstrated during Phase I through a process specification and demonstration of industrial reproducibility. Deliver to the government surface coating treatments. Demonstrate the scale up to component size and test coatings. Present an approach for manufacturing the surface coating.

PHASE III: The final protective coating technologies shall be developed with performance specifications satisfying targeted acquisition program requirements coordinated with technical point of contact. Perform verification and validation of the developed process. Demonstrate system reliability, maintainability, and environmental ruggedness in the overall system design.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: All weather surface solutions/treatments compatible with high voltage/high electric field equipment has immediate application in the commercial power industry.

REFERENCES:
1. VLF Radio Engineering; by Arthur D. Watt; Pergamon Press, 1967.

2. VLF/LF High-Voltage Design and Testing, SSC San Diego TECHNICAL REPORT 1904; by Hansen, Peder & A. D. Watt, September 2003.

3. “Superomniphobic Surfaces for Effective Chemical Shielding” S.Pan et al. J. Am. Chem. Soc., 2013, 135 (2), pp 578–581. DOI: 10.1021/ja310517s.

KEYWORDS: VLF antennas; high power; surface coatings, all weather conditions superhydrophobic surfaces