NAVY
STTR 11.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). The Navy STTR Program Manager is Mr. Steve Sullivan. If you have questions of a general nature regarding the Navy's STTR Program, contact Mr. Sullivan (steven.sullivan@navy.mil). For general questions regarding NAVAIR topics N11A-T001 through N11A-T012, please contact the NAVAIR STTR Program Manager, Mrs. June Chan (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 **28 February 2011**. Beginning **28 February**, for technical questions you must use the SITIS system **www.dodsbir.net/sitis** or go to the DoD Web site at **http://www.acq.osd.mil/sadbu/sbir** 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. Phase I technical proposals, including the option, have a 25-page limit (see section 3.4). 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 proposal, DoD Proposal Cover Sheet, Cost Proposal, 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. Each of these documents is submitted separately through the Web site. To verify that your technical proposal has been received, click on the "Check Upload" icon to view your uploaded technical proposal. 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. ET). Your proposal **must** be submitted via the submission site before **6:00 a.m. EST, Wednesday, 30 March 2011**. An electronic signature is not required when you submit your proposal over the Internet.

***** A small business concern must negotiate a written agreement between the small business and the research institution allocating intellectual property rights and rights to carry out follow-on research, development, or commercialization (ref: DoD Section 3.5(e) Agreement between the Small Business and Research Institution). It is requested that all Navy STTR offerors upload this agreement as part of the STTR proposal submission - it will not count towards the page limit. If you are selected for award, and have not transmitted the agreement to the point of contact identified in the selection notice, you will be required to submit the signed agreement within 18 calendar days or forfeit your selection. *****

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.

PHASE I SUMMARY REPORT:

All awardees must submit a non-proprietary summary of their final report (without any proprietary or data rights markings) through the Navy SBIR website. Submit the summary at: **http://www.onr.navy.mil/sbir**, click on “Submission”, and then click on “Submit a Phase I or II Summary Report”. A template is provided for you to complete. This summary, once approved, may be publicly accessible via the Navy’s Search Database.

PHASE II PROPOSAL SUBMISSION:

Phase II proposal submission is strictly by invitation. Only those Phase I awardees who achieved success in Phase I, measuring the results achieved against the criteria contained in the DoD solicitation preface, section 4.3, “Evaluation Criteria – Phase II”, will be invited to submit a Phase II proposal. If you have been invited to participate, follow the instructions provided in the invitation. The Navy will evaluate and select Phase II proposals using the evaluation criteria in the DoD solicitation, Section 4.3. All Phase II proposals must be submitted electronically through the DoD SBIR/STTR Submission Web site. The Navy does NOT participate in the FAST TRACK Program.

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.

All awardees, during the second year of the Phase II, must attend a one-day Transition Assistance Program (TAP) meeting. This meeting is typically held during 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.

As with the Phase I award, Phase II award winners must electronically submit a Phase II summary through the Navy SBIR/STTR Web site at the end of their Phase II.

ADDITIONAL NOTES:

1. The Naval Academy, the Naval Postgraduate School and other military academies are government organizations and therefore do NOT qualify as partnering research institutions. However, if an otherwise-qualifying proposal presents a compelling need for participation by such an institution (or any other government organization), then, subject to a waiver granted by the Small Business Administration (SBA), this organization can participate in the role of a subcontractor. Such a government subcontractor may be proposed only IN ADDITION TO the partnering research institution; and the contract award will be contingent on the receipt of the SBA waiver.

2. Because of the short timeframe 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 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 <u>must be met</u> or your proposal will be REJECTED.

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

2. **Include tasks to be completed during the option period and include the costs in the cost 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. **The Phase I proposed cost for the base effort does not exceed $80,000. The Phase I Option proposed cost does not exceed $70,000. The costs for the base and option are clearly separate, and identified on the Proposal Cover Sheet, in the cost proposal, and in the work plan section of the proposal.**

5. **Upload your technical proposal and the DoD Proposal Cover Sheet, the DoD Company Commercialization Report, and Cost Proposal electronically through the DoD submission site by 6:00 a.m. EST, 30 March 2011.**

6. **If the Agreement between the Small Business and Research Institution is not included with the proposal submission, it must be provided within 18 calendar days after receipt of the award selection notice, or the award selection will be forfeited.**

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

NAVY STTR 11.A Topic Index

NAVY STTR 11.A Topic Descriptions

N11A-T001 TITLE: Automated Human and System Performance Assessment in Operational Environments

TECHNOLOGY AREAS: Air Platform, Information Systems, Human Systems

OBJECTIVE: Develop a self contained deployable system to automatically quantify combined human and systems performance in real-time and for after-action-review by fusing output of normative models of behavior, human state, system state, and contextual situation state.

DESCRIPTION: Complex weapons systems require years of training for crews to master all aspects of the system, the situations in which they are deployed, and the human to human interactions that are necessary for mission success. While such systems are developed on the basis of stringent functional requirements to meet the needs of the ultimate users in the fleet, it is possible that expert crews have become accustomed to and compensate for adverse system traits that would be unacceptable or even dangerous when the system is used by crews with less experience in demanding theater operations. Expert crews are usually very skilled operators of the systems they operate with an extremely well developed behavioral knowledge base to recognize appropriate sequences, tactics, and contexts of the situation. Such a high level of expertise is necessary to apply the system to its full potential in tactical situations with rapidly changing parameters and limited time to evaluate possible decisions. For example, experienced pilots can operate most aspects of the aircraft with a high degree of skill and focus on the mission evolution rather than being occupied by inner-loop control of the aircraft and associated systems. However, experienced pilots may inadvertently use their expertise to compensate for and overcome adverse systems traits without much effort or attention whereas less experienced pilots in the same situation may encounter the system as unacceptable or even dangerous. Aside from the fact that undesirable system traits can adversely affect flight safety, the costs for design changes to address adverse system traits increase exponentially throughout the system development cycle and for fielded systems the costs can take on catastrophic proportions. With the proper measurement tools, it would be possible to detect adverse system traits early on.

What is needed is research, development, and technology transition to arrive at a self-contained deployable system that automatically supports assessment of the combined human-systems performance on the basis of intelligently fused sources of real-time information derived from normative behavior models, the human operator, the system, and the situational context. The proposed systems concept should be based upon a novel model that addresses the differences in procedural and cognitive behaviors that would be expected at varying levels of expertise. The system should be able to provide performance assessment feedback in real-time and during after-action-review and it should be based on accurate real-time system state data such as position, velocity, accelerations, control manipulations, as well as human state data such as eye tracking, heart rate variability, and neural measures of performance from existing commercially available sensors and situation context such as planned trajectories and performance envelopes.

The developed system should provide detailed means to record, annotate, process, transmit, and display pertinent information derived from the source data to indicate overall systems performance, operator state including attention and loading, and performance deviations from normative expectations. The system should provide the means to generate a detailed and easy to understand record of a test sortie so that potentially adverse system traits can be identified, documented, and predictions could be made on how these traits, if left unmitigated, could affect system performance in an operational tactical environment with normal fleet user characteristics.

As such a technology would be most useful if it could be deployed in operational and possibly distributed systems it is important that considerable attention be given to design of the form factor, processor miniaturization and integration, transmission protocols, and technical readiness of the proposed sensor solution.

PHASE I: Define and develop a novel model that captures differences in cognitive and procedural behaviors, concept of operations, architecture, necessary algorithms, research, development, and transition plan to develop a system that can automatically quantify combined human and systems performance in real-time and for after-action-review by fusing output of normative models of behavior, human state, system state, and contextual situation state.

PHASE II: Produce a deployable prototype of the Phase I concept, collect development and validation data in a high fidelity simulation test environment that closely approximates an operational system of interest to a transition customer, and demonstrate its use and benefits to transition stakeholders. Refine transition plan on the basis of study data and demonstration feedback.

PHASE III: Finalize design developed in Phase II, conduct testing in an operational environment and transition to interested parties.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: It is conceivable that non-military commercial application opportunities will exist for testing of operational systems in an industrial setting such as automobiles, aircraft, information systems, and consumer products.

REFERENCES:

1. Dwyer, D. J. & Salas, E. (2000). Principles of Performance Measurement for Ensuring Aircrew Training Effectiveness. In O'Neil Jr., H.F. & Andrews, D.H. (Eds.), "Aircrew Training and Assessment" (223-244). Mahawan, NJ: Lawrence Erlbaum Associates.

2. Gevins, A. & Smith, E. (2005). Neurophysiologic measures for Neuroergonomics. In Schmorrow, D.D. (Ed.) "Foundations of Augmented Cognition" (841-850). Mahwah, NJ: Lawerence Erlbaum.

3. Stevens, S.M., Forsythe, J.C., Abbott, R.G., & Giesesler, C.J. (2009). Proceedings from the 5th International Conference on Foundation of Augmented Cognition. Neuroergonomics and Operational Neuroscience: Held as part of HCI International: "Experimental Assessment of Accuracy of Automated Knowledge Capture." San Diego, CA.

KEYWORDS: Automatic Performance Assessment; Human State Data; Normative Behavioral Models; Operational Systems; Distributed Systems; After Action Review

TPOC: (407)380-4749
2nd TPOC: (407)380-4631

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

N11A-T002 TITLE: Compact Radar Technology For Over the Horizon Small-Boat and Semi-Submersible Detection and Tracking

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop a compact multi-input, multi-output Ka-band radar system to provide over-the-horizon maritime target detection and tracking utilizing evaporation duct propagation.

DESCRIPTION: The long-range detection, tracking, and classification of maritime surface contacts including detection and discrimination of small targets such as periscope masts is an essential Naval capability. Long-range, over-the-horizon microwave propagation over the sea is a very desirable means to achieve this capability. Over the horizon propagation may occur in the presence of atmospheric and hydrological environments with super-refraction or atmospheric waveguide (low height and evaporation) conditions. These conditions are extremely common. In addition, as a result of changes in the troposphere complex weather phenomena, atmospheric inhomogeneity, turbulence and level of stratification, the recurrent emergence of strong convection can cause scattering layer so that a long-range performance can also be achieved through troposphere scattering.

Multiple-input multiple-output (MIMO) radar technology may be particularly well suited for this very wide angle surveillance task. Some analyses indicate that MIMO radar may outperform its phased-array counterpart significantly in parameter identifiability, spatial spectral estimation resolution, clutter suppression capability and transmit beampattern design. Another potential advantage of coherent MIMO radars is that they enable the use of sparse arrays without the adverse effects of sidelobes. For maritime target moving indicator radars MIMO may provide improved angle estimation and minimum detectable velocity. In order to take full advantage of the complex propagation conditions, the adaptive tailoring of the transmitted waveform to the propagation medium and the target scattering characteristics may significant enhance overall detection and false-alarm performance.

To date the analyses supporting MIMO performance have not been sufficiently validated through experimentation to the satisfaction of the radar community. In fact, the merits of MIMO radar and a matter of strong dispute in the community with many members polarized on opposite ends of the opinion spectrum. The goal of this work is to design and demonstrate of a proof-of-concept Ka-band MIMO radar system for over-the-horizon maritime target detection and tracking utilizing evaporation duct propagation. The demonstration shall be executed in a manner to allow full assessment of fundamental MIMO radar capabilities. The effort should include the design of signal processing algorithms including adaptive waveform design and receiver signal synthesis.

PHASE I: Demonstrate the feasibility of a Ka-band MIMO radar system through modeling and simulation demonstrations. Candidate tasks are (1) comprehensive modeling of evaporation duct propagation as it relates to the radar usage; (2) adaptive waveform designs for improved detection performance; (3) performance evaluations of the design in terms of target detection and localization capabilities; (4) identification of performance limitations and hardware requirements to prepare for Phase II hardware implementation. Preliminary hardware design should be in place and ready for Phase II effort.

PHASE II: Develop a prototype Ka-band MIMO radar system. The design initiated in Phase I should be implemented using commercial-of-the-self hardware components. Effort should fully investigate adaptive waveform design and the performance and capability of the demonstration system.

PHASE III: Further refine algorithms and the design to improve performance robustness for practical operation scenarios. Effort may be focused on further developing the capability and transition to military programs.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Commercial applications include homeland security maritime area monitoring.

REFERENCES:
1. Anderson, K.D. Radar detection of low-altitude targets in a maritime environment. (1995). ”Antennas and Propagation, IEEE Transactions on", 43(6), 609 - 613.

2. Li , J. & Stoica, P. (Eds.). (2009). "MIMO Radar Signal Processing." New York: Wiley.

3. Lin, Jiao & Zhang, Yong-gang. The effects of radar detection in heterogeneous evaporation duct conditions. "Antennas, Propagation and EM Theory, 2008. ISAPE 2008. 8th International Symposium on", 1402 – 1405.

4. Yuanwei Jin, Moura, J.M.F., & O'Donoughue, N. Time Reversal Transmission in MIMO Radar. "Signals, Systems and Computers, 2007. ACSSC 2007. Conference Record of the Forty-First Asilomar Conference on", 2204 – 2208.

KEYWORDS: Radar; Maritime Surveillance; Ducted Propagation; Multi-Input Multi-Output; Adaptive Waveforms; Environmental Sensing

TPOC: (301)342-2637
2nd TPOC: (301)342-2043

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

N11A-T003 TITLE: Plasmonic Enhancement of Receiver Circuits for Energy Harvesting

TECHNOLOGY AREAS: Materials/Processes, Sensors

OBJECTIVE: Develop novel solutions for plasmonic field enhancement of receiver circuits for energy harvesting applications.

DESCRIPTION: Plasmonic field enhancement is now a viable technological tool. It is used extensively in enhancing the sensitivity of a number of spectroscopic techniques. Surface enhanced Raman spectroscopy and spectroscopy depending on Stark effect are key examples. It appears to be possible to achieve improvement for electromagnetic energy detection (and possibly, enable harvesting of energy from the thermal ambient) using plasmonic field enhancement. The establishment of a plasmon wave has been shown to enhance the electric field in nanoantennae. While plasmonic enhancement of the electric field in optical nanoantennae has been demonstrated, the tunneling diode resistance capacitance (RC) time-constant of a diode monolithically integrated with a nanoantenna was found too large for assuring electric field rectification and to lead to meaningful detection. This solicitation seeks solutions to the limited bandwidth of "rectennae" by reducing the forward diode resistance and capacitance, leading to an overall increase of the coupling efficiency of radiation to the "rectenna" and to an overall increase in conversion efficiency. It will also be expected to improve understanding of the way plasmon generation affects the way light can couple to antenna structures

"Rectennas" are integrated structures (antenna, tunnel-diode hybrids) in which the detection element (diode demodulator) is directly embedded at the feed-point of the antenna. They have been shown to function in the terahertz frequency range. As such, they can act to “detect” ambient IR radiation, scavenging it from the environment. The “rectified, optical energy can be used to charge batteries or capacitors. These structures are small (less than 10 microns in their largest dimension) to enable the demodulation of light in the near-infrared (IR) frequency range.

The end-line goal of this project is the development of large area, inexpensive sheets that can transform incident infrared radiation into electricity with efficiency suitable for energy harvesting applications. The work also has possible application in the area of IR commuinication. The rectenna structures could be detector circuits for any near-IR communication scheme.

Proposed rectenna array solutions should be low cost and be able to transduce beamed infrared power to electric energy and to store the energy in a capacitor or in a battery. Performance metrics include a minimum of 5% conversion efficiency in a 1cm x 1cm array.

PHASE I: Investigate and outline a method of integrating antenna and detector structures in such a way as to utilize plasmonic field enhancement to lower the effective diode turn-on voltage. Outline a pathway to lowering the diode time-constants by lowering either (or both) diode forward resistance and capacitance. Demonstrate the viability of the chosen approach.

Initial Phase I milestone will be the demonstration of a functioning “rectenna” device capable of detecting infrared radiation in the millimeter wave range of frequencies. Provide a benchmark measurement of conversion efficiency (the ratio of incident infrared power to electric power dissipated in a load). Propose a plan for specific set of interim demonstrations for Phase II of conversion efficiency for their rectenna design as well as conversion efficiency in an area array (e.g. 1mm by 1mm) of rectennas leading to the end goal.

PHASE II: Demonstrate infrared detection using the Phase I proposed “rectenna” structure. The goal is to demonstrate a minimum of 5% conversion efficiency in a 1cm x 1cm array with an agreed to set of interim demonstrations for quantifying progress during Phase II. Quantify the ambient heat (10 micron wavelength) to electric energy conversion efficiency of the developed rectenna arrays. Investigate a low cost manufacturing process for rectenna arrays.

PHASE III: Transition the developed technology to appropriate DoD platforms.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The private sector potential includes: Enhanced-detection efficiency in microwave communication systems and the possibility of infrared energy scavenging from the environment. The resulting system can be used to distance power unmanned autonomous vehicles (UAVs) as well as to perform energy scavenging for power management.

REFERENCES:
1. Bean, J.A., Tiwari, B., Bernstein, G.H., Fay, P., & Porod, W. (2009). Thermal infrared detection using dipole antenna-coupled metal-oxide-metal diodes. “Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures,” 27(1), 11–14.

2. Faris, S., Gustafson, T. K., & Wiesner, J. (1973). Detection of optical and infrared radiation with DC-biased electron-tunneling metal-barrier-metal diodes. “IEEE Journal of Quantum Electronics,” 9(7), 737–745.

3. Heiblum, M., Shihyuan, W., Whinnery, J., & Gustafson, T.K. (1978). Characteristics of integrated MOM junctions at dc and at optical frequencies. “IEEE Journal of Quantum Electronics,” 14(3), 159–169.

4. Hobbs, P.C.D., Laibowitz, R.B., Libsch, F.R., LaBianca, N.C., & Chiniwalla, P.P. (2007). Efficient waveguide-integrated tunnel junction detectors at 1.6 µm. “Optics Express,” 15(25), 16376–16389.

KEYWORDS: Plasmonics; Energy Harvesting; Infrared Detection; Rectenna; Energy Conversion; Diodes

TPOC: (301)904-3502
2nd TPOC: (301)757-7016

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

N11A-T004 TITLE: High Resolution Measurement of the Flow Velocity Field in a Supersonic Jet Plume

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop a non-invasive (non-seeded) approach to measure the unsteady, 3-D velocity field of a supersonic jet plume for a stationary aircraft. Looking also to make high resolution, time resolved measurements of the turbulent flow field for Short Take-Off/Vertical Landing (STOVL) aircraft with both subsonic and supersonic flow regions.

DESCRIPTION: Modern supersonic jet aircraft engines produce a high amplitude noise field with complicated characteristics. The apparent dominant noise source as measured and mapped using acoustic holography methods occurs from 1 to 30 nozzle diameters behind the engine due to a variety of turbulent behaviors of the hot jet. This complicated aeroacoustic problem is not easily modeled using classical analytical approaches. Significant effort is being expended to model the flow field aft of the engine exhaust nozzle using Large Eddy Simulation (LES) methods. Researchers are looking to better understand the characteristics of the turbulent structures in the jet plume in the hopes of developing treatments to engines that might reduce the noise emissions. A significant obstacle to making these simulations practical and realistic for engine design purposes is the lack of methodology to measure the velocity field of the jet plume for purposes of correlating computational results. High quality measurements of the velocity field at and ahead of the exhaust nozzle exit plane would improve the upstream boundary condition definition for use by these analytical methods as well.

A further need for this technology is for imaging the supersonic and subsonic turbulent flow field around a STOVL aircraft. This is needed to correlate CFD models that seek to understand the safety and other impacts of the flow field on support personnel and equipment.

The various commonly used current velocity field measurement methods are inadequate. Hot wire anemometry methods are limited to flows of Mach 0.5 or less. Flow rakes using pitot tubes significantly disrupt the flow field and have very coarse spatial resolution. Supersonic jet flows in wind tunnels have been mapped using Particle Image Velocimetry (PIV) methods. This method makes use of either solid "seed" particles or some other added "seed" material such as olive oil. However, the “seed” particles used are judged to be impractical and damaging to use to image flow velocities in a turbo machine.

Laser based methods, such as Light Detection and Ranging (LIDAR) methods have shown very good results for measuring low speed turbulent air flows in large regions of the atmosphere, and is a promising weather tool. This tool does not require a "seed" material (herein termed a "non-invasive" approach), but rather makes use of aerosols naturally occurring in the air, which either phosphoresce from or reflect the projected laser light in order to image the flow.

Innovative non-invasive approaches to measure the velocity fields of supersonic jet plumes for a stationary aircraft are sought. Electromagnetic imaging methods may be a good solution to this problem. Light based methods such as LIDAR are expected to hold excellent promise, particularly as various light frequencies have been shown to have the ability to image various gases. It is expected that either one of the various naturally occurring or combustion byproduct gases in a supersonic engine jet plume may be amenable to such an imaging method.

Proposed solutions must work without the addition of imaging particles or fluids to the jet engine intake or exhaust. Spatial resolution of measurement methods must capture the features of the unsteady velocity field with fine enough resolution to capture large and small scale eddies, turbulent boundary layer characteristics and shock structures. Method must also work with flows that are not combustion byproducts, and in the subsonic case. Measurement methods must capture results with sufficient time resolution to track the advection of both large and small scale turbulent structures in a supersonic jet plume. Any velocity measurement method that meets the above requirements will be considered.

PHASE I: Demonstrate the feasibility of an imaging method capable of measuring the flow field of a subsonic or supersonic jet plume. Evaluate the three dimensional spatial resolution limits and explore methods to improve the resolution. Demonstrate the limits of temporal resolution of the measurement and the technological limits defined. Improvement to temporal resolution is desired. Contractor may make use of public domain jet flow facilities, such as wind tunnels operated by academic institutions for demonstration purposes.

PHASE II: Extend the Phase I methodology to improve any deficiencies, such as spatial or temporal resolution issues. Develop and deliver a prototype measurement system capable of meeting the objectives outlined above. Improve upon the Phase I laboratory method to make it practical and affordable for future commercialization. Any differences between Phase I and Phase II methodologies are to be noted and explained.

PHASE III: Further develop the measurement method into one that may be sold, or the service provided for private sector and other government uses.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The ability of current technology tools to image high speed flows is limited by several factors. If successful, it is expected that this technology will provide excellent benefits for aircraft designers in both the commercial and military sectors and will be generally useful as a research and engineering tool. Significant benefits will be gained in high speed flow imaging for a wide variety of aerospace applications from rockets to commercial jet engines. A large segment of the aerospace community would be potential customers of this method.

REFERENCES:
1. Kelley, N.D., Jonkman, B.J., Scott, G.N., & Pichugina, Y.L. (2007). Presented at the American Wind Energy Association WindPower 2007 Conference and Exhibition: "Comparing Pulsed Doppler LIDAR with SODAR and Direct Measurements for Wind Assessment". Los Angeles, California.

2. Frelich, R., & Cornman, L. (2002). Estimating Spatial Velocity Statistics with Coherent Doppler Lidar. "Journal of Atmospheric and Oceanic Technology", 19(3), 355-366.

3. Mikkelsen, T., Hansen, K., Angelou, N., & Sjoholm, M. (2010). Proceedings from European Wind Energy Conference (EWEC) 2010: "LIDAR Wind Speed Measurement From a Rotating Spinner". Warsaw, Poland.

4. Hewitt, J. (03 Jul 2008). "Doppler Lidar Gives Olympic Sailors the Edge". Retreived from http://optics.org/article/34878

KEYWORDS: Flow Visualization; Supersonic Jet Noise; LIDAR; PIV; Jet Plume Flow Measurement; Flow Velocimetry

TPOC: (301)757-2306
2nd TPOC: (301)342-9434

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

N11A-T005 TITLE: Modeling of pulse propagation in a four level atomic medium for gyroscopic measurements

TECHNOLOGY AREAS: Air Platform, Sensors

OBJECTIVE: Develop robust, versatile and computationally efficient models for an as yet not designed gyroscope based on a four level N-scheme atomic system and a bidirectional ring resonator.

DESCRIPTION: It has long been known since the pioneering work of Sagnac that light can be a utilized to perform interferometrically sensitive measurements of rotation. If one considers a ring cavity rotating about an axis perpendicular to the cavity plane, light traveling in one direction experiences a different cavity length than a light beam traveling through the cavity in the opposite direction. Assuming a dispersionless medium, the speed of light is constant, which means that the transit time of the light in the cavity in one direction is different than the transit time of the light in the other direction. This difference in path lengths directly translates to a phase shift.

On the other hand, the field of “slow light” is still in its infancy. It has only been since 1999 that researchers have been able to slow the group velocity of light from 300,000 km/s to 100’s of m/s. Through the use of a specially prepared medium consisting of two lasers (a ‘pump’ and a ‘probe’) and an atomic gas, an extremely narrow resonance can be generated in the absorption spectrum of the probe. Using the Kramers-Kroneig relation, this implies a sharp feature in the mediums’ index of refraction. Since the group velocity of the probe light is inversely proportional to the derivative of the index of refraction, a sharp feature in the index of refraction directly translates to a decrease in the group velocity of light. For this work, it is noteworthy that if the medium consists of one excited state and two ground states (the configuration that yields the largest amount of light slowing) the two beams of light need to be co-propagating for this effect to take place: a beam that is counter-propagating relative to another will not experience any significant light slowing, due to the Doppler shift. Thus, one can envision the possibility of one pump beam circulating in one direction around a ring cavity and two probe beams, one co-propagating with the pump and the other counter-propagating with the pump. Because of the light slowing effect, one beam will have a dramatically increased cavity transit time as compared to the other. Ultimately, this leads to an increased sensitivity for a gyroscope over a conventional gyroscope. Since the change in the group velocity is on the order of one million, this same factor is the anticipated increase in sensitivity.

Slow light gyroscopes have been the focus of some in-house research. The novelty of the scheme currently being investigated is the inclusion of a third field (the ‘control’) that allows optical control over the group velocity. In this four level scheme, the group velocity is a function of the control field intensity in a manner that is fundamentally different than the dependence of the group velocity on the pump laser in a three level scheme. Here, the group velocity can be made arbitrarily small or large (up to c) and can even be made negative. This control over the group velocity translates into the ability to control the dynamic range of the gyroscope. During periods of slow rotation rates, the gyroscope can be operated in “high sensitivity” mode by selecting the correct control intensity for slowest group velocity. During periods of large rotation rates, the group velocity can be changed so as to “degrade” the sensitivity to current fiber-optic gyroscope performance.

A full initial model has been developed that includes all laser fields with arbitrary strength and frequency detuning with respect to atomic transitions, all atomic levels with associated decay rates and dynamics, and propagation of all fields. However, the current model is cumbersome to implement, difficult to adapt to changing configurations and computationally intensive. This program seeks to develop robust, versatile and computationally efficient models to help guide experiments and assist in the designing of a gyroscope based on a four-level slow light atomic system.

PHASE I: Develop equations necessary to model the full four-level three laser field system, including all atomic parameters, laser parameters and resonator parameters. Develop a methodology that will enable the development of a full scale numerical program in Phase II. A successful Phase I will demonstrate a methodology that is computationally efficient and adaptable to changing configurations.

PHASE II: Develop an algorithm and full numerical model based on the methodology developed in Phase I. Initial model and algorithm validation can be performed in collaboration with experiments being performed at Pax River or an outside laboratory. Develop a laboratory proto-type design based on the modeling results. Fabricate and evaluate the prototype for use in operational areas such as long-term GPs denied areas or areas with high rotation rates.

PHASE III: Finalize and validate design. Transition the developed technology to appropriate platforms.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Any commercial application that requires a sensitive and stable gyroscope that may also be subject to large and sudden rotations will be able to use this technology. This can include, but is not limited to air navigation and underwater navigation.

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KEYWORDS: Slow Light; Gyroscope; Atomic Media; Maxwell-Bloch Equations; Computer Modeling; Light Propagation in Dispersive Media

TPOC: (301)342-0097
2nd TPOC: (301)342-2535

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

N11A-T006 TITLE: Advanced Thin-film Battery Development

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: Develop novel light weight high efficiency thin-film batteries for use in Unmanned Autonomous Vehicles (UAVs), remote sensors, expendables, energy harvesting and in “wearable” flexible electronics.

DESCRIPTION: Energy harvesting is important for distributed networks used in remote sensors, perimeter protection, intruder alerts and for widespread monitoring of bio-threats. Most energy harvesting schemes currently under consideration require some means of energy storage. Batteries, with their low internal leakage, long life and their ability to source low levels of power for very long periods of time are ideal for such an application.

The development of novel light weight high efficiency thin-film batteries is sought. The anticipated advantage of thin-film cells would be easy, seamless integration with the harvester. For example, thin-film cells could coat housings, structural components or the back-side of a solar panel, eliminating the need for a bulky “battery farm.” Proposed solutions must be flexible, so that they can conform to a variety of surfaces or be processed to conform to standard battery formats. For example, they can coat the airframe of an airborne UAV. If successful, this would save cargo space for weaponry and instrumentation packages on board the vehicle. It is also hoped that the thin-film cells could be made to resemble “battery cloth” and as such, could be used as removable jacket liners. This would distribute the weight of the power source over a war-fighter’s body, eliminating the need for bulky, unwieldy batteries. The cloth could also be used to back flexible displays.

Areas of research focus should be battery capacity, internal leakage, shelf life and cycle capacity. Proposed materials must be environmentally compatible and low-cost, as large numbers of batteries are required for all envisioned applications. It is not an objective to extend conventional battery technology.

PHASE I: Demonstrate proof-of concept for thin-flim batteries. Analyze various battery requirements and target one or more of the key performance parameters (battery capacity, internal leakage, shelf life, cycle capacity, etc.) and carefully benchmark the current state-of development. Analyze compatibility with possible energy harvesting techniques.

As a starting point, the demonstration target will include:
- Capacity: greater than 1mA.Hr/cm2
- Internal leakage On Charging: less than 100 uA/cm2
- Demonstrated Shelf Life: 1 month at a minimum
- Cycle Life: greater than 100 cycles at 80% of capacity, greater than 500 cycles at 20% of capacity

Outline an improvement plan for the chosen metric(s) and provide a proof-of-principle demonstration that improvement is possible with the outlined plan.

PHASE II: Develop a prototype thin-film battery. Demonstrate significant improvements in the cited metric(s) from Phase I. Demonstrate compatibility of the chosen process technology with volume manufacture. Demonstrate integration of the metric-enhanced battery with some product target as mutually agreed upon by the offeror and the Navy. Demonstrate battery charging techniques to include harvesting.

At the end of Phase II, demonstrate the minimum performance targets:
- Capacity: greater than 10mA.Hr/cm2
- Internal leakage On Charging: less than 10uA/cm2
- Demonstrated Shelf Life: greater than 6 months (or longer)
- Cycle Life: greater than 500 cycles at 80% of capacity, greater than 1000 cycles at 20% of capacity

PHASE III: Demonstrate large volume manufacturability of various batteries, conformal coatings and/or battery cloth(s) using the chosen processes. Transition the developed technology for use in DoD platforms. Supply the battery packs to system suppliers in ready-to-use format for the intended applications.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: A clear private sector commercial utility will exist for advanced thin-film batteries in any of their potential formats (standard, conformal, wearable). Selected technology may permit routine energy harvesting in the commercial as well as the military environments. The private sector potential includes: powering of “foldable displays,” battery liners for hand-held/lap-top devices, battery inserts for first-responder (e.g., firemen, EMTs, etc.) outfits, power supplies for structural integrity monitors (bridge maintenance and airframe integrity.)

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KEYWORDS: Thin-film; Flexible Battery; High-Efficiency Energy Storage; Energy Harvesting; Battery; Wearable Batteries

TPOC: (301)904-3502
2nd TPOC: (301)995-4559
3rd TPOC: (301)757-7016

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

N11A-T007 TITLE: Modeling to Quantify Improved Durability of Superfinish Gear Processing

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Develop physics based gear health models to quantify the benefit of superfinish over conventional gear processing techniques with regard to pitting, spalling and tooth bending fatigue failure modes.

DESCRIPTION: Superfinish processed gears have demonstrated improved performance and durability over conventionally processed gears. However, this improvement has not been quantified. In addition, there is some concern about the uniformity of the process in key areas such as contour surfaces or the root ends of the gear teeth. The Navy needs modeling capability that will quantify the expected performance improvements of superfinish over conventional processing in order to understand lifecycle expectations of this new technology.

The goal of this topic is to develop physics based models which are capable of quantifying the benefits of superfinish processed parts over conventional processing, particularly for key performance metrics including reduced susceptibility to pitting, spalling, and tooth bending fatigue failure modes. The proposed models should also be able to generate accurate virtual test data.

End goals are to use the developed model to:
1. Quantify benefits of super finish over conventional processing
2. Determine the optimum amount of processing for super finish for the H-53K application, to minimize processing time and cost
3. Evaluate alternative super finish processes to quantify the benefit of increased uniformity
4. Potentially enable life credits at some point in the future to capture the benefits of the super finish processing, by modeling and quantifying durability improvements
5. Develop a modeling methodology that enables virtual testing (supplemented by smart selection of limited physical tests as needed), and allows for affordable application to additional material systems and geometries.

Accuracy of proposed models should be demonstrated through validation of virtual test data with actual test data, and deficiencies should be identified and mitigated to the maximum amount practicable. Refine the physics based models based on data collected from component level gear tests. The capability of the developed models to accurately quantify the advantages of superfinish over conventional processes while capturing the risk areas of the process such as the contour surfaces, or the root ends of the gear teeth should be validated via demonstration tests. Pyrowear 53 is the primary alloy of interest for this effort. Other relevant alloys, such as AISI 9310 may be considered during Phase I if availability of technical data for Pyrowear 53 is an issue.

PHASE I: Demonstrate feasibility of physics based gear models to quantify performance advantages of superfinish processing over conventional processing when applied to Pyrowear 53 gears. Alternatively, AISI 9310 steel may be considered during Phase I if Pyrowear 53 technical data is not available to researchers during the limited Phase I timeframe. Demonstrate feasibility of virtual test models to: 1) generate accurate simulated test results; 2) quantify superfinish improvements to the key gear performance metrics described above; and 3) identify the gear features which account for the most uncertainty such as contour surfaces, or the root ends of the gear teeth. Propose a method to address the uncertainty inherent in the models.

PHASE II: Continue to refine and develop the superfinish gear models, with specific application to Pyrowear 53. Develop the modeling methodology in such a way that it allows for reapplication to additional material systems and part geometries. Increase accuracy by accounting for surface finish and machining characteristics, alloy composition and materials characteristics, geometry, case and core hardnesses, case depth, and ratio of case thickness to tooth thickness. Incorporate robust methods of handling uncertainty associated with key features identified in Phase I. Develop and demonstrate the capability to determine optimum amount of superfinish processing to maximize the benefit while minimizing processing time and cost. Evaluate benefits of alternative superfinish processes to quantify the benefits of improved uniformity. Validate via demonstration tests the capability of the developed models to accurately quantify the improved performance of superfinish gears and generate virtual test data. Identify shortcomings of the models as revealed by the demonstration tests, and reduce the shortcomings to the maximum extent practicable.

PHASE III: Finalize the physics based gear models with major Department of Defense end users, airframe, and engine manufacturers and conduct necessary qualification testing for the applications.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The physics based superfinish gear models developed under this topic would significantly enhance the state of the art for commercial aviation, as well as other areas including ship and ground vehicle applications. The capability would also reduce developmental test costs. The technology is directly transferable to commercial gearbox applications.

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KEYWORDS: Gear; Superfinish; Models; Health; Pitting; Fatigue

TPOC: (301)757-0508
2nd TPOC: (301)342-0878

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

N11A-T008 TITLE: Modeling Tools for the Development of Innovative Wavelength Division Multiplexed (WDM) Local Area Networks (LAN)

TECHNOLOGY AREAS: Air Platform, Information Systems, Electronics

OBJECTIVE: Develop and demonstrate innovative analysis, modeling, and optimization tools and approaches that can characterize the complex interactions between optical network components.

DESCRIPTION: Single-mode optical fiber based dense wavelength division multiplexing (DWDM) optical networks are well established as a leading solution for data communication links for commercial long distance telecommunications.

Due to a great potential for weight reduction, the Navy is investigating the use of DWDM optical networks for avionics applications. Weight savings can be achieved simply by converting a copper link to glass. With DWDM, that weight reduction is multiplied for each additional wavelength overlaid on a single optical fiber. Additionally, these DWDM networks provide the promise of future upgradeability to hundreds of independent wavelengths over the International Communications Union (ICU) C-band, L-band, and possibly X-band or beyond similar to that which the commercial market is achieving. Yet an additional potential avionics benefit includes the possibility of being able to carry independent applications as well as to isolate different security levels.

Current state of the art modeling tools for optical networks have been developed around long length telecommunication networks where dispersion and non-linearities are key limitations. Local area networks are shorter in length with lots of connections which result in unique limitations. These include loss which must be overcome by significantly more gain than typical long distance systems, signal denigration resulting from passing through a larger number of nodes before signal regeneration, and impact of multi path interference resulting from the reflections from a higher number of interfaces (e.g. from connectors) than are present in telecommunications network which are fused together eliminating return loss or utilize high return loss connectors.

Innovative analysis, modeling, and optimization tools are sought to overcome the above limitations so that the designers of a next generation wavelength division multiplexed (WDM) local area network (LAN) (e.g. draft SAE AS5659) have the necessary design tools. Proposed tools should be verified through focused experimentation and limited test bed application. The developed tools will be used to characterize alternative fiber optic wavelength division multiplexed (WDM) network architectures and control methodologies for aerospace platforms, whereby multiple optical wavelengths simultaneously transmit broadband signals via optical fiber throughout the airframe.

PHASE I: Determine the complex optical network component interactions for development based on the limitations identified above, develop an innovative modeling approach for next generation WDM LANs to address the identified limitations, and demonstrate the feasibility of the tools for practical application. Propose a process for verification for the developed tools.

PHASE II: Based on the results of the Phase I effort, develop a prototype of the modeling tool. Design and execute limited experimentation to demonstrate the accuracy of the developed tools. Ensure that the test bed is applicable to the development activities of an industry standard open architecture (e.g. SAE AS5659).

PHASE III: Complete the development effort and transition the design tools into commercially available products applicable to general purpose avionic platform networking for Naval application.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The general purpose WDM network is anticipated to provide highly integrated connectivity for short distance application. This is the same need that the commercial data communications world has. The long distance telecommunication network commercial world has already demonstrated commercial success of the existing modeling tools which apply to the long distance market. The next logical extension of WDM technology is to the short distance data communications market (which looks a lot like an aerospace platform) as the bandwidth needs at short length exceed the capability of copper. Consequently, the design tools developed under this topic will directly apply to the development needs for this market.

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KEYWORDS: Fiber Optics; Networking; Wavelength Division Multiplexing (WDM); Avionics; Standardization; LAN

TPOC: (301)342-9124
2nd TPOC: (301)342-9115

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

N11A-T009 TITLE: High Density, High Efficiency Electrical Power Generation System for UAS Applications

TECHNOLOGY AREAS: Air Platform, Electronics

OBJECTIVE: Develop a high-density, high-efficiency aircraft electrical power generation system with the goal of optimizing heat load, output power, size, and/or weight of future power generation systems.

DESCRIPTION: Electrical power generation systems have inherent inefficiencies due to electrical and mechanical loss mechanisms. New technologies are sought to increase the power density and efficiency of today’s electrical power generation system. Proposed solutions for improvements to the existing electrical power generation system or through new and novel power generation system architectures/designs will be considered. This effort should specifically focus on improvements to state of the art 270 Volt Direct Current (VDC) and/or 115 Volt Alternating Current (VAC) generation systems. Potential baseline systems include 30 kVA, 115 VAC variable speed constant frequency (VSCF) and 160 kW, 270 VDC machines used in current UAS and other advanced aircraft platforms.

This topic is expected to develop and demonstrate an innovative approach to power generation that provides a 20 - 50% increase in power capacity and 10 - 15% improvement in efficiency over the planned baseline systems while maintaining equivalent weight and volume. Proposed solutions must meet all applicable military standards.

PHASE I: Define and demonstrate proof-of-concept for a high density, high efficiency power generation system for UAS applications. Validation can be accomplished through analytical tools or through bench top hardware/test data. Selected candidates are encouraged to maximize the use of computer modeling and simulation techniques in this study.

PHASE II: Design, develop and provide a bread board demonstration or detailed analytical model of a high density, high efficiency electrical power generation system for UAS applications. Provide a detailed analysis as to the expected improvements (i.e. power density, efficiency, reliability, etc.) when compared to the baseline UAS electrical power generation system. Provide a comprehensive analysis of all integration and interface issues which may result from the new design.

PHASE III: Package new electrical power generation technology to perform demonstrations in a high fidelity laboratory environment (including full qualification testing) and/or flight test demonstration. Transition the developed technology to appropriate Navy platforms.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The results of this work can be commercialized to numerous industries requiring electrical power generation systems including aviation, automotive, utilities, etc. This will result in an increase in power density and efficiency for electrical power generation devices that will ultimately result in improved reliability, smaller size/weight, and increased power output when compared to today’s state-of-the-art generation capabilities.

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6. MIL-G-21480. Generator System, Electric Power, 400 Hertz, Alternating Current, Aircraft; General Specification for.

7. MIL-STD-810. Environmental Engineering Considerations and Laboratory Tests.

KEYWORDS: Generator; Power Density; Efficiency; Electrical Power; Aircraft; Thermal

TPOC: (301)342-0868
2nd TPOC: (301)342-0816

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

N11A-T010 TITLE: High Fidelity Helicopter Lag Damper Model for Comprehensive Rotor Analysis

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop an experimentally validated high fidelity nonlinear lag damper model that accurately predicts behavior of passive and semi-active or active lag dampers for a range of temperatures, amplitudes, and frequency range, for implementation into a comprehensive rotorcraft analysis system for rotor loads prediction.

DESCRIPTION: The use of a Health and Usage Monitoring System (HUMS) facilitates the monitoring of critical systems on helicopters, including rotor system, drive train, engines and life-limited components [1]. Rotors and their associated dynamic components operate in high-cycle and environmentally challenging conditions. To maximize the benefits of HUMS for rotor and dynamic components, accurate load prediction via a comprehensive rotorcraft analysis tool are crucial to conduct fatigue analysis and determine Remaining Useful Life (RUL). The key challenge in effectively predicting the lead-lag motions and resulting rotor loads is the lack of a high fidelity lag damper model.

Lag dampers are typically passive [2], and incorporate elastomeric [3], hydraulic [4-6], or adaptive damping capabilities based on smart fluids [7-8]. These dampers are integrated into existing rotor heads to augment stability of in-plane rotor bending modes while the helicopter is on the ground (i.e. mitigation of ground resonance) or in high speed forward flight (i.e. air resonance). Because lag dampers must be implemented in the rotor hub to augment rotor stability, innovative analysis is critical for the coupling between dampers and rotor blade motion. The complex behavior of lag dampers provides significant challenges for modeling such devices even for passive configurations. Current analytical models oversimplify the complexity of the operational environment and make assumptions about operating parameters, thus hindering an accurate prediction of damping.

Recently, semi-active or active lag dampers have been introduced with a goal of improving rotor stability via a feedback control system to compensate for substantial losses in damping capacity in passive elastomeric dampers as the amplitude of lead-lag excitation increases [2, 5]. Such losses of damping capacity in the face of excitation amplitude increases, dual frequency excitation, and increases in temperature due to self-heating and ambient temperature, remain a challenge in lag damper development that could be aided by effective damper models.

A high fidelity lag damper model is sought that can predict stiffness and damping forces over a wide range of amplitudes, temperatures, and frequencies. Proposed models should successfully predict the onset of resonance phenomena, resulting fatigue loads arising from damper implementation and their impact on rotor and dynamic components. The required outcome for this topic is an innovative and comprehensive approach to the prediction of stiffness and damping forces introduced by lag dampers having different configurations (e.g. snubber vs. linear stroke), materials, and feedback control strategies.

The lag damper model should be able to:
1) Predict the stiffness and damping of lag dampers comprising of elastomeric and/or (smart) fluidic components using appropriate material test data;
2) Predict forces induced by stiffness and damping for an appropriate range of amplitudes, temperatures (-50 to 120 degrees Fahrenheit based on altitude-dependent temperature profile) and frequencies (up to 40 Hz or 5/rev) representative of full scale lag dampers;
3) Predict performance improvements in stability augmentation and vibration loads reduction when implementing passive or semi-active (e.g., elastomeric, hydraulic, and/or fluid-elastomeric) lag dampers with feedback control; and
4) Integrate damper modeling approach with existing and future comprehensive rotor analysis codes.

PHASE I: Using existing data from the literature, develop innovative concepts for accurately predicting the lag damper behavior in response to both single and multi-harmonic steady state sinusoidal excitation, as well as transient excitation, for dampers comprising elastomeric materials and/or (smart) fluidic components. Incorporate effects of temperature dependent behaviors into this framework. Demonstrate via rotor analysis the benefits that would be expected (both in performance and computational capability) when implementing this analysis framework in a comprehensive rotor analysis. Develop a plan to experimentally validate the analysis at the component and rotor level.

PHASE II: Implement the concepts developed under Phase I and develop a prototype predictive analysis tool. Initiate verification and validation of the analysis tool through a demonstration showing predictive simulations track damper loads, and damping capacity, and that the predictive analysis can be readily incorporated into a comprehensive rotor analysis. Assess the effects of damper behavior, with and without adaptive control, on rotor loads.

PHASE III: Refine and expand the simulation capability to handle specific lag damper configurations. Develop and execute technology transfer plan to enable comprehensive rotor analysis codes to exploit this new lag damper simulation capability across the industry.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: This lag damper analysis system will have broad application to both civilian and military helicopter systems.

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KEYWORDS: Helicopter; Rotorcraft; Rotor Load; Lag Damper; Nonlinear; Analysis

TPOC: (301)342-8396
2nd TPOC: (301)342-8267

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

N11A-T011 TITLE: Monolithic Beam-Combined Mid-Infrared Laser Array

TECHNOLOGY AREAS: Air Platform, Sensors, Electronics, Battlespace

OBJECTIVE: Develop a power-scalable, robust, chip-based solution for a monolithic beam-combined quantum cascade laser (QCL) array with high continuous wave (CW) output power in the tens to hundreds of Watts and excellent beam quality in the mid-wave infrared (MWIR) spectral range for infrared countermeasure and other relevant DoD applications.

DESCRIPTION: High-power, monolithic, cost-effective, compact, and reliable MWIR laser sources operating in CW regime on thermoelectric coolers (TEC) are desirable and critical for current and future Navy applications, such as directional infrared countermeasure (DIRCM), and other surveillance and sensing applications. Individual QCLs emitting at ~ 4.6 micron with 3 Watts CW output power and wall-plug efficiency close to 15% have been recently demonstrated [1]. A possible method to increase the aggregate output power level of the laser sources while simultaneously maintaining near-diffraction-limited beam quality, is to combine multiple laser beams using coherent beam combining (CBC) or spectral beam combining (SBC) [2]. Most or all of today's CBC or SBC schemes demonstrated in the shorter wavelength ranges other than MWIR require hybrid integration of laser arrays with external optical elements and/or electronics, and hence a more cumbersome, costly and less reliable platform for demanding military field applications

It is the goal of this program to seek a power-scalable, chip-based platform that enables monolithic beam combining (MBC) of high-power CW QCLs. A complete MBC solution is sought that comprises a QCL array, QCL power amplifiers, and compact passive combiners that produce high-power outputs with excellent beam quality. Proposals on MBC of MWIR non-QCL semiconductor laser arrays will also be considered. Emission of the array's aggregate wavelengths over a narrow wavelength range is very desirable. The capability to electronically tune all of the emission wavelengths of the entire monolithic laser array is also sought as this unique tuning capability will be very advantageous for various existing and future DoD applications, even though wide wavelength tunability is not a requirement in the current solicitation. It is also the intent of this program to seek a monolithic, power-scalable semiconductor laser platform with electronic tunability in wavelength. Any proposal on the laser array wavelength tunability that requires thermal tuning of the lasers or mechanical tuning elements such as those in external-cavity configurations will be considered non-responsive.

PHASE I: Demonstrate the feasibility of TEC-cooled, high power (greater than 15 Watts) QCL arrays at ~4.6 micron with a monolithically integrated MBC configuration resulting in a single output with M2 less than 1.5. Modeling must include the detailed integrated characteristics of the various passive and active optical elements, and the associated thermal management at the chip and the system level. A clear development path and plan describing how the power can be monolithically scaled to power levels between 50 to 100 Watts and how the devices can be economically fabricated with high production yield (greater than 10x of the current process) must also be provided.

PHASE II: Demonstrate and deliver a prototype compact CW QCL array with a monolithically integrated MBC configuration with more than 15 Watts of CW power over a narrow wavelength range centered around ~ 4.6 micron and M2 less than 1.5. Overall wall-plug efficiency of the overall MBC laser array solution must exceed 10%. Provide an assessment of manufacturing yield and product reliability of the monolithically integrated laser array solution.

PHASE III: Fully develop and transition the MBC CW QCL array for DoD application in the areas of DIRCM, advanced chemical sensors, and LIDAR.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The commercial sector can significantly benefit from this technology development in the areas of detection of toxic industrial gases, environmental monitoring, and non-invasive medical health monitoring and sensing.

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KEYWORDS: Mid-Infrared; Monolithic; Semiconductor; Beam Bombining; Laser Array; Quantum Cascade Laser (QCL)

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

N11A-T012 TITLE: Emitter Geolocation Enhancements for Time-Sensitive Targeting and Naval Battlespace Awareness

TECHNOLOGY AREAS: Sensors, Battlespace, Weapons

OBJECTIVE: Develop, analyze and deploy enhanced techniques to improve emitter detection and geolocation performance for improved time-sensitive targeting and Naval Battlespace Awareness

DESCRIPTION: Traditional techniques for emitter geolocation include Angle of Arrival (AOA) for single sensor platform situations and Time Difference of Arrival / Frequency Difference of Arrival (TDOA/FDOA) as a technique involving dual/multiple sensor platforms. These methods provide limited performance due to constraints on platform size, cost, antenna size, instrument errors, processor throughput, signal propagation modeling errors associated with changing geometries, attitude and Doppler changes over a data collection or signal processing time interval, and the types of challenges as itemized below.

Performance parameters associated with emitter geolocation include, but are not limited to –
(1) Time to deploy to region
(2) Signal detection sensitivity
(3) Geolocation accuracy
(4) Time to detect
(5) Time to geolocate to a given accuracy.

Current emitter geolocation technologies fall short on the needed “time and throughput” requirements.

The performance capabilities associated a specific geolocation approach are often interrelated, and scenario and technology dependent.

The time to deploy to region often depends on the system size. For example, technologies which require large antennas and high-power, are often deployed on large Unmanned Air Vehicles (UAVs) or manned aircraft, whereas small antenna and technologies which can be implemented with small weight, size and power requirements may be implemented on small, low-cost UAVs, which can often be deployed in theater more quickly.

Signal detection sensitivity is an important factor for detecting weak signals or even some relatively strong signals at large ranges. While the processing gain for detection can be increased using large antennas, the use of small antennas is often preferred to allow use of smaller, lower cost sensor platforms as mentioned above. The use of large directional antenna may introduce a larger time for detection as compared to the use of omni-directional antennas due to the time to scan or slew a directional antenna to cover a large region of interest. Improvements in signal processing can enable enhancements in signal-to-noise ratio (SNR) compared to traditional “snapshot” algorithms, by enabling longer coherent integration time intervals. For example, at the Global Positioning System (GPS) L1 frequency, the coherent integration time interval for traditional techniques may be limited not to exceed 1 millisecond for some scenario. However, if precise sensor platform navigation and timing information is utilized, then the coherent integration time interval may be extended by a factor of 100 or more for some scenarios, corresponding to a factor of 100 (20 dB) processing gain enhancement for detection of weak signals.

The geolocation accuracy depends on such parameters as the number of sensor platforms, the geometry, the coherent integration time and the observation time. As a numerical example, at the GPS L1 frequency, a ½-meter diameter antenna can achieve an ideal geolocation AOA accuracy of about three degrees using the traditional MUltiple SIgnal Classification (MUSIC) algorithm [1]. However, in some cases, the synthetic aperture technique can enable an (effective) antenna size of 50 meters or more, corresponding to a factor of 100 or more improvement in geolocation AOA accuracy. The Cramer Rao bound [2] for the traditional TDOA/FDOA technique typically assumes a single “snapshot” observation, whereas multiple observations over an extended interval of time, can enable improved accuracy which exceeds the Cramer Rao bound for some scenarios.

The time to detect depends on such parameters as the emitted power, the range, the processing gain, and the required time to search a certain region. Dual-platform methods require that both platforms be deployed in suitable geometries within the emitter signal antenna beam, whereas single platform methods may require that after an initial detection occurs, that the platform fly to a second location for triangulation. Depending on the technology, the time to search will depend on whether the sensor is directional and so needs to scan a region through multiple looks, or able to scan a wide region in one look.

The time to geolocate to a given accuracy depends on such parameters as geometry, SNR and observation time. The Cramer Rao bound applicable to a single “snapshot” look, e.g. 1-second, may be significantly exceeded by tracking an emitter signal over an extended interval of time, e.g. 10 to 100 seconds associated with multiple time-varying geometries.

Enhanced techniques for improvement of emitter geolocation performance are sought to enable sensor platforms to operate at much larger stand-off ranges with larger coverage areas for time-sensitive targeting and/or improved naval battlespace awareness. Recent studies have shown that performance may be enhanced through the use of enhanced signal processing techniques (e.g. Kalman tracking filters), improved signal propagation and emitter models, and exploitation of the precise Position-Velocity-Timing (PVT) information provided by GPS carrier phase signal processing. Synthetic aperture signal processing has also been shown to offer great opportunities for improvements in weak signal detection and geolocation accuracy.

It is understood that potential enhancement techniques may not function well for all scenarios, but improved performance as compared to traditional techniques are desired even under restrictive scenario conditions for problems of interest. For example, synthetic aperture techniques may work well for a radar signal emitter, but will not function well for an emitter which only remains turned on for a short interval of time. Long coherent integration time intervals to enhance SNR for detection and geolocation accuracy may not be possible for certain types of signals, waveforms and geolocation methods.

Some of the additional challenges associated with this research are the development of robust techniques which also address --
• Detection and accurate geolocation of low-power emitters ≤ 1 Watt
• Mitigation of error sources, e.g. multipath
• Geolocation of multiple emitters with similar signal characteristics
• Isolating unauthorized emitters from legitimate signal sources
• Geolocation of closely spaced emitters
• Poor geometry conditions
• Geometry, attitude and Doppler changes over signal processing time intervals
• Elimination or mitigation of processing latencies to support real-time operations
• Elimination of latencies, timing and frequency errors
• Moving emitters and emitters with time-varying signal characteristics
• Emitters which turn on and off
• Directional radiators
• Relativistic effects
• Extended (i.e. non-point) emitter sources, e.g. IR images
• Developing efficient search and signal processing techniques, including signal detection, false alarm rejection and selection of signal processing parameters for fast and robust operation

PHASE I: Develop concepts for improved emitter detection and geolocation techniques, algorithms and procedures. Perform trade and sensitivity analyses to demonstrate a strong understanding of stressing scenarios, driving requirements and technology limitations and shortcomings for various scenarios and conditions. Demonstrate proof-of-concept through simulation and error analyses which illustrates significant improvement relative to traditional techniques.

PHASE II: Develop prototype emitter detection and geolocation techniques, technologies, algorithms, and procedures for incorporation into new and/or existing operational systems. Develop requirements for integration of algorithms into new and/or operational systems. Demonstrate significant performance improvements relative to the traditional and state of the art techniques.

PHASE III: Integrate the algorithms and procedures into new and/or operational systems to provide improved emitter geolocation capabilities.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The developed technology could potentially be applied in commercial geolocation services, e.g. location of cell phone transmitters or satellite interference sources.

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KEYWORDS: Electronic Warfare; Electronic Support; Emitter Geolocation; TDOA/FDOA; Naval Battlespace Awareness; Detection

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

N11A-T013 TITLE: Mitigation of Fuel Tank Explosions and Fires from IED Blasts

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Sensors, Human Systems

ACQUISITION PROGRAM: Medium Tactical Vehicle Replacement (MTVR) Program: ACAT I

OBJECTIVE: To research, understand, and develop strategies for mitigating fuel tank explosions from improvised explosive device (IED) blasts for Marine Corps vehicle applications.

DESCRIPTION: With the increased threat of IEDs during combat operations it is imperative to create a solution to decrease the severity of IED blasts on vehicles, particularly blasts impacting the fuel tank. When combat vehicles encounter these IEDs during combat operations fuel tank explosions can occur creating serious health threats on the troops as well as putting the troops in an unfavorable combat situation. Understanding the thermodynamics and combustion process of fuel vapors in fuel tanks can lead to the development of materials that can be used to mitigate secondary explosions. Research on fuel vapor interaction with IEDs and potential transition to explosion would prevent numerous casualties and provide a safer operating vehicle.

Research and understanding should be conducted to provide reliable explosion prevention, crash resistance in fuel tanks, emissions reduction, liquid stabilization, electrostatic discharge without causing significant fuel volume loss or increased maintenance, and to understand other properties of fuel under high temperature environments. Thermal fatigue, mechanical fatigue, exposure to a corrosive environment and safety to the warfighter should be considered when conducting research. Modeling and simulation are encouraged to guide the design in developing a prototype material for the Marine Corps combat vehicles. A prototype material should be able to be applied across all USMC vehicle platforms, but particularly be compatible with the Medium Tactical Vehicle Replacement (MTVR) and Logistics Vehicle System Replacement (LVSR). A material that could also be compatible with military air and sea vehicles would be an advantage.

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

PHASE I: Provide an initial development effort that demonstrates scientific and technical understanding of the thermodynamic and combustion properties of fuels at elevated temperatures. Develop an initial model of fuel vapor interaction at elevated temperatures.

PHASE II: Develop an initial set of materials for the fuel tank that could be used to mitigate secondary explosions.

PHASE III: Produce an explosion and fire mitigation prototype material and define field test objectives and conduct limited testing.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Successful development of fuel tank fire mitigation materials should enable vehicle design engineers to select new and innovative methods to optimize fuel tank safety features. There is a strong need for the development of this in military air, land, and sea based vehicles which could help mitigate secondary explosions in commercial aircraft, automobiles, trucks, and ships.

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KEYWORDS: Fuel Tank Explosions; Explosion and Fire Mitigation, Thermodynamics, MTVR Fuel Tank

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N11A-T014 TITLE: Advanced Flame Resistant Resin System for Carbon Fiber Reinforced Composite Shipboard Applications

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: Potential acquisition program DDG1000

OBJECTIVE: To develop new affordable non-halogenated polymeric resin materials that have the improved structural, thermal and Fire, Smoke, and Toxicity (FST) behavior when compared to conventional brominated vinyl esters (Derakane 510A) which are currently in use by the U.S. Navy in topside structures. Special emphasis will be given to the structural and thermal characteristics of the polymeric system as they relate to high stress loading around joints, and fire, smoke and toxicity (FST). Equally important in the evaluation criteria will be the affordability of the process, and the compatibility with the carbon fibers.

DESCRIPTION: Organic matrix based composite materials offer a large number of advantages over conventional metals when applied to the naval environment. Composite materials can have the strength of steel at a fraction of its weight and will not corrode. The fatigue performance of composite materials is exceptional. While the material costs are higher than those of structural steel, the long term behavior combined with the low maintenance requirements can afford better total ownership cost (TOC) characteristics. Furthermore, these materials lend themselves to multi-functionality due to high degree of flexibility during fabrication which permits imparting additional properties such as RAM, EM window, etc.

Two major obstacles have impeded the wide dissemination of these materials across the fleet; the initial manufacturing cost and their poor FST performance. The poor FST performance limits the use of composite materials to topside unmanned structures. In addition, currently used vinyl esters have shown less than desirable compatibility with carbon fiber which is undesirable for use in high stress loading areas such as composite joints. The purpose of this effort will be to address these obstacles. While composite materials have been successfully used in aircraft structures because of the high performance requirements combined with their relatively small size, this has not happened with our ships. Not only are the amount of materials required to build ships 2 or 3 orders of magnitude larger than those required for aircraft fighter but also the strict mission requirements that exist on the materials to resist and contain fire for long periods of time have limited their use aboard ships.

NAVSEA has published Design Data Sheet (DDS-78-1) to facilitate the transition of the new composite materials in U.S. Navy shipbuilding. The material fire performance requirements described in this design data sheet are intended to provide consistent safety criteria for the application of composites aboard ships. These requirements have been developed based on Navy fire safety policy and international maritime standards for fire safety. Fire performance requirements for surface flammability, fire growth, smoke generation, fire gas toxicity, fire resistance, and structural integrity under fire have been established.

PHASE I: The technical team will include a nonprofit organization and a private sector business while the Government personnel will serve as advisors when requested or needed. During Phase I of the program, the technical team shall investigate relevant flame resistant chemistries that are compatible with carbon fibers (such as phosphorus based epoxy resins, benzoxazine chemistry, and others). The PI will demonstrate that: 1) The candidate resin system has mechanical properties that are comparable or better than those of standard epoxy systems as evidenced by mechanical tests such as Tension (ASTM D638), Compression (ASTM D695), Interlaminar Shear (ASTM D3846), Flexure (ASTM D790), Fracture toughness (ASTM D 5528), etc.; 2) The FST behavior of the candidate resin system shall be better than that of the standard brominated vinyl ester, and closer to a standard phenolic resin system as evidenced by fire tests such as heat release rates (ASTM E-1354), flame spread (ASTM E162), smoke generation (ASTM E-662), and fire gas toxicity (ASTM E-800); 3) The processability of the new resin system is comparable to that of vinyl ester systems in terms of room temperature or low temperature curing capability and low viscosity amenable to VARTM processing; 4) That the proposed resin system is compatible with carbon fiber reinforcement for structural applications. The PI will determine the resin manufacturing cost as a function of the material quantity.

PHASE II: During the Phase II the contractor will investigate alternative chemical routes to synthesize the resin system looking at improving yield and reducing manufacturing costs. Also, the contractor will fabricate carbon fiber reinforced composite materials of various sizes for testing. The PI will fabricate panels to characterize the mechanical, structural, and FST performance of the material. The FST performance testing will include ISO 9705 room corner fire tests, and UL-1709 fire resistance tests. A demonstration prototype such as the section of a composite mast, or a helicopter hangar, or a deckhouse will be fabricated. Cost estimates will be determined.

PHASE III: Large scale manufacturing of the resin will be optimized and documented in coordination with a NAVSEA program office and technical personnel. The PI will manufacture components for complete characterization in accordance with requirements and specifications recommended by the technical personnel of the Program Office, and, if successful, build a prototype for at sea trials including shock.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Commercial ship, aviation industries, and transportation sector would benefit significantly from a material system of this nature as well. Fire smoke and toxicity are problems common to all structures where people live.

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KEYWORDS: High stress loading, Fire, Smoke Toxicity, High Temperature Resins, Composites, VARTM

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N11A-T015 TITLE: Image Feature Extraction for Improved EW Classification

TECHNOLOGY AREAS: Sensors, Weapons

ACQUISITION PROGRAM: PMS-450 Virginia; PMS-397 SBSD

OBJECTIVE: The objective of this topic is to develop an innovative data sharing and data fusion approach for improving situational awareness by combining feature extractions from both the on board imaging sensor (i.e., Photonics Mast and AN/BVS-1) and EW sensors (i.e., AN/BLQ-10) to create better separation in the decision space, resulting in an improvement in automatic classification and a reduction in operator workload. This requires research and development of advanced image processing techniques for automatic feature extraction, multi-modal sensor data fusion algorithms and a synchronized data sharing infrastructure to effectively integrate the sensors.

DESCRIPTION: The problem of classifying an RF emitter as a threat, although not trivial, is fairly well understood and traditional EW systems and approaches continue to drive current Navy EW operations. With the proliferation of inexpensive commercial radars and communication devices, the number and type of RF emitters in littoral environments has grown with increasing rapidity and in turn has increased system acquisition costs as well as drastically increased operator workload in order to deal with this growing number of emitters.

In order to contend with the increase in RF contacts that need to be accurately classified and managed as friend, foe or neutral in a rapidly changing electromagnetic environment (EME), a more automated approach needs to be taken which fuses imagery with EW emitter parameters to increase automation and the probability of correct classification.

The Navy seeks advanced multi-modal data fusion algorithms and image processing techniques for improved automatic emitter classification and identification. Currently, Imaging systems and EW systems aboard US submarines are “stove-piped”. Therefore, in order to exploit the information contained in both, the Navy seeks the development of 1) an efficient data/time synchronization and sharing mechanism in order to be able to associate and integrate image features and features extracted from EW sensor information; 2) image processing algorithms, focusing on the region of interest, which support the integration of visual features extracted from real-time (or near real-time) imagery data into an enhanced RF emitter feature vector and; 3) the development of Bayesian data fusion/classification algorithms which utilize the corresponding multi-dimensional vector space. This implies the ability to maintain synchronization with the frame rate of the critical video distribution subsystem (30 Hz) and have access (and also maintain synchronization with) contact information that contains pulse descriptor words (PDWs) and external features extracted from received communication signals in a dense target littoral environment.

PHASE I: Research and development of an overall concept and detailed description of the synchronization mechanisms developed which allow the sensors to synchronously share information. Provide a detailed explanation of which features are to be extracted (can be traditional or non-traditional) from both the received imagery and RF signals which maximize separation in the decision space and the Bayesian techniques used to classify the target in the resulting non-linear decision space. Provide an estimate of the improvement in probability of correct classification (Pcc) and demonstrate the improvement with a simple demonstration based on simulated data.

PHASE II: Extend the proof-of-concept development from Phase I to demonstrate the effectiveness of the approach using a real world scenario in a laboratory environment. Evaluate performance using government provided data and develop specifications for transition to system insertion.

PHASE III: Transition the system into a production Navy system such as Virginia Phonics Mast.

Private Sector Commercial Potential/Dual-Use Application: Multi-modal data fusion algorithms are applicable to the telecommunications industry as well as industries requiring surveys, searches, or mapping, or even search and rescue operations.

Multi-modal data fusion algorithms are sensor independent. They are applicable in any application where disparate information can be vectorized and weighted in such a way as to create a vector space in order to more accurately interpret (classify) real-time sensor data. For example, in the telecommunications industry, wireless network planning is highly dependent on the very dynamic electromagnetic environment (EME). Currently, test vans with collectors roam urban areas to attempt to characterize the EME in terms of detecting potential co-channel interference or areas of obscuration. This data is then manually processed and assessed to determine where to place new cell towers and repeaters. An algorithm capable of fusing collected information with other types of sensors (imagery, terrain maps, meteorological information, GPS, etc.) and is adaptable to the dynamic urban environment would be very useful to this industry in order to reduce 1) the search area of the van; 2) automate the classification of the co-channel interference (TV station, other cell tower, communications transmitter); 3) learn via the incorporation of a new training set to adapt to changes (frequency allocations, new communications infrastructure, etc.).

Fusing imagery with RF signal information can also assist in search and rescue operations. Many ships, planes and even hikers carry rescue transponders or emergency beacons which radiate upon activation. Ships/individuals who are lost or in trouble at sea or in wilderness areas as well as plane crashes in rough terrain, all present situations where being able to correlate/fuse real-time imagery with RF emissions can shorten the time to rescue.

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KEYWORDS: electronic warfare; data fusion; multiple target tracking; adaptation; image processing

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N11A-T016 TITLE: Tunable Bandstop Filters for Suppression of Co-site Interference and Jamming Sources

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: NA, IWS 2.0 will transition technology into developing Radar and EW Systems

OBJECTIVE: To design and develop tunable bandstop filters capable of dynamically changing bandwidth, center frequency, and stop band attenuation in the 2 GHz to 18 GHz band for ship board co-site interference and jamming source mitigation.

DESCRIPTION: The radio spectrum has become extremely crowded in the past decade due to the exponential growth of wireless systems. With multiple wireless system technologies allocated close to one another in the radio spectrum, optimum performance of one system cannot be achieved due to interference caused by another system that is located physically and/or spectrally close to the desired communication system. This problem is further compounded aboard naval vessels where multiple high power systems are co-located on the same mast or submarine sail thus eliminating the possibility of interference mitigation through spatial separation of the wireless systems and even jamming sources.

In order to mitigate the effects of co-locating multiple high power systems on the top side of naval vessels, it is desirable to have a low-loss filter on the input of the receiver for a given system. While bandpass filters are an acceptable solution for this purpose, in order to achieve low insertion loss performance, relatively high quality factors are required, leading to large, bulky front end filters. Therefore, it is desirable to have a bandstop filter on the front end that is capable of extremely low loss out of band characteristics while simultaneously providing a high rejection of an interferer in a compact form factor. Compounding the problem is an ever changing radio environment and potential jamming sources. Therefore, in order for the front end filter to provide flexible, dynamic mitigation of co-site interference and other undesirable RF signals it is necessary for the bandpass filter to posses the ability to change its center frequency, rejection bandwidth, and notch depth to optimize the interference mitigation and maximize system performance. The tunable bandstop filter proposed for this topic should cover the band from 2 GHz to 18 GHz and should be capable of adjusting both stop band bandwidth as well as the notch depth.

PHASE I: Demonstrate feasibility and provide initial design/simulation of the developed tunable notch filters and establish a fabrication and testing plan for the prototype devices in Phase II. Key technology features shall be demonstrated empirically and an initial assessment of risks and reliability in a fielded EW/Radar system shall be conducted.

PHASE II: Fabricate and characterize prototype tunable notch filters for co-site interference mitigation. By the end of this phase, the tunable bandstop filters should be demonstrated as a stand-alone component. As part of the demonstration a user should be able to enter the desired stopband bandwidth and notch depth via a graphical user interface (GUI). The filter should have the ability to automatically tune the stop band to the frequency, bandwidth and depth specified by the user without any further input from the user. It is anticipated the tunable notch filter should also be capable of handling higher power levels of > 30 dBm input power in the stop band. Initial assessment of the technologies reliability, manufacturing and cost factors shall be studied and application limitations identified.

PHASE III: Produce production tunable notch filters and integrate the notch filters into actual ship-board EW/Radar system demonstrations working with prime contractor and Navy Program personnel. Establish reliability, manufacturing and cost data to support transition.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Successful development of the tunable bandstop filters should provide the commercial sector the ability to mitigate co-site and other radio frequency and microwave interference in current and future commercial wireless systems.

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KEYWORDS: Tunable, Bandstop, filters, Radar, EW, cosite, Jamming

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N11A-T017 TITLE: Underwater Sensor System Autonomous Burial and Operation

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors

ACQUISITION PROGRAM: PMS 485 Maritime Surveillance Systems

OBJECTIVE: Develop innovative approaches to autonomously install, bury, power and communicate from a bottom mounted underwater sensor systems

DESCRIPTION: Underwater surveillance in shallow water requires rapidly deployable systems which feature autonomous sensor installation with enhanced survivability against commercial fishing. In addition to rapid deployment, the need exists to bury sensors to enhance survivability against fishing gear that snags/breaks the bottom mounted sensors. Past solutions to deployment of shallow water systems have not been able to solve the need to limit the amount of time a deploying platform is engaged in the deployment process. Current underwater burial systems are not autonomous; they depend on sled-type vehicles towed from a mother ship (See reference 1.). Also, rapid deployment concepts from autonomous platforms have focused on non-burial techniques (see, for example, reference 2.). To date burial solutions require extensive additional time for deploying platforms (mother ship) to complete the installation. An approach is needed to achieve rapid deployment and sensor burial with minimal mother ship involvement. (A desirable by-product of this effort is reduced fuel use by the mother ship.) In general, most autonomous underwater vehicles are either designed for general purpose missions or for special applications, such as hull inspection, not related to the specific task of sensor burial.

Preliminary studies show that an operationally suitable package within a pre-determined form shape and deployed from an installing platform in a "fire and forget" mode could resolve many of the current issues. Reference 3 provides information about these studies for illustrative purposes. Offerors are not required to base their approach on these studies. Conceptually, a desirable system would self configure into an autonomous plow vehicle as it descends through the water column when dropped from the installation vessel. Upon landing, the plow would then bury a sensor system in a predetermined configuration (preliminary studies validate the feasibility of a small plow to bury sensors which significantly increases system life in high density fishing areas). After successful completion of the installation, the plow would self bury by water jetting or another method and become the power, processing and reporting node for the system.

Requirements of the burial vehicle are that it must be autonomous and carry its own power as well as the payload. This payload includes the sensor system to be deployed as well as the power, electronics and communications system as part of the operational node after deployment. Critical elements of the vehicle include burying a sensor system up to 1 Km long with multiple sensors at depths in the 4 – 6 inches range (or more) depending on soil type, deploy on bottoms with up to 5 degree slopes and bottom currents up to 1 Kt, have the ability to negotiate obstacles (e.g., rocks/cables), navigate and operate over various soil conditions and bottom types, be able to make one 90 degree turn during the installation in addition to maneuvering if needed for obstacle avoidance. The government envisions the sensor system cable diameter to be up to 75mm and to contain up to one hundred 2.5 cm diameter passive acoustic sensors spaced along its length. The deploying vehicle must be packaged to minimize space in transit.

PHASE I: Develop a concept for an autonomous vehicle that will install and bury an underwater sensor system to protect against threats and hazards due to fishing activity. Perform analytical analyses on critical elements of the installation and burial system to characterize the physical limits to the system as input to the design. Provide convincing support for the feasibility of the proposed conceptual design, integration techniques, and installation method.

PHASE II: Develop a prototype burial system and demonstrate its ability to install the sensor system while preserving the acoustic, electrical and mechanical functionality needed for the overall system application. Full functionality is not required, only demonstration of the burial aspect; other system functions can be shown to be accommodated by engineering drawings. Propulsion of the device can be conducted by surrogate means as long as the engineering drawings accommodate space for the power generation and fit within the total system weight / volume constraints. Full "blooming" of the system from stored to deployed state can be demonstrated by design drawings; the at sea demonstration does not need to feature starting from the stored (compact) state. Detailed design drawings are required.

PHASE III: Transition the technology to undersea surveillance systems to be situated in littoral environments where bottom fishing activity is present. Possible environments are in overseas locations to be specified. This deployment and burial concept can be applied to all sensor systems that could fit within the packaging parameters of the vehicle, providing a long term shallow water surveillance capability currently not available.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The oil and gas, commercial telecommunications industries and scientific communities that operate in the littorals all have similar issues with survivability of distributed infrastructure components. Large companies often rely on smaller niche robotic developers to solve their deployment and burial challenges, so extension of the cable burying technology developed under this STTR has ready dual-use applications.

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3. [Public release information being prepared on SPAWAR Systems Command Pacific Autonomous Burial Vehicle Engineering Study and patents pending]

KEYWORDS: array; cable; deployment; burial; underwater; surveillance

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N11A-T018 TITLE: Automated Situational Understanding for Undersea Warfare Decision Support

TECHNOLOGY AREAS: Information Systems, Battlespace

ACQUISITION PROGRAM: Program Executive Office Integrated Warfare Systems (PEO-IWS) 5E

OBJECTIVE: This topic seeks to develop and deploy an innovative information processing capability that can provide Anti Submarine Warfare (ASW) operators with enhanced operational insights, alerts, advisories and recommendations based on deeper situational understanding inferred from not only traditional ("hard") data sources, but also non-traditional ("soft") information sources (that are currently being incorporated into the decision support process via other programs) which are beyond the typical contact and track data. The goal is to employ the automated situational understanding results to improve the timeliness and quality of the operator's ability to identify valid detections and engage them beyond that provided by existing and planned decision support capabilities.

DESCRIPTION: The decision environment in which the Anti Submarine Warfare Commander (ASWC) must operate during threat prosecution is characterized by severe time pressure, complex, multi-component decision tasks, and rapidly evolving and changing information and situational state. Past and current work has focused on automatically simplifying and decluttering the user displays with an emphasis on processing and fusing sensor data. The next stage of innovation in extending the ASW decision support capabilities is to leverage information from additional sources, including sensor and track meta data (e.g., variance, frequency, behavior over time, etc.), codified (automated) narrative (e.g., HUMINT, chat, doctrine, rules of engagement, etc.), mission directives and objectives (e.g., operating area), data bases, and even prior situational assessment results[1,2]. Thus, the decision support products will result from processing information across time, geography, and source modality. Now that a more extensive set of hard and soft information is being made available to the decision support environment in a digital format, a set of situational assessment and understanding models and a modular, flexible processing framework to manage their construction (knowledge engineering) and execution (processing) are sought. The resulting solution must be able to be readily and unobtrusively integrated with the USW-DSS software framework.

PHASE I: Design a multi-modal situational understanding environment that can be applied to support ASW threat prosecution that improves the quality and effectiveness of users. A test case will be defined at program kickoff that will be used to demonstrate 1) the process for constructing a situational assessment and understanding model and 2) its usefulness in assisting ASW operators. Unclassified state data and operationally important features will be provided as GFI during Phase I. The key metrics to be used in evaluating the effectiveness of the approach will be reduction in the detect-to-engage timeline and improvement of detection quality.

PHASE II: Build an automated prototype that has a development environment for constructing and integrating situational assessment and understanding models and a runtime environment for executing them. It is expected that such a runtime environment will rely on a modern Service Oriented Architecture to facilitate integration with other Navy ASW systems.

PHASE III: Transition the automated situational assessment and understanding environment to USW Decision Support platforms.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: This situational assessment and understanding product should be able to add value to other complex decision support settings, such as mission planning, airspace/battlespace management and logistics. In addition to the US Military sector, potential users include other federal and state governmental agencies (e.g., FAA, DOT, DHS) and industry (e.g., transportation and logistics companies). Adherence to a modular, Service Oriented Architecture should enhance the portability of the work products to these other sectors.

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KEYWORDS: Situational Assessment; Perception; Understanding; Decision Support; Anti Submarine Warfare; Knowledge Engineering; Service Oriented Architecture; Battlespace Management

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N11A-T019 TITLE: High Fidelity Digital Human Models for Protective Equipment Design

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: STK-FY09-06

OBJECTIVE: To develop comprehensive high fidelity physics based digital human model to simulate human movement, study behind armor blunt trauma as well as the internal effects of ballistic penetration.

DESCRIPTION: The Office of Naval Research (ONR) has been investigating modeling efforts as a means to produce cost effective tools which will be utilized during design and evaluation of personal protective equipment. In this instance, digital human models assist armor and equipment designers to prove concepts, fitment and interfaces relating to body armor, combat helmets and other related protective equipment. Models exist which simulate human motion based on different inputs such as the load/weight a person is carrying and where on the body that load is located. On-going efforts are exploring the integration of CAD models into the simulations to interact with the avatar. This capability will enable affordable integration and evaluation of novel armor concepts by means of a software suite during the design phase of new armor solutions. The tool will allow for down selection of concepts prior to physical demonstrations. Once validated, these simulation tools will significantly reduce the time and cost to design and integrate new armor concepts with current and new equipment.

The funding of this requirement would be utilized to expound on the current digital human modeling effort under an ONR FNC. The current model is a physics based predictive model utilized to evaluate human motion under different loading conditions. The tool can predict human motion during predetermined tasks. In addition the model will be integrated into other existing casualty prediction models. The model will also be enhanced to be anatomically correct. To date all modeling efforts, such as the Air Force Total Body Model, are static, meaning the position of the avatar is not altered during the event. The benefits of this proposed effort over existing efforts are as follows:

- Dynamic predictive physics based motion to be incorporated into existing casualty predictions tools
- Digital human model which is anthropometrically and anatomically correct

• Motion prediction model which will be utilized to design new personal protective equipment.
• Streamlining of equipment designs – Form, fit and function can be optimized before prototyping. This is a valuable down selection tool for armor designers and will leverage work currently being completed under an ONR FNC.

To reduce the time from defining requirements to concept development and implementation, it is imperative that the U.S. Navy and Marine Corps have a virtual human and protective equipment simulation suite. The proposed work will revolve around improving digital human modeling to further the Office of Naval Research's personal protection and mitigation efforts. Areas of improvement desired include, but are not limited to the following: validation, motion simulation, posture predicted motion, improved realism, simulation of complex and applied dynamic tasks for evaluating armor performance, implementing soft armor components, increased fidelity of biomechanics and physiology, as well as modeling of anatomy. The goal is to refine and advance digital human modeling so it can be utilized as a reliable prediction tool when evaluating personal protective equipment.

PHASE I: Provide an initial development effort that demonstrates scientific merit and capabilities of simulating a high fidelity digital human along with soft armor modeling.

PHASE II: Create modeling simulation suite based on defined obtainable objectives identified in Phase I. Validate simulation software against other existing modeling efforts to verify outputs of model. Create a Phase III plan to validate modeling simulation suite against experimental data for ballistic armor. Obtain user input relating to interface and desired operation of software.

PHASE III: Collaborate with government and industry to execute a full scale validation of model developed during Phase I and II. Conduct user evaluation and refine interface, inputs and outputs.

DUAL-USE APPLICATIONS: Successful development of a high fidelity digital human model will translate to other government and industry applications. Potential applications for the model include: vehicle and aircraft simulations, equipment development and anthropometric studies.

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KEYWORDS: Physics-based Predictive Modeling, Digital Human Modeling, Surrogate, Ballistic, Body Armor, Personal Protection.

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N11A-T020 TITLE: Visible Electro-Optical (EO) System and LIDAR Fusion for Low Cost Perception by Autonomous Ground Vehicles

TECHNOLOGY AREAS: Information Systems, Ground/Sea Vehicles, Sensors

ACQUISITION PROGRAM: ONR 30 Maneuver Core (Discovery and Invention) Funding

OBJECTIVE: Develop a low-cost perception/classification system for the joint exploitation of LIDAR and passive multi-spectral data obtained across the visible spectrum employing self-calibrating algorithms for use in autonomous ground vehicles

DESCRIPTION: Unmanned Ground Vehicles (UGVs) are an important part of the Navy's ongoing technology strategy. The developing autonomy capabilities of today's UGVs are driving requirements for sophisticated sensing which may include coordinated sensors.

Passive electro-optical visible (EO) image-based sensing provides a detailed picture of the environment but the picture can often be difficult to interpret in terms of the local terrain structure. Spatially sparse range information can substantially aid the process of interpretation. Methods are available to infer the range information from the visible EO-sensor developed scene by stereoscopic or algorithmic methods. LIDAR sensors are capable of providing a point cloud of distance and intensity information in real-time that provide an alternative approach to creating the ranging information desired for augmentation of the EO sensor developed scene.

While LIDAR, multi-spectral visible sensors, and their associated perception algorithms are maturing, methods for fusing information from the sensors and their associated self-calibration are generally less well developed.

An integrated approach to fusion will drive the need for precise calibration to recover both the internal characteristics of the sensors (intrinsic parameters) and the position and orientation of the sensors with respect to the overall system (extrinsic parameters). The resulting calibration procedures using state-of-the-art methods will be complicated and time consuming. Manual calibration significantly complicates the fielding and maintenance of UGVs. Furthermore, failure to maintain calibration in deployed systems can lead to poor performance in the field

This topic seeks to develop methods that fuse the features that can be extracted in a low-cost visible multi-spectral (less than 10 bands) EO system with LIDAR developed sparse point clouds of distance and intensity information. The development of a fusion algorithm that reduces the required density of the LIDAR point cloud is expected to lower the cost of the combined EO/LIDAR perception system. This topic seeks to reduce dependence on in-the-field calibration. Sensor modules must be field-replaceable without requiring explicit calibration, and must tolerate prolonged use under harsh conditions without requiring explicit recalibration. When vibration, mechanical damage, or maintenance procedures introduce changes to the sensor calibration, the system must be "self-healing" so that the loss of calibration is corrected without intervention from military personnel.

PHASE I: Design a concept for a low cost (< $30,000 at 1000 unit annual production rate) modular, self-calibrating fused LIDAR/EO perception system for an autonomous ground vehicle. The system shall be able to provide perception about the environment sufficient so that an autonomous vehicle can perform mission-level adaptation in response to real-world contingencies in a multiple terrain types and environments without human intervention. The architecture shall strive to minimize the combined cost of the perception suite by optimal allocation of the requirements and exploitation of the benefits of a true data fusion scheme.

PHASE II: Build a demonstration sensor system based on Phase I design, with attention to power constraints and the use of operationally appropriate embedded hardware. Demonstrate effective self-calibration on logged data, with results comparable to those obtained using manual calibration routines.

Conduct static experiments to demonstrate perception performance in structured lab conditions. Then conduct static experiment in more complex unstructured terrestrial environments. . Conduct in-the-field testing to demonstrate self-calibration and on-the-fly recovery from changes in sensor calibration

PHASE III: Demonstrate a robust capability (without the use of GPS) of an autonomous unmanned ground vehicle using a "low cost" sensor suite composed of fused LIDAR and visible EO sensors conducting a resupply mission in a militarily relevant manner while executing complex and doctrinally correct behaviors.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Unmanned vehicles are becoming increasingly important for agriculture, mining, and other private sector applications. Many of these applications will benefit directly from robust, modular, self-calibrating sensor technology.

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KEYWORDS: Sensor Fusion; LIDAR, EO systems; Autonomy; Unmanned Vehicles; Autonomous Navigation; Sensor Calibration; Self-Healing Sensors

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N11A-T021 TITLE: Low Power, Long Life, Smart ISR Sensors

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

ACQUISITION PROGRAM: POM13 EC candidate and WFVPS ground Station (Persistent ISR) POR

OBJECTIVE: Provide very low to ultra low power smart ISR sensors to enable long term unattended situational awareness.

DESCRIPTION: Battlefield threat identification and intrusion warning remains a high importance topic to OSD, Navy and Marine Corps. For applications such as securing high valued assets to securing areas of interest, the life expectancy of the energy source and processing power requirements remain the limiting factors in determining how long sensing and analytic capabilities can remain operative while unattended. The need for long term smart sensing technologies was articulated by General Petreus recently when he requested urgent action in identifying technologies for container security. The long range goal is to investigate and validate the feasibility of producing a sensor field cognitive sensor manager that can discover and task low cost, ultra low power sensors and supporting analytic services to enable area and container situational awareness for extended periods of time. Networked sensors should be able to monitor situational awareness factors such as temperature, shock, acceleration, acoustics, the presence of tagged objects and other sensor signals. Shared network analytic services should be able to perform the fusion of data required to enable situational awareness using power aware and efficient algorithms. The overall sensor field should be able operate, in ultra low power, semi-dormant modes, until a trigger of interest occurs. Once a trigger occurs, additional sensors and analytic services should be activated as required to develop situational understanding. The sensor field also needs to be able to transmit relevant alerts to a larger enterprise as required. The trigger (set of rules) should be programmable in easy office tools by the users to establish the criteria that should produce an alert. To support versatility of this technology, the sensor package should provide a family of compatible micro sensors, a library of application services and programmable user modules to allow the users to easily select rules of relevance to their application. The sensors should be able to function alone or in collaboration with other sensors to produce actionable intelligence. The target life sensor string life expectancy is ten years. Sensors used in demonstrations should not exceed the size of commonly used low profile RFID devices used to tag valued assets.

The specific goal of this topic is to investigate and validate the feasibility of developing a power efficient cognitive sensor manager that can provide dynamic and situational control of a diverse array of smart micro sensors and activate analysis services as needed to achieve and maintain situational awareness while minimizing the overall power consumption of the sensor system. It should be assumed that sensors need to be distributed across an area of interest, on containers and may even need to be on individual assets contained within the containers. Sensors modalities can include active and passive RFID devices, cameras, audio sensors, etc – as needed to secure the environment. Data fusion services need to be discoverable by the cognitive sensor manager. The overall system should be able to provide a clear picture of the "life" and associations of containers. To this end, power efficient cognitive or other advanced algorithms will need to be matured that can provide an understanding of the area surrounding a container. Likewise a power efficient cognitive sensor manager is needed that can discover and task distributed sensors as needed. This topic includes development of algorithms required to perform necessary sensor and data fusion using ultra low power or equivalent processing techniques and processors.

Challenges for this topic include the 1) development of power efficient sensor and service discovery protocols; 2) development of a library of friendly rule selection modules for various applications; 3) identification of small, low power, low cost sensors and application services that can support the above mentioned processing and life expectancy; 4) development of a power efficient, mission aware cognitive sensor manager

The overall goal of the topic is to develop an ultra low power, low cost, smart sensor capability to provide real time container security for many years.

The Navy will only fund proposals that are innovative address R&D and involve technical risk.

PHASE I: Complete a feasibility study and research plan that demonstrates the ability of a power efficient cognitive sensor manager to effectively control low power, long life, smart sensors and power efficient fusion algorithms. The development should enable a power efficient framework not unlike the ozone widget framework SOA architectures are increasingly based upon. A feasibility demonstration should show the potential of the developed cognitive sensor manager to utilize power efficient microsensors and fusion services to maintain situational awareness of containers and areas for many years. In the phase 1 effort performers may utilize any of the small, lower power sensors currently available in the open market. Performers can also select from readily available low power processors to host the control algorithms and rule sets. Demonstration of feasibility should bear in mind that future work (Phase II, etc) will be aimed at ultra low power techniques to support a system like goal of ten years. The feasibility plan should clearly identify the critical technology elements that must be overcome to achieve success and the approach to overcome these. Technical work for all phases should focus on the risk reduction of critical technology elements. Prepare a research plan for Phase 2.

PHASE II: Produce a prototype of an ultra low power cognitive sensor manager that controls low power, long life, smart sensors and power efficient discoverable applications that can be demonstrated in a realistic environment. The prototype should demonstrate the viability and potential benefits of the system to long term container and area security applications. The prototype should be relevant to both DoD and commercial use cases. Deliver a technology transition/commercialization plan.

PHASE III: Produce a system capable of deployment and operational evaluation. Demonstrate the system in a relevant setting in a stand-alone mode and as a component of larger system (programs of record). The work should focus on tailoring the developed capability in order to achieve a transition to a program of record in one or more of the military Services. The system should provide metrics for performance assessment.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The development of long lasting smart sensors that can automatically surveill an area would be valued by the private security market as well as by other government agencies. The requirement for persistent surveillance at places of interest remains high in the post "9-11" time period.

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KEYWORDS: Power efficient cognitive sensor manager, Low power smart sensors, Ultra low power, On-demand processing, Energy efficient processing, On-board processing, Service discovery

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N11A-T022 TITLE: Hybrid Technologies Amplifier Chain for >30 Gbps Per Data Link Energy Efficient Digital Output from 4K

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

ACQUISITION PROGRAM: InTop, Silk Thread

OBJECTIVE: The objective is to demonstrate means of transporting high speed, digital data from 4K to 300K via a well integrated set of technologies that will minimize the heat loading on the low temperature stages.

DESCRIPTION: After the inherent inefficiency of 4K coolers is considered, the consumption of wall power by Nb superconducting digital logic in performing its calculations is 100x smaller than SOA 22 nm Si. However, for systems with high levels of processing to realize a net energy benefit, parasitic heat loads associated with signal and data communications between room and low temperature need to be severely limited since all that energy must be removed from the low temperature end. Optical data transport from 300 to 4K is well advanced and should be assumed to occur. However, current optical modulators do not exist with V(pi) of less than 25mV for speeds above 50 Gbps per line. Thus the heat load associated with transitioning to optical data transmission at 4K is unacceptable. Therefore some of the temperature gradient must be spanned by electrical signals and an amount of amplification sufficient for the signals to remain visible above the upper end noise floor is essential. Superconducting digital logic operates on the basis of magnetic flux quanta, each of which has a voltage /time area of 2 mVps and current devices produce pulses of ~1 ps duration. The conversion temperature must be selected to minimize the total energy dissipation, including issues such as inherent noise of amplifiers, stage temperature of coolers, and energy efficiency of different stage temperatures of coolers. Moreover, the output data format must be converted from the RZ logic of superconductivity to the NRZ norm of room temperature logic somewhere on its way up the cryopackaging. This situation requires proper co-design of the first stage amplifiers which combine the superconducting output drivers and another digital technology capable of gain, ideally on a single 4K substrate, plus other, higher temperature amplification/signal conditioning stages sufficient to deliver the data without induced errors to 300K. The goal is for the entire chain to minimize total energy consumption for realistic values of cooler efficiency at each heat sink temperature and lead thermal transport.

PHASE I: Develop and demonstrate by simulation of energy consumption and bit error rate a complete amplifier chain that deposits via dissipation and thermal conduction less than 1 mW at 4K for each 30 Gbps data link exporting data from 4K to 300K with BER < 1 in a trillion. The likely manufacturing cost and simplicity of production and assembly into packaging serving >100 simultaneous data streams will be secondary criteria in evaluating the goodness of designs. The phase 1 proposal should include at least a notional definition of the sort of amplifier chain to be worked.

PHASE II: Convert the circuit simulations into real demonstration articles and perform multiple fab/test/redesign cycles to produce the desired demonstration. Demonstrate these links operating in a real superconducting dsp processor during the phase 2 second option and confirm the magnitude of the system energy efficiency benefit.

PHASE III: Transition the new technology into advanced digital/mixed signal superconducting systems, such as full spectrum RF awareness receivers, beam formers, or high performance computing.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Successful development of this amplifier chain will enable the full speed advantage (>5x fastest semiconductor digital logic demonstration) of superconducting logic to be used in high speed circuits. These are needed in cell phone ground stations (spectrum reuse by multiple subscribers), server farms serving applications such as 4G wireless, Google, and cloud computing, and for computer animation and simulation such as for the entertainment and weather forecasting communities.

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KEYWORDS: Low power amplifiers, high speed amplifiers, low noise amplifier, bit error rate, thermal modeling of digital circuits, heterogeneous digital technologies, low power optical modulators

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N11A-T023 TITLE: Enhancing System Software Resiliency via Function-Level Artificial Diversity

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop function (component) level artificial diversity in a computing system, and evaluate its capability and performance.

DESCRIPTION: To achieve information dominance, the Navy requires information assurance within its information infrastructures. Today's networked computer systems are exposed to compromises, creating potential for system and application damage which impact performance. It is important that our computing systems successfully operate in a condition where they are constantly being probed and attacked. In this environment, a strategy for system recovery by replacing a damaged component with its uncompromised version is not a good option, since it will soon be compromised again by the persistent attack. Replacing a damaged component with a functionally similar one, but with a distinct implementation, as prescribed by artificial diversity approach, is a better choice.

This STTR topic is a building block for a larger autonomic system capable of self-healing and graceful-degradation for mission assurance. The goal for this STTR topic is to develop function level artificial diversity and evaluate its capability and performance. The emphasis is on supporting automated system reasoning for controlling diversity, determining configurations and enabling problem analysis along with the required infrastructure to guarantee performance and adapting to threat environment. It is expected that the configuration control mechanism provides interface (hooks), for later improvement in the algorithm for system reasoning. The goal for the overhead associated with supporting artificial diversity and system reasoning at function level is 15 percent or less. Compromise and damage detection, as well as breach analysis are complementary, but are not within the scope of this topic. For the purpose of this solicitation, detections can be assumed, and fixes are the response.

Artificial diversity at function level implies that there are (multiple) redundant or overlapped and distinct implementations for a particular module/functionality. These modules similar functionalities but of diverse expressions are readily interchangeable. Artificial diversity at function level can be used to either limit the potential contamination from a breach within a pool/cluster of computing system, and/or to enhance the response time of a self-healing system. In a self-healing system, it is desirable that the reconstituted system is no longer vulnerable to the initial breach after recovery/reconstitution. The availability of artificial diversity enhances the system's recovery/reconstitution. The availability of redundant and distinct implementations ready for temporary (or permanent) deployment can significantly shorten recovery time, and thus may hide or buy time for a time consuming breach analysis. Function-level diversity applied to a cluster of computing system, means that each individual diversified computing system will have its own configuration of set of modules/functions, distinct to its peers. A cluster of diversified computing systems will have a diverse set of vulnerabilities, hence limits the propagation of a particular security breach, targeting a certain set of vulnerabilities.

The manifestation of function diversity may include, but is not limited to, diversity in the execution environment, such as C-based implementation, java-based implementation, python-based implementation, etc., or abstract-interpretation [3] and mutation-operator [3] methods or calling arguments' sequence diversity [2]. Other methods for artificial diversity such as instruction set diversity [4][5], and labeled instruction randomization [2] require the use of emulator or hardware support, and are not of interest in this STTR topic.

Genesis [2] is an example of a system that provides artificial diversity based on virtual machine. It employs two artificial diversity techniques, calling (arguments') sequence diversity (CSD) and (labeled) instruction set randomization (ISR). It has proven effective against code injection and return to libc attacks and it has survived "Red Teaming" exercises. Its use of binary rewriting and virtual machine has a total overhead of over 70 percent, and does not provide any system reasoning capability. One of the goals for this STTR is to provide system reasoning and substantially reducing the overhead, while maintaining performance.

PHASE I: Develop overall system design and approach that includes specification for enabling function (component) level artificial diversity in a computing system, with support for system's reasoning. Demonstrate the functionality and efficacy of proposed approach on a pared down open source operating system.

PHASE II: Develop and demonstrate a prototype system in a realistic environment. Conduct testing to prove resiliency, practicability, and performance of the function-level artificial diversity in preserving the operation of a computing system and a computing system cluster under attack.

PHASE III DUAL USE APPLICATION: This system could be used in a broad range of information security products within the military, as well as in civilian enterprise applications. The technologies developed in this STTR will be beneficial in providing additional resiliency to networked enterprise computing system against malwares and intrusions.

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KEYWORDS: Resilient system; artificial diversity; dynamic reconfigurable system software; resiliency via redundancy; function-level diversity; system reasoning; configurable diversity

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N11A-T024 TITLE: Development of an EO/IR Common Aperture Modular Multifunction Sensor

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PMA 266, PMA 263 and PEO (U&W)

OBJECTIVE: To explore and develop the technologies needed to combine a number of passive and active electro-optical functions, currently being accomplished through multiple apertures, into a single aperture.

DESCRIPTION: Electro-optical surveillance and targeting systems are very numerous in the DOD and involve substantial complexity. They usually consist of large focal plane imagers, lasers and electronics, and are in many cases packaged in gimbaled enclosures to facilitate flexible pointing and tracking. Many of these EO/IR systems now incorporate multi-functional capabilities that involve 2 or 3 functions combined in a given gimbaled enclosure to increase capabilities within a maximum allowed size, weight, and power (SWAP). These systems involve conventional components such as bulky glass optical lenses, conventional lasers, and multi-axis mechanical turrets. The turrets are heavy and require substantial power to operate and, in the case of turrets mounted on aircraft, must protrude into the airstream and therefore induce substantial drag. In order to circumvent these issues and provide a major advance in capability, it is desirable to develop a phased array capability in the EO/IR regime similar to that practiced in the microwave radar domain. To this end, a flat panel arrangement of optical elements needs to be developed. Such a system would require far less weight, power and space, and would eliminate the need for a gimbal mechanism such as a ball turret. This would lead to more aerodynamic and lower cross section structures and would afford higher performance by providing broader spectrum coverage in a smaller SWAP.

To realize these advantages, it is necessary to develop optical phased array technology that would permit both transmission and reception of EO/IR signals by a planar, phased array optical structure that might be conformally mounted on the sides of military platforms. There exist several optical technologies in which prototype demonstrations at the basic component level have been accomplished. One example is an array of vertical cavity surface emitting lasers (VCSELs) in which the emitting elements can number in the millions. These VCSELs are in use in the telecommunication industry but they have only been phased locked (a necessary condition) in small numbers in the laboratory1-4. It is necessary to demonstrate phase locking of large arrays and at substantial powers before flat panel transmitter arrays can be realized for military use. Electronic beam control and steering control technology must also be developed further to enable useful flat panel arrays. Focal plane detector arrays exist that function effectively as incoherent receivers requiring bulky lens systems. To convert these into lens-less, phased array receivers, the same phase sensing, electronic beam control and steering control will have to be developed. Another option to develop flat panel transmitters and receivers involves the use of slotted planar waveguides using corporate feed techniques similar to those used for many years in the microwave regime. In this case, planar optical waveguides5 with appropriate out couplers are fed in columns with a laser source and the out-coupled radiation is externally phase controlled by optical phase modulators, enabling electronically-controlled beam steering. In the reverse direction, radiation is coupled into the waveguide and sensed in column fashion by a single detector per row. Given successful demonstration of these and other flat panel optical array structures, major advances in the SWAP and performance of optical systems as described above can be realized.

PHASE I: Provide detailed modeling of flat panel array structures that are suitable for transmission and/or reception of phase controlled optical signals. Show that the proposed structure has the potential to be scaled to militarily useable performance. Perform a laboratory demonstration at the component level or use literature data to verify the model.

PHASE II: Fabricate and test an optical phased array to verify the array design. Demonstrate the beam steering, beam control and phase sensing needed to control the array so that the array design can be fully validated. The array should be at least a 10x10 element array and the spacing of the elements close enough so that the array side lobes do not interfere with the interpretation of the data.

PHASE III: Produce a 100x100 element optical phased array that performs to design specifications including minimum element spacing relative to a wavelength, accurate phase detection and control, and near theoretical beam spread.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The availability of optical phased array transmitters and receivers would be used to replace ball gimbaled surveillance systems widely used by the military and law enforcement. It would enable new consumer products such as digital cameras with new electronic scanning and focusing capabilities, miniature movie projectors, helmet mounted displays, and display products of various types including low cost projection televisions.

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KEYWORDS: optics; infrared; focal plane imagers; phased array; electro-optical; sensors

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N11A-T025 TITLE: Low-Power Arctic environmental sensors for UUVs

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors, Battlespace

OBJECTIVE: With the increased interest in Arctic environmental prediction and sensing, new sensors are required to make the observations needed to enable integrated earth system models to accurately forecast future environmental conditions in the Arctic. UUVs can be used to increase the sensing capability in the Arctic, but they require the development of new sensing technologies to allow adequate observation of key environmental variables, such as ice thickness, temperature and salinity, that can be integrated onto long endurance UUVs.

DESCRIPTION: UUVs developed over the last decade have dramatically increased our ability to observe the ocean. However, there is a need to develop new technologies for environmental sensing, particularly in demanding regions such as the Arctic Ocean. Undersea gliders and powered UUVs like REMUS permit remote environmental monitoring, and these tools have been developed to increase the sensing capability that constrains numerical ocean models used to provide predictions. The next extension is to develop the specialty sensors needed to measure the characteristics needed to properly predict the environment in the Arctic.

Goal of the project are to develop robust, long endurance UUV-specific sensors (i.e size and power limited) for environmental measurements of the Arctic. This includes:
- Ice thickness measurements
- Undersea ice mapping
- Bottom mapping
- Salinity, temperature and depth in harsh Arctic conditions

The combination of sensors should be able to fit into a 12-3/4 " diameter UUV with a power draw goal of less than 60W.

There are many different approaches that can be used to solve this problem including new algorithms development, new low power processor, new materials (such as but not limited to single crystal), or completely new technology The topic is open to all sensor design approaches. In addition, working in the cold arctic environment may require modification from current environmental sensors to overcome the extreme cold environment.

PHASE I: Develop a preliminary design for the ice thickness and environmental sensor payload. This may include one sensor or multiple sensors. There if flexibility in the system design to meet the above sensing goals. Provide the theoretical predictions of the system and develop a technology development plan for Phase II. The deliverable should be a concept design of the system. If the design or components of the design are very high risk, a risk reduction plan should be included.

PHASE II: Complete the system design. This task should include any risk reduction tests, detailed design review, and test plan. Fabricate prototype sensor payload and complete laboratory. Complete development tests to determine performance of the system in simulation or laboratory.

PHASE III: Integrate the developed STTR environmental sensor as a payload onto ONR UUVs. Provide technical support at sea tests of the STTR sensors on a government UUVs during the experiment. Mature the STTR technology sensor package to a TRL 7 and develop a transition plan to integrate the new sensor into NAVO UUV acquisition programs

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: There is significant interest in Arctic operations and logistics from the science community and commercial industry. There is significant interest from international partners in Arctic research which could utilize this technology to advance scientific research in the Arctic.

Private industry is very interested in Arctic sensing technology development, as the Arctic may contain a vast amount of untapped natural resources. The oil and gas industry continues to gather as much information on this area as possible to plan for future oil drilling operations.

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KEYWORDS: sensor, UUVs, Ice Thickness, Environmental

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N11A-T026 TITLE: Low cost acoustic transmitter

TECHNOLOGY AREAS: Sensors, Battlespace

OBJECTIVE: Develop, fabricate, and demonstrate an acoustic transmitter consisting of an underwater acoustic projector, a self-contained very high efficiency power amplifier, signal generation and control circuitry, and a long endurance power supply. An innovative utilization of new transduction technology, integrated power amplification and a novel energy source is desired that can be compact and low cost for operational scenarios and applications that require a specific combination of frequency band, power output, operating depth, and operational life. The primary focus is on the development of low cost transduction technology that can be combined with an innovative power subsystem. The goal is for a new transduction type that can be manufactured at a cost at least 50% less than existing technology.

DESCRIPTION: A low cost, integrated package containing an underwater sonar active transducer, power amplifier and tuning, energy source and appropriate control circuitry is desired for a variety of ASW-related applications. As an example, purely notional, a package could be envisioned for a sonobuoy sized package that operates somewhere in a band encompassing 500 to 1000 Hz and capable of producing a tone with an acoustic output in excess of 50 watts and lasting 500 ping-seconds. The desire is to identify and develop a transduction mechanism that can be used for this specific combination of performance needs and low cost and be capable of being redesigned for different performance needs at higher or lower frequencies, power levels and operational life. For example, an alternative would be a larger transducer at a lower frequency with an output above 100 watts and capable of being part of an array. The innovation desired is the novel mating of transducer, amplifier, and energy source in a potentially low cost assembly that can be seen as a toolkit and further can be seen conceptually as a new class of underwater sonar transmitter.

PHASE I: Identify a 'transduction mechanism/power amplifier/energy source' combination that can be developed to meet a notional need while being inexpensive in both material and fabrication costs. Perform analysis to determine the allocation of 'resources' between and transducer and power amplifier and energy source; i.e., can a cost analysis point toward a combination of of components that delivers the best performance/$ ratio. Undertake 2 or 3 notional paper designs to assess the strength of the approach. Target several ASW scenarios in which these designs can be utilized including those that are volume and weight constrained. Select a design to pursue in Phase II and analyze all aspects of the design and perform a cost analysis for large production.

PHASE II: Complete the design selected in Phase I and fabricate a prototype including transducer, amplifier and energy source. Fabricate and test components separately and then combine to test and assess performance versus prediction. It is possible that the development will lead to an application that will prompt the effort in Phase II to be deemed classified. In addition to the development of the selected prototype, perform a design synthesis to demonstrate the versatility of the overall concept. Based on the cost analysis of the components determine alternates based on performance needs.

Phase I will be UNCLASSIFIED, and the contractor will not require access to any classified data (in other words, if the research outcome relates to applicability to potential transition to systems that involve classified performance requirements, the work itself can be performed using notional requirements that mimic the same level of complexity). Though Phase II work may become classified, the Proposal for Phase II work will be UNCLASSIFIED. If the selected Phase II contractor does not have the required certification for classified work, the related DoN program office will work with the contractor to facilitate certification of related personnel and facility.

PHASE III: Extensively test the prototype(s) fabricated in Phase II and test for severe environmental conditions. Fabricate several other prototypes with differing performance requirements. Do an analysis of cost effects by varying frequency, power, and endurance and determining what performance requirements affect the overall cost. If applicable, place prototype systems in at-sea testing environments.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The development of this technology will have application to the oceanographic and oil industries in that the ability to have a self-contained, deployable source will enhance the acquisition of data for both oceanographic research and for oil exploration.

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KEYWORDS: underwater; transducer; sonar; transmitter; projector; low-cost

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N11A-T027 TITLE: Compact, Light Weight, Low Cost, Precision, Non-inertial Underwater Navigation Sensor

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors, Battlespace

ACQUISITION PROGRAM: Oceanographer of the Navy, PMS-NSW, PMS-403, PMS-485, and PMS-495

OBJECTIVE: Design and develop a compact, light weight, low cost, non-inertial sensor capable of providing external navigation reference information for small UUVs conducting environmental and tactical reconnaissance in littorals and riverine areas. The system shall be easily integratable as a module to a number of existing underwater deployed sensors and unmanned underwater vehicles.

DESCRIPTION: For naval forces operating in riverine and coastal areas, environmental and tactical reconnaissance is an indispensable part of any operation prior to entry. With on-going advances in capabilities, growing number of unmanned platforms are expected to conduct preoperational reconnaissance missions autonomously. Compared to other unmanned vehicles, UUVs provide unique advantages of conducting reconnaissance missions in riverine and coastal environments including their ability to conduct missions covertly and to employ acoustic sensors that are not affected by water turbidity or surface waves often predominant in such environments. Full submergence in the water column, however, means that UUVs may not have ready access to GPS.

For submerged UUVs, there are navigational methods such as dead reckoning, INS, Doppler velocity log (DVL), or acoustic beacon based systems such as LBL and USBL. Among these methods, DVL has a unique capability of directly sensing the vehicle velocity relative to the seabed. It doesn’t require any pre-emplacement of beacon network, thus DVL is an ideal navigation sensor for covert underwater missions. Some of the commercial UUVs offer integrated INS/DVL navigation systems with remarkable accuracies while submerged. There are, however, some issues of integrating a DVL into a man portable UUV for conducting reconnaissance in rivers and coastal areas. For the naval forces operating from a small platform in such areas, key requirements for unmanned vehicles are small, light weight, low cost, and accurate navigation. For a small UUV, DVL integration may take up to forty percent of both the total cost and the weight of the vehicle. An innovative new concept is therefore solicited to develop an affordable, light weight, precision non-inertial underwater navigation sensor capable of providing external reference information suitable for integration into a compact UUV system. Although acoustics may to be the most robust modality for navigational measurements in turbid water, other modalities such as optics may also be considered if an innovative concept is available to alleviate the issue of optical opaqueness of riverine and littoral water. A compact UUV with a vehicle weight less than 10 lb has been viewed as ideal for riverine and littoral reconnaissance missions, therefore the alternative navigation system shall not weight more than 1 lbs with a volume nominally 30 cubic inches. The derived overall navigational accuracy shall be equivalent or better than currently available DVL based sensors, and per unit cost shall be nominally $2000.00 or less. Since the expected operating environment is littoral or riverine, the design depth shall be no more than 40 feet.

Phase I: Specific design concepts of material, hardware, and software components of the non-inertial navigation sensor to achieve the objective requirements should be proposed along with an integrated system design. Component level and system level modeling and analyses are to be conducted to justify the proposed design and system integration. The design analyses should focus on feasibility of any new proposed concept of transducer material, component, and integration for overall system performance in the riverine and coastal environments.

Phase II: A prototype will be produced and fully demonstrated in Phase II. Test and analysis will document the navigation sensor system performance with respect to the stated objectives as well as performance limitations in laboratory and in near shores and in rivers. In addition to operational performance issues, the Phase II efforts should address issues such as reliability, manufacturability, and toughness in severe environmental conditions.

Phase III: Proposer will develop an acquisition-ready alternative navigation sensor system description that meets well defined operation guidelines. Full manufacturing documentation will allow rapid production to occur with the vendor team.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Commercial production and distribution of an affordable, compact, non-inertial navigation system parallels Navy interests. The same alternative concept of the non-inertial measurement of reference environmental motion may lead to new flow velocity field measurements currently done by ADCP type sensors. Affordability and compactness of the alternative concept would attract designers of developing alternative ADCP type sensors for private sector use. Primary applications in the near-term will address environmental baselining, monitoring, and change detection seasonally and in response to incremental or episodic events. Communities, ports, and resource management entities are likely the first customers, and their requirements for affordability and size requirements will be similar to the Navy requirements.

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KEYWORDS: navigation; DVL; sensor; UUV; IMU; doppler

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N11A-T028 TITLE: New Affordable Energy Storage Technologies for Power Grids and Micro-Grids

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: DASN-Energy and Commander Naval Installation Command/Naval Facilities

OBJECTIVE: Develop new affordable energy storage systems to increase grid security, facilitate micro-grid development, and increase use of renewable energy technologies at shore-based facilities and for forward operating bases.

DESCRIPTION: Power grids can be adversely affected by variable power demands, weather events, accidental damage, and deliberate attack. Furthermore, the transient nature of many renewable energy technologies can cause detrimental fluctuations in power grids that lead to reliability problems. To mitigate these adverse effects, electric power companies are required to maintain spinning reserve to manage the transients imposed by variable demand, local grid damage, and fluctuating renewable energy sources (e.g. wind speeds, cloud cover, ocean wave variability, etc.). Such standby generators are usually fossil fueled and expensive to operate. To reduce the need for standby power and increase grid/micro-grid security, appropriate energy storage technologies can be used to enhance power quality management and provide additional energy capacity to meet power demands when renewable or primary power sources are off-line or inadequate. Such energy storage systems can also augment emergency backup power sources for critical facility infrastructure, thus reducing or eliminating the need for fossil fueled emergency generators.

The key parameters for grid/micro-grid energy storage technologies are power level, stored energy capacity, power and energy densities, capital and lifecycle costs, and cycle and calendar operational life. The time scale required of the technology is very broad (seconds to tens of hours) with corresponding power and energy requirements spanning multiple decades (typically kW-to-MW and kWh-to-MWh, respectively) depending on the grid size and the various power load demands. Such performance characteristics can come from a range of energy storage mechanisms, including electrochemical (e.g. batteries, flow batteries, and electrolyzer/fuel cell combinations) and mechanical (e.g. compressed air, pumped hydro and flywheels); however, the cost to implement many of these technologies is often commercially prohibitive at the required operational scales.

This STTR is focused on providing new energy storage technologies that can ultimately be implemented at affordable prices. Energy storage technologies capable of meeting both power and energy requirements, as described above, are of particular interest; however, consideration will be given to technologies addressing only one aspect of the problem: transient power management or stored energy capacity for extended backup power demand. In all cases, affordability will be considered in the selection process. While power and energy densities will be considered in the selection process, the anticipated cost of a viable technical system will weigh more heavily in the selection process. Only new energy storage technology approaches are desired; therefore, incremental improvements of existing energy storage technologies are not acceptable for this STTR topic.

PHASE I: Demonstrate proof-of-concept of the new energy storage technology at the small unit or component level. Concept demonstration may consist of a bench-scale or larger working unit or the demonstrated performance of key system components at the bench-scale or larger size. Work should include data collection and analysis, concept design of a commercial energy storage system, and cost estimate of an energy storage system employing the new technology on a power grid or micro-grid with 10kW to 100MW power range and with an energy capacity sufficient for up to 24 hours of operation.

PHASE II: Based on Phase I results, a prototype energy storage unit will be design, fabricated and tested at a size sufficient such that performance data collected can be extrapolated to provide an engineering design. Work will consist of data collection and analysis, engineering design of a commercial energy storage system, and refined cost projections for implementation of the energy storage technology on a power grid or micro-grid with 10kW to 100MW power range and with an energy capacity sufficient for 24 hours of operation.

PHASE III: Design and construct an energy storage system and demonstrate full performance at a government facility. The power level and energy storage capacity of the system will be defined at a future date and will depend on the availability and requirements of the designated test site and the performance parameters of the energy storage technology. Prepare performance purchase specifications for Navy use to replicate these systems at other facilities.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: This technology would be attractive for any shore-based facility, building complex, housing community, etc. The technology is required to increase commercial grid security, implement energy efficient commercial micro-grids, and increase commercial penetration of transient renewable energy sources into the main power grid. This technology will be readily adopted by the commercial power and building/construction sector.

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KEYWORDS: Energy Storage; Electochemical; Mechanical Engineering; Grids; Micro-grids; Batteries; Flow Batteries; Fuel Cell; Electrolyzer; Compressed Air; Pumped Hydro; Flywheel

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N11A-T029 TITLE: Affordable High Strength Mo-Si-B Alloys for High Temperature Applications

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Mature Mo-Si-B material production methodology for Aerospace use. In Phase 1 the process of maturation will optimally include the demonstration of medium scale material production, material lots of 1 to 10 pounds, and the assessment of the benefit of extrusion on the mechanical properties of Mo-Si-B alloys.

DESCRIPTION: Maturation of material production methodologies/techniques is needed for Mo-Si-B alloys. Mo-Si-B powder can be manufactured by a handful of production techniques. One of the most promising avenues for producing Mo-Si-B powder with the necessary cleanliness for aerospace and marine applications is the Spray Dried + Reaction technique. However other processing techniques will be considered if they demonstrate low interstitial impurities (O, N, C). The potential for medium scale production of this powder including the accompanying methodologies for handling and reaction of this powder needs to be demonstrated. This would ideally be demonstrated via processes that can be scaled-up to standard production techniques. Characterization of the powder chemistry and interstitials should be document during each stage of the processing. Following development of a specific process to produce medium scale material lots of Mo-Si-B powder, maturation of the parameters required to perform a small scale Mo-Si-B extrusion is also required. Characterization of the extruded material properties should be performed. Ideally this characterization would include measurement of the tensile properties up to 2300 degrees F and potentially 2500 degrees F, as well as the creep resistance of the alloy at 2000 degrees F or higher. This characterization should also include documentation of the static oxidation resistance at three or four key temperatures across a range between 1500F to 2500 degrees F.

PHASE I: Formulate and produce a moderate quantity of a Mo-Si-B alloy by spray-drying. Process the material to a full density low interstitial material via heat treatment in a suitable atmosphere. Extrude samples of the processed powder and measure the tensile properties of the material. Samples should exhibit a ultimate tensile strength of 60 Ksi or more.

PHASE II: Develop a detailed test plan to scale-up the material production and processing approach from the laboratory size in Phase 1 to an industrial scale. Execute a proto-type small scale industrial production of the material and assess the material properties. Conduct material property tests at the level required to provide data for the design of a suitable component for demonstration in an OEM or DoD core engine test. Provide material for manufacture and test of the suitable component.

PHASE III: Transition the material production methodology to a suitable industrial material producer. Commercialize the material for use in DoD and civilian markets.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: If this technology was successfully developed, the material would have utility as high temperature material of construction for civil air transport and as a high temperature forging die material for both commercial and military production equipment.

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KEYWORDS: Molybdenum Alloys, Refractory Metal, Intermetallic, Oxidation Resistant Alloys, Powder, Powder production, Extrusion

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N11A-T030 TITLE: Novel Torque Sensing for Condition Based Maintenance

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Sensors

OBJECTIVE: To explore the use of and demonstrate the effectiveness of novel torque sensing devices for condition based maintenance of Navy rotating machinery (motors, generators, pumps, gear systems, etc.). Rate-of-change torque sensors, for example, have demonstrated both a sensitivity and time resolution high enough to not only recognize failing machinery, but to specifically identify the failing part. This topic is open to rate-of-change torque sensors and alternative torque sensing approaches having potential for benefitting the Navy from a cost, maintenance, reliability, or performance standpoint.

DESCRIPTION: Rate-of-change torque sensors1-3 differ from normal torque sensors in that the torque rate-of-change is not calculated, but measured directly. The sensors consist of a circumferentially-magnetized shaft and a pick-up coil1. In many cases, the original shaft material can be utilized either by permanently magnetizing the shaft or by using a sensor arrangement including a small magnet. In either case, no contact between the shaft and sensor is required. As compared to simply differentiating the output of a normal torque sensor, the direct measurement results in higher sensitivity, higher time resolution, and lower noise. The lower noise results from the avoidance of differentiation which inherently accentuates the high frequencies.

An example of rate-of-change sensor performance is given in Reference 2. In one test, two, four and six flute one inch diameter end mills were used to mill an aluminum block. The magnetic properties of the high speed steel used in the end mill were such that an external magnet was not needed. Instead the tool was magnetized by a 550 A, 2 ms axial current pulse. The pickup was a 1000 turn coil on a bobbin slipped over the shank of the tool. At 600 rpm, the moment that each flute contacted the aluminum block was clearly delineated. A second experiment progressively dulled one of the flutes on the two flute end mill. The signature of the damaged flute was visible and noticeably different from the good flute.

The rate-of-change torque sensor technology shows great promise for use in condition based maintenance applications. It is sensitive, has enough time resolution to pinpoint the point in the rotation that is failing, is temperature tolerant, and, if the existing shaft has suitable properties, can be retrofitted onto existing machinery without dissembling the machinery. Further S&T is needed however to gain an understanding of which shaft alloys and / or treatments are best suited to the task, the method of magnetizing shafts, the transfer functions necessary for interpreting the data, suitability for a Navy environment, and the scaling potential for the technology with respect to torque levels, shaft speed, applications, etc.

PHASE I: Phase I consists of laboratory scale experiments into the limits of sensitivity, time resolution and noise floor accompanied by a modest modeling effort to predict scalability and performance in specific applications. Investigate materials and magnetization methodology for various classes of applications. Model transfer functions necessary for sensing and data analysis. Develop an understanding of operating environment on performance of the proposed torque sensing approach.

PHASE II: Phase II consists of studies on actual machinery with simulated failures to validate the Phase I results under realistic conditions. For example, a motor-pump system where a motor bearing is replaced by bearings with various states of wear.

PHASE III: Installation of proof-of-principle torque sensors on in-service Navy machinery. Multiple platforms/applications shall be chosen for demonstration to validate performance and Naval value of the sensor technology.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Improved condition based maintenance (CBM) is an important goal in many areas of the private sector, especially in the manufacturing sector. Without CBM, either the equipment must be allowed to fail and the results of the failure dealt with or, if the consequences of failure are unacceptable, preemptive replacements of equipment or parts must be accomplished, even if the parts would have had substantial service life remaining. Obvious examples are pumps in municipal water systems, machine tools, vehicles, and construction equipment such as cranes.

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KEYWORDS: condition based maintenance, torque sensors, failure sensing

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N11A-T031 TITLE: Multi-Perspective Decision Making in a Networked Environment

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: Virginia Block IV and Ohio Replacement Program

OBJECTIVE: Develop a decision aid (selected display and algorithm products) to dramatically enhance submarine decision making by allowing rich multi-perspective interaction between local control room operations and alternative operational command centers.

DESCRIPTION: Across warfare and mission areas, and between and across echelons of command, the rate at which information is presented to decision-makers continues to outpace the rate at which Command and Control (C2) systems and human decision-makers have been able to effectively and prioritize, filter, and assimilate the information. In many cases the decision-maker is presented with too much information, while in other cases there is too little critical information. In many of these cases, the information is ambiguous, contradictory, and or contains uncertainties which are not well understood by the decision-maker. Consequently, the commander is increasingly challenged to make good decisions within critical operational timelines given the massive amount of information provided to him, and the increasing difficulty to determine the relevancy and uncertainty of that information. This mismatch between increasing amounts of information – and the difficulty in determining relevancy and uncertainty – and the need to make decisions within shortening timelines available also hampers the Navy's desire to migrate to a C2 environment which is flexible and rapidly adaptable to unanticipated changes in C2 organizational structures and missions. Until the root causes for this mismatch are addressed, the decision-maker's ability to meet critical operational decision timelines will deteriorate as new sensors and systems (such as multiple unmanned vehicles) and information sources are introduced into the operational environment, and manning levels are decreased.

Submarine mission scope and complexity continues to grow. Although always a platform of choice for stealthy operations, since the end of the Cold War submarines have been increasingly operated in the littorals. There, submarines are expected to support asymmetric warfare operations and to become full-spectrum participants in net-centric warfare. Reflecting these trends, the submarine fleet is now asked to take on the challenge of incorporating unmanned aerial vehicles (UAVs) as a sensor in support of the Over-the-Horizon Targeting (OTH-T) missions, for strike and littoral surface warfare. This includes both deploying the UAVs while submerged, and ingesting their data to augment the tactical picture to plan and execute OTH-T missions. Robust network investment and advances in computing capabilities combined with the planned development of secure communications at speed and depth for submarines yield the potential to remotely perform (both on- and off-board) command functions currently located within the submarine's control room.

In preparation for this communication bandwidth capability, several technical challenges remain before a decision aid can be used. Specifically, integration of data and information from disparate modalities, mismatch between the temporal rates at which sensors produce the data, management and quantification of uncertainty inherited from all sensors and sources during processing, identification of relevant information and critical decision time-lines, integration of spatially disparate and heterogeneous information, and presentation of information in a manner that human decision-makers to choose from among several alternative COAs. Technological advances suggest ways of improving command effectiveness by escaping the "work station paradigm" (WSP) (Kranz et al., 2010). This traditional paradigm focuses information on single displays and passing information "up the chain" to a single decision-maker. Recent work in the area of teaming computer agents with human agents (Maarten et al., 2003) has developed a human-centered approach to human-agent interaction such as would be required by earth-bound controllers interacting with a remotely deployed vehicle, whether a UAV or Mars-bound explorer. Though this C2 enhancement has the potential to greatly enhance information gathering, analysis, and assimilation capabilities of enhancing team performance (Salas et al., 2007; Kozlowski & Ilgen, 2006) a comprehensive analysis for deployment of those capabilities that minimizes risk and enables comprehensive evaluation of tiered alternatives is needed, i.e., assuming future operational context for the UAV capability is fully networked, so elements of the UAV OTH-T process should be capable of modular offloading to networked elements.

The output of this effort would provide a decision-maker multiple automatically generated valid courses-of-action (COAs) for a given mission that are tailored to the cognitive capabilities of the commander or command team. A robust methodology for defining mission-focused, decision-driven cognitive C2 information architectures based on local (control room-based) human control of some functions and decisions but remote participation in some set of operational decisions. Research is required for how decisions are to be divided among the operational (both on- and off-board) teams, how this decision structure changes with operational and environmental conditions, and what roles (both legacy and new) are required to execute in this environment. It is anticipated that scientific inquiry into the nature of decision making, optimal structures and protocols for collective and participatory decision making, and cognitive engagement depending upon decision making responsibility will be required. Especially important will be the avoidance or mitigation of potential "automation surprises" triggered when own ship operators are presented with status changes caused by automated alerts that are generated outside human involvement. The challenge is not only to develop a decision aid for understanding the information architectures that would lead to shared decision making and problem solving, but also to develop a system of mechanisms to allow dispersed teams of individuals to collaborate on operational decisions in ways that are both adaptive and resilient (Wreathall, 2006).

Assuming a robust secure communication network is available at speed and depth, the final product may be selected display and algorithm products that adhere and implement elements of the cognitive information architecture, and which measurably demonstrate increased effectiveness in presenting the decision-maker with viable COAs in the time available. Achieving this programmatic vision for submarine decision making will identify (1) which decisions are best left to local command, and under what circumstances, (2) which decisions are best assigned to the off-board team because of analytical perspective or data access, and (3) a structure for assessing these decisions in a dynamic environment. Submarine force would implement this decision aid (selected display and algorithm products) in the command and control center to enhance C2 for on- and off-board communications.

PHASE I: Provide a theoretical structure and work model, managing higher levels of risk in a controlled and deliberate manner, for developing operational decision making among local and remote team members. The concept should include strategies for deconstructing decisions, involving teams, and making criteria explicit. Develop a detailed method for evaluating the theory that includes both qualitative and quantitative measures. Enumerate a set of requirements for a proof of concept to be implemented in Phase II.

PHASE II: Design, develop, and demonstrate decision aid prototype for the target application environment as investigated in Phase I. The implementation will test the predictions of the theory through measurements of the evaluation criteria developed in Phase I. Phase II will demonstrate the implementation in applications that illustrate the positive and negative consequences of multi-modal, multi-perspective decision making. A useful example would be to demonstrate critical decision making by a submarine command team in a non-routine situation using the proposed structure. Iterative research into cognitive models and workload will be required to assess the impact of the proposed structure. The Phase II effort may or may not be classified due to the content of the decision aid.

PHASE III: This topic has many dual use applications, including the development of improved decision making in commercial as well as military environments. Additionally, there are potential total ownership cost implications of reduced recruiting and retention costs as a result of higher levels of employee engagement and control. Critical solutions would benefit industry, the government, and the military, and indeed, all large organizations that manage difficult, complex problems.

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KEYWORDS: decision modeling, cognitive models, operational command center

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N11A-T032 TITLE: High-level tools and languages for faster Intelligent Tutoring System(ITS) model development

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: High-level abstractions for new tools and languages capable of increasing the efficiency of expert and student model development for intelligent tutoring systems.

DESCRIPTION: One of the success stories for artificial intelligence and cognitive modeling techniques has been in the area of intelligent tutoring systems (ITS). ITS have proven to increase levels of student learning by 1.5 standard deviations over traditional forms of educations and they have the potential for not only increasing student learning but also increasing instructor domain expertise. ITS applications automate portions of the educational process, including curriculum delivery and adaptation, assessment of student performance and knowledge, and student-oriented guided interaction. Intelligent tutoring systems have been developed across a wide range of domains, from high school mathematics and physics (Anderson, Corbett et al. 1995; Vanlehn, Lynch et al. 2005), to complex procedural skills such as electronics troubleshooting (Katz, Lesgold et al. 1998) to more "ill-defined" domains such as learning to interact with someone from a different culture (Lane and Johnson 2008).

A common approach to the successful operation of intelligent tutoring systems is to model the learning domain itself. The learning domain includes both the task being tutored and the student's progress and potential pitfalls in the learning domain (Woolf 2008). Task models can be used to evaluate student performance, allowing the ITS to identify errors in the student's problem-solving actions, the student's current level of subject mastery, as well as specific gaps in the student's problem-solving knowledge. By modeling the larger learning domain, the model also gives an ITS a capability to recognize a wide range of errors and incorrect behaviors that, individual students might exhibit, and to tie those errors directly to a known set of knowledge gaps or incorrect strategies that can then be targeted during subsequent lessons.

Although intelligent tutoring systems have proven remarkably successful, their large-scale development and application remain elusive. They are labor intensive and thus expensive to build. Currently, the learning domain models in a tutoring system are almost always developed by cognitive scientists and cognitive engineers, who have extensive expertise in building cognitive models and tuning them appropriately for use in intelligent tutoring systems. While this approach creates high-quality tutoring systems, it is difficult and expensive for instructors to extend existing tutoring systems to new problems types, curricula, error types, reasoning strategies, etc. In an era of rapidly changing missions and training requirements to support them, the cost and inflexibility of "expert-created" models limits the applicability of intelligent tutoring systems in many Navy training areas.

One approach to helping make ITS more scalable and flexible, would be to enable curriculum developers, instructors and less highly-skilled developers to develop ITS models. ONR has invested successfully in improving the cost effectiveness in cognitive modeling via the development of high-level modeling abstractions and task-specific tools (e.g., see Ritter, Haynes et al. 2006 for a review of numerous relevant research projects). For example, the development of programming language or a set of tools that directly support the creation of student models. This approach is in contrast to current state of art, where models are developed conceptually but then must be translated and mapped into an implementation language (like Java). The high-level abstraction makes it possible for modelers to express modeling concepts directly in the code.

In general these methods enable modeling at the level of "task reasoning" rather than the level of "memory retrieval and deliberation" that is current best supported by cognitive modeling architectures. Higher-level and domain-specific abstractions allow end users to concentrate model design on the target knowledge for the models (and the tutoring systems) without having to worry about specific types of memory management and action-selection regimes.

This research topic seeks approaches to improving the cost effectiveness of task modeling for intelligent tutoring systems, focusing specifically on the adaption of existing techniques or new techniques for supporting high-level and domain-specific languages and tools for designing and building ITS models. Proposed solutions should maintain and support the formal nature of model definition while being general enough to be applicable to various ITS modeling approaches, various modeling framework/architectures, and different ITS learning domains.

PHASE I: Phase I addresses two major goals: (1) Reduce the developmental costs of ITS, and (2) Diminish required expertise of potential developers. The bidders should propose a language and/or set of tools that use high-level abstractions to make it easier and cheaper to build models for intelligent tutoring systems. Designs should identify specific, appropriate abstractions gleaned from analysis of existing intelligent tutoring systems and their models, as well as any studies performed with potential end users. Phase I should outline an evaluation approach that will be used in Phase II to create and demonstrate the effectiveness of the new languages/tools and identify specific metrics for measuring the effectiveness of the tools.

Design efforts in Phase I should demonstrate or provide arguments to show the generality of the approach across existing modeling architectures and ITS platforms.

Finally, Phase I should deliver a plan for implementing, evaluating, and deploying the new languages/tools.

PHASE II: Implement and evaluate the language and/or tools designed in Phase I. Design and implement a modeling environment compatible with one or more existing intelligent tutoring systems, demonstrating a capability for end users/instructors to extend existing tutoring systems cost effectively, without requiring the participation of cognitive engineering experts. Refine, complete, and generalize designs for multiple architectures and tutoring systems.

PHASE III: Deploy the new languages and tools as part of the product packages for one or more intelligent tutoring systems. Evaluate cost effectiveness of user-configurable models and curriculum development using the new technology.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: High-level tools and languages for faster Intelligent Tutoring System (ITS) model development

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KEYWORDS: Cognitive Architectures, Programming Languages, Knowledge Representation, Human Behavior Models, Intelligent Tutoring Systems

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N11A-T033 TITLE: <u>Multi-Sensor Data Collection Suite for Unobtrusive Human Performance Measurement</u>

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: Capable Manpower FNC (CMP-FY11-02)

OBJECTIVE: Develop lightweight, unobtrusive, modular, and wearable recording device(s) to capture, synchronize, and download environmental, physiological, physical, and subjective measures that contribute, and are associated with physical and cognitive fatigue. The device(s) or system(s) should also be capable of objectively and reliably assessing fatigue uncontaminated by individual factors such as aptitude, learning effects, yet sensitive to phenotypic differences in vulnerability to fatigue.

DESCRIPTION: Current Naval platforms and systems require increased operational capability with reduced manpower. The ability to accurately predict warfighter performance (e.g. accuracy and reaction time for job duty tasks) on these platforms and systems is an essential component of conducting cost, schedule, and performance tradeoffs between hardware, software, and human capabilities and limitations. These tradeoffs are increasing done with human performance models such as Total Crew Model and IMPRINT. While the capability to model warfighter performance has made great strides over the last several decades, models still lack the fidelity to support fine grained tradeoff analyses. Furthermore, most models are not validated, and have little capability to account for the impact of environmental stressors. The need to account for environmental stressors such as fatigue, motion, vibration and extreme temperatures is critical because they can result in physical and cognitive fatigue, leading to degradation in warfighter performance.

A significant challenge in validating human performance models is the ability to collect environmental and performance data from warfighters in an operational setting. Current methods are primarily paper based, although, standalone recording devices such as actigraph may also be used. Several limitations are associated with these current methods. First, from a participants' perspective, generating responses while performing mission tasks is cumbersome and time consuming. Second, from an experimenters' perspective, coding self-reported responses is time consuming and increases the likelihood of errors in data entry. In addition, experimenters may not be able to attend an experimental event in person (e.g. live fire testing) or collect all the environment conditions that a warfighter experiences (e.g. motion, vibration, noise). Third, data analysis cannot be performed until all data sheets are collected and coded thus delaying when the analysis is performed, and eliminating the possibility of real-time (or near real-time) analysis. Lastly, the lack of synchronization between devices and subjective reporting makes associations between objective and subjective data more difficult.

The end result of these limitations is that researchers focus more energy and time on collecting and processing a limited amount of data, then on assessing the impact of environmental stressors on fatigue. Accurately accounting for the effects of environmental stressors on operator performance will allow human performance models to better support assessment, analysis, and mitigation of stressors during system development, testing, and acquisition. To overcome the data collection challenges associated with validating human performance models, and ensure an accurate account for the effects of environmental stressors on performance, a novel, integrated, non-obtrusive data collection and analysis system is needed.

The selection of sensors needed for the data collection suite should capable of objectively and reliably assessing fatigue and based on theoretical models (Mallis, Mejdal, Nguyen, and Dinges, 2004). Recent advances in individualization algorithms are making possible a new generation of systems to tailor mathematical model-based assessments of fatigue to track trait-like differences among individual operators. (Van Dongen et al., 2007). Measures of fatigue that do not involve obtrusive or invasive physiological monitoring, that have high face validity for operator performance relative to vigilance based tasks, and that are free of contaminating factors such as aptitude and learning effects should be explored. These measures would be combined with state-of-the-art, mathematical model-based analysis and individualization algorithms to account for individual state and trait related performance changes due to fatigue (Kan et al, 2009; Mollicone, Van Dongen, Rogers & Dinges, 2008; Mott et al., 2009). The system would provide visualization tools based on behavioral alertness data to assess operationally relevant performance features sensitive to fatigue that are associated with phenotypic differences across individuals.

Academia and industry are increasingly developing portable and wearable data collection technologies. These systems are part of a larger effort of ubiquitous and pervasive computing applications and often have a set of typical sensors with them (Beigl, Krohn, Zimmer, and Decker, 2004). Some devices such as the iPod touch also have the capability of obtaining subjective responses via an embedded rating system. However, none of these devices nor technologies provide the capability for non-obtrusively collecting and then integrating data spanning environmental, physiological, physical, and subjective measures of fatigue. In addition, to these sensors it is necessary for designers to consider the usability of these systems. Based on prior work, Tapia, Intille, Lopez, and Larson (2006) developed four usability goals (i.e., ease of installation, ease of use, adequate longitudinal performance in natural setting, affordable for researchers) for a portable sensor kit that could be used for non-laboratory studies. Consideration of such usability guidelines is critical for the successful adoption of data collection tools.

PHASE I: Develop the framework for a data collection suite for measuring human performance. The components in the framework should build on and extend the state-of-the-art capabilities in portable and wearable sensors / devices and performance measurement (including environmental, physical, physiological, and subjective indices). All sensors / devices must be capable of collecting multiple sources of data simultaneously and synchronizing that data. The selection of sensors needed for the data collection suite should capable of objectively and reliably assessing fatigue and based on theoretical models (Mallis, Mejdal, Nguyen, and Dinges, 2004). In addition, the user software must allow data to be quickly downloaded onto a Windows based-PC, and reset the sensor / device for another data set. The components in the framework should work within an open systems architecture.

PHASE II: Develop a prototype suite of data collection tools based on the framework established in Phase I. Submit appropriate and necessary regulatory documents for testing using human participants. Validate the tools through empirical evaluations with the targeted user community.

PHASE III: Produce and market the suite of data collection tools for integration with ship and submarine test and evaluation programs.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The suite of tools will have widespread applications to military, government, and private sector organizations in which it is important to assess performance (e.g., when fewer personnel are required to perform the same tasks and missions without degraded performance).

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KEYWORDS: portable and wearable systems; measurement; assessment; modeling; pervasive computing

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N11A-T034 TITLE: Energetic Materials—RDX/HMX Performance with TATB Sensitivity

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: Selectable Output Weapon FNC

OBJECTIVE: Design, develop, characterize and demonstrate methods for the preparation of an advanced energetic whose energy output is similar to or exceeds RDX but whose sensitivity characteristics are similar to those of 1,3,5-Triamino-2,4,6-trinitrobenzene TATB.

DESCRIPTION: Solve the following paradox: “Mission requirements impose the following conflicting demands for weapon systems” -- for which we lack a fundamental science base
• Resistant to inadvertent initiation, to save lives

• Significant enhancements in delivered energy in smaller weapons, to reduce system & platform cost

Since the end of the Cold War, the United States faces primarily military conflicts of an asymmetric nature. Our military opponents seek to use surprise and strategy to offset deficiencies in quantity and quality of their weapons relative to the United States. The most obvious limitation of Energetic Materials (EM) used today is that the Navy is using 19th century ingredients in 21st century weaponry to meet 21st century warfighting requirements. Most commodity EM ingredients (Nitroglycerin (NG), Nitrocellulose (NC), Trinitrotoluene (TNT) Ammonium Perchlorate (AP), RDX--AKA the workhorse industrial based high energy ingredients used for gun propellants, general purpose bomb fills and call for fires date from WW-2) and cannot meet today's safety, environmental and IM regulations. These materials were designed and produced in a different time with different military operational criteria in place. These 19th century materials need to be phased out of Navy use in favor of the next generation EM meeting today's applications and regulations.

Over the past 50 years RDX and HMX have been the most commonly used energetic ingredient used in advanced military weapon system for both explosive and propellant applications. While these systems function well, there inherent sensitivity to shock, impact and thermal hazards make their use a continuing safety and environmental hazard to users and manufacturers. Another line of energetic materials, TATB or FOX-7 ingredients demonstrate extremely favorable sensitivity properties, but lack the required performance. The focus of this program is to develop new revolutionary advanced energetic materials to replace RDX and HMX in current weapon systems and achieve TATB sensitivity characteristics.

The new ingredients should provide the following general characteristics:
Density > 2g/cc
Oxygen content > CO balance
Melting Pt >200 C
Low vapor pressures
Min. No. of Synthetic Steps
Sensitivity comparable or superior to Trinitrotoluene (TNT) and approaching TATB.

PHASE I: Design and prepare conceptual synthesis routes to new insensitive ingredients with the calculated energy of RDX, but with anticipated sensitivities similar to TNT or TATB. Down select and synthesize up to 5-gm samples of these new materials after consultation with the program COTR. Provide characterization, analysis, and delivery to government laboratories for evaluation of sensitivity characteristics—impact, ESD, VTS and friction (to be conducted at an independent Navy laboratory).

PHASE II: Scale-up and optimize the synthesis process to pound quantities for larger-scale evaluation. Investigate process research and establish parameters to define process for manufacturing of pure material for delivery of 2000lb. per year.

PHASE III: Transition technology to next generation propulsion and ordnance systems per appropriate PMA/PMS road maps. Provide costing and data package for pilot production of materials based on requirements and need. Examples include missile systems, general purpose bomb ordnance and underwater explosives.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: While the principle application for high energy ingredients is military in nature, insensitive materials with RDX performance could be used for selected commercial applications, potential custom explosive applications in mining and drilling can be envisioned, particular for a safe, stable, long-shelf life material.

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KEYWORDS: Insensitivity; Energetic Materials; Explosives; Monopropellants; Synthesis; Weapons

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N11A-T035 TITLE: Safe High Voltage Cathode Materials for Pulsed Power Applications

TECHNOLOGY AREAS: Materials/Processes, Electronics, Weapons

ACQUISITION PROGRAM: Office of Naval Research Code 352: Railgun Innovative Naval Prototype (INP)

OBJECTIVE: To develop electrochemical materials for high density Li-ion batteries capable of supporting high transient and pulsed loads while offering enhanced safety and lifecycle performance.

DESCRIPTION: Future Navy applications will require large amounts of stored energy to support loads which have high discharge and transient characteristics including pulses and similar waveforms. A wide variety of coordinated equipment may be employed to support performance requirements, and lithium-ion batteries are a technology which will likely be part of an energy storage module to support these loads. Current state-of-the-art Lithium-ion energy storage devices extensively utilize energetic metal oxides and flammable electrolytes as a cornerstone for maximizing energy content and providing optimal volumetric and gravimetric densities. These designs provide concern for both safety and cycle life, particularly under high-rate operations.

In order to provide the highest performance, most of the current battery chemistries rely on somewhat unstable cathode materials that can undergo runaway reactions and provide their own source of oxygen in the event of a modest temperature rise, due to something such as an internal cell short. Research into advanced electrode materials that do not contribute oxygen or a significant exotherm under a cell failure scenario, while at the same time maintaining the high energy and power density potential that Li-Ion batteries can provide are needed. Materials such as Lithium Iron Phosphate, which appears to offer abuse safety advantages versus “hotter” cathode materials such as Lithium Cobalt Oxide, also provide an electrochemical penalty in reduction potential, thus decreasing overall energy of the battery. Thus, materials that offer safety while also offering higher operational voltages and long-term stability are desired.

Innovative R&D is needed to investigate alternative cathode materials that limit the potential for energetic failure in a cell, while also offering high rate discharge performance over a large number of cycles. The intent of this solicitation is to produce advanced materials which overcome some of the typical tradeoffs which may effect operational voltage, energy content, etc. In order to enable widespread utilization of highly dense power and energy storage, advanced technologies must embody designs that are scalable/flexible and have robust design to be applicable to a variety of energy storage requirements with varying bias. These materials should offer long life, and allow a significant number of cycles to be obtained both under pulsed and continuous high-rate deep discharge operations. In the case of the use of dopants to effect cathode characteristics, material migration and agglomeration over long-term use must be addressed with respect to safety and performance.

Specifically, this solicitation requests the following characteristics for a lithium-ion battery cathode material:

- Average voltage: >4.0V
- Gravimetric capacity: >180mAh/g
- Cycle life: >2000 deep cycles with >80% original capacity
- Cycle life: >10000 pulse discharges @ 10C or higher within range of 25-75% SOC with >80% original capacity
- Suitable for combination with current and future anode and electrolyte materials
- Scalable to cells with >25Ah capacity
- Suitable in batteries with discharge ranging from 5C to 10C or higher and charge rate up to 10C
- Minimum onset of thermal runaway: 290°C
- Maximum exothermic release @ heating to < 900°C: 150J/g
- Low impedance with minimal growth over cycles and time at elevated SOC and temperature
- Cost in range with current SOA materials including NCA, NCM and LiFePO4

The Navy will only fund proposals that are innovative address R&D and involve technical risk.

PHASE I: The offeror will determine the feasibility of the cathode materials selected via the production of small-scale cells suitable for use as proof-of-concept. Electrochemical and calirometric analysis must be performed to determine and validate the suitability of the material for Li-ion battery application.

PHASE II: The offeror will produce cells of form/capacity no less than a 26650 Li-ion cell, for evaluation. Cell geometry may include jelly roll, pouch cell or other designs. Evaluation of these cells will be performed including validation of cycle life, capacity, thermal behavior and stability of operation at temperatures up to 60°C. These cells will also be combined into modules of 24-48VDC, and evaluated in the same way. The offeror will build multiple battery modules and expose them to a variety of abusive conditions in accordance with NAVSEAINST 9310. The offeror will produce and fine-tune the requirements for a battery management system for operation of these Li-ion battery modules, both separate and in series with others.

PHASE III: The offeror will apply the knowledge gained in phase II to build a complete 1000VDC string of batteries, including BMS, and characterize its performance at a range of charge and discharge rates as described in the solicitation.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Successful development of safe high voltage cathode materials will enable a new generation of lithium-ion battery technology, which offers greater safety and designs which encompass larger quantities of stored energy, and higher discharge performance. Such materials will offer utility in applications ranging from small consumer electronics through automobiles, and also in commercial/capital equipment supporting frequency regulation, load leveling and renewable energy.

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KEYWORDS: Lithium-ion; battery; cathode; pulsed power; safety; energy storage

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N11A-T036 TITLE: Weather and Environmental Software Tool for System Requirements Investigation

TECHNOLOGY AREAS: Air Platform, Information Systems, Battlespace, Weapons

ACQUISITION PROGRAM: Office of Naval Research Code 352: Railgun Innovative Naval Prototype (INP)

OBJECTIVE: Develop a validated analysis software package that can be used as a system requirement estimation tool to aid the aviation/missile development community in establishing real-world probabilities of encounter various weather related events. This tool will be able to predict the probability of encounter for a wide variety of weather events and phenomena. As weather databases tend to be large and contain an extensive amount of data, the problem of data synthesis and extraction can quickly become unmanageable. The development of the global adverse weather encounter probabilities therefore needs to employ analyses techniques and innovative data extraction strategies to make the currently available satellite databases amenable for the end user. These large databases need to be distilled in such a way to create the aloft hydrometeor and sand/dust profiles that will be employed for subsequent system performance estimates. Such events/phenomena could include: rain, global cloud cover, hail, ice, sand/dust, and volcanic ash. This task will significantly enhance affordability for current and future aviation and missile systems by reducing costs due to component over-design, while simultaneously assisting in verifying the performance, versatility, and durability of materials in realistic environments. Over-testing in unrealistic weather scenarios, due to lack of understanding of the real-world events drive higher component costs for radomes, shrouds, fairings, window anti-reflection coatings and seals, helicopter blades and even booster cases. As the “all weather” Navy unfolds, research tools such as this are critical for proper in-theater all-weather capabilities for all flight systems and can provide the opportunity to hasten the availability of this new technology to the operational Navy.

DESCRIPTION: The event characterization must be global in coverage to include oceanic environments as a function of geographical latitude and altitude. This code will provide the aviation (helicopter and aircraft) and missile system integrators with an accurate tool needed to properly link weather event ground testing to real-world flight environments. This tool will also be valuable to aviation parts manufactures such as window and rotorblade designers to estimate a more realistic flight environment for their products.

In recent years we have pushed the ground test facilities that were developed in the 1960’s and 1970’s to near their limits. There currently exist significant constraints on these facilities to “match” flight test weather event levels. These limitations make it all the more important when the system integrator must extrapolate the ground test results nearly an order of magnitude to match flight test data. Because of this, understanding the real-world weather environment becomes essential if the system component is not to be significantly over-designed. Coupled to this is the speed and performance of missiles, high-speed aircraft, and helicopter rotor systems currently in development, we are pushing the performance envelope beyond what the standard materials commonly used in older systems can deliver. These legacy materials are now no longer acceptable and new materials are currently under development. Due to the lack of experience utilizing these newer materials however, it is essential that the proper flight environment be tested so that realistic flight performance can be predicted.

The definition and probability of weather events at various latitudes will form primary core of the program. Such information is calculated and measured in the meteorological community. Radar data has established both the particle size and size distribution, as functions of ground track, altitude, and precipitation type and shape. The code will be able integrate these large data structures into a compact form which can then be utilized in establishing various weather scenarios that can predict the incident mass flux and integrated mass flux for a generic flight system given the trajectory or flight plan as input. Weather encounter probabilities can be accomplished through hind-casting methods, development of archetypical weather realizations tied to ground rain fall rates, or other such methods. Methods that can extract the probabilities of cloud cover over global regions are also of interest. The code will then be able to perform numerous simulations across multiple trajectories to determine the worse case launch point or flight path for a given weather event. The code will also have a flexible output file capability such that the Navy can quickly utilize this data in various other types of system analysis software currently in use.

The code shall be able to provide various performance metrics that will enable the engineer to rapidly assess how the weather environment changes as a function of its various input parameters. The highest-level of the software architecture should be able to perform hundreds of hands-free trade studies in order to assess the most optimal path for the problem at hand. A user interface should incorporate a Graphical User Interface (GUI) for ease of use. The software needs to run on personal computers running Microsoft operating systems.

The Navy intends to promote exploration into "all-weather" system design as an enabling technology for aircraft and weapon platforms. It is also the intent to develop software technologies as innovative research tools to aid the design and testing processes for multiple air/weapon platforms across DoD and private sector agencies. Software tools provide the opportunity to improve overall platform design and experimental test validation, thus enhancing system R&D quality and platform life-cycle costs.

PHASE I: Develop a software hierarchy as to what methodologies, codes, techniques, and weather databases will be used to deliver the weather assessment and optimization software. The elements that must be present in the software include:

- Trajectory/flight path simulation (altitude, velocity, as a function of time)
- A library of weather events (example: particle type, size, distribution, as a function of altitude and ground track, etc.) developed through innovative extraction methods utilizing current databases with rigorous validation to measured weather events.
- The probabilities of encounter associated with each event as a function of latitude or global position based on novel statistical assessments of the large weather database information.
- A architecture to perform multiple runs and assess worst case launch points/flight paths with respect to given or random weather formations.
- Simplified and flexible input and output capabilities to interface with other codes.
- Output plotting routines such that large amounts of data can be quickly assessed with statistical significance.

PHASE II: Provide a completed and integrated weather encounter software package enabling more accurate definitions of the weather space enabling the end user to perform more accurate analyses and optimization of aviation components. The code shall be fully checked and benchmarked against measured storm and event data with the results presented. A full set of user documentation shall be provided which will enable end users to fully utilize the capabilities of the software. The checkout cases utilized in validating the software during the Phase I and Phase II efforts will be detailed.

PHASE III: Enable Government, major aviation/missile system integrators, and subsystem component developers to produce superior aviation and flight systems with sufficient design margin to make advanced systems "all-weather" capable. The completed software package could be marketed as an enabling technology to predict realistic flight environments for suppliers of aviation parts to verify/validate their part's performance. Products that would derive benefit from this technology include but are not limited to: helicopter blades, missile radomes, aircraft antennas, aircraft windows, seals, infrared windows, and anti-reflection and radar absorbing coatings. The resulting weather definitions as integrated into analysis software would provide significant benefit to commercial aviation systems and military planners if the final system was linked to real-time meteorological databases providing up to the minute situational awareness. These benefits could be recognized in subsonic flight environments to support erosion and impact damage assessments on coatings, optical windows, aircraft wing/blade leading edges, as well cockpit canopies/windows.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: It is anticipated that the weather definition capability developed under this program will directly lead to the development of real-time vehicle assessments for flight operations through adverse weather conditions. The commercial applicability of this technology will have directly applicable to missiles, aircraft, rotorcraft, and unmanned aerial systems (UAS). Organizations such as the Federal Aviation Administration (FAA), all elements of the Department of Defense (DoD), and the National Oceanic and Atmospheric Administration (NOAA), would all directly benefit from this technology. The ability to estimate the impact of weather on any flight system, to include both real-time data and weather forecasting, will enable just-in-time estimation of potential flight hazards including the likelihood of wind shear and atmospheric turbulence required by both commercial aviation and UAS vehicles. The product developed under this program will also enable a significant advancement to radar and seeker designs as it can be utilized in order to understand the power requirements to operate in adverse conditions. Currently the power requirements for these systems high, therefore producing a significant cost driver to the overall system designs. By utilizing high-fidelity 3D weather realizations validated by both ground and satellite truth data, the seeker and imaging requirements are expected to be appreciably reduced resulting in significant system cost and weight savings.

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KEYWORDS: Weather definition; meteorology; optimization software; Monte Carlo simulations; particle demise; rain/snow/ice encounters; trajectory shaping; graphical user interface

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N11A-T037 TITLE: Desktop Manufacturing with Micro-robot Swarm

TECHNOLOGY AREAS: Information Systems, Materials/Processes

OBJECTIVE: Develop a swarm of micro-robotic fabrication machines that will enable the manufacture of new materials and components. Address the major technical issues in developing these micro-robotic machines, the platform hardware, and the architecture for their communication and control.

DESCRIPTION: Desktop manufacturing is the ability to use a personal computer to drive a miniature fabrication station for the creation of new objects with complex geometry. The manufacturing platform could be a micro-factory that is capable of building high-value components with small dimensions while consuming fewer resources. Its small-scale motivates new and different approaches to the means of production, not just shrinking the equipment size. This topic focuses on a particular approach of using a coordinated and distributed swarm of micro-robots that are capable of handling and manipulating nano- and micron-scale building blocks in the process of synthesizing novel materials and structures. Each micro-robot would perform a specific task, often a single rudimentary task, repeatedly. Collectively, these tasks would be choreographed in purposeful activities for manufacturing. A micro-robot swarm should be able to perform material synthesis and component assembly, concurrently. The micro-robots could be designed to perform basic operations such as pick and place, dispense liquids, print inks, remove material, join components, etc. These micro-robots should be able to move cooperatively within a workspace to achieve highly efficient synthesis and assembly. This behavior should be programmable, in particular, the micro-robotic behavior should be more adaptive as the ability for real-time in-situ sensing increases. The research focus is on the enabling manufacturing technology; however, as a proof-of-concept demonstration, a component of interest will be produced by this technology that highlights its unique capability. Examples of complex material systems of potential interest include but are not limited to: multi-functional materials, programmable materials, metamorphic materials, extreme materials, heterogeneous materials, synthetic materials, etc.

PHASE I: Develop proof-of-concept for manufacturing with distributed micro-robot swarm. Select any complex material system of interest to Navy/DoD, and, based on it, design and develop hardware for task-specific micro-robots and overall desktop manufacturing platform, and software for communication and control algorithms.

Develop the architecture for a networked real-time embedded system, i.e., cyber-enabled manufacturing, to design, plan and operate this micro-factory for desktop manufacturing.

PHASE II: Build a micro-robot swarm system that is capable parallel processing in the production the selected complex material system. Demonstrate operation of micro-robotic swarm system in the manufacture of prototype complex material system of interest. Ensure accuracy in material placement, consistency in product quality, and reliability in production.

PHASE III: Transition the micro-robot swarm desktop manufacturing technology to critical military use and the civilian sector. Build marketable manufacturing units and demonstrate the fabrication of test-beds.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: A successful swarm micro-robot desktop manufacturing system would be useful for a variety of commercial applications. Such a manufacturing platform can be used to create super-strong components, ultra-lightweight materials, composite and hierarchical structures, complex part geometries, and/or multi-functional components.

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KEYWORDS: Micro-robot Swarm, Desktop Manufacturing, Control Algorithms

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N11A-T038 TITLE: Scenario Based Tactical Radio Channel Simulator

TECHNOLOGY AREAS: Information Systems, Sensors

ACQUISITION PROGRAM: JPEO JTRS ACAT 1D

OBJECTIVE: Research and develop a RF channel simulation framework to test the next generation of mobile multi-protocol wideband tactical systems. The framework would allow for the generation of a model based scenario via a script based interface or via a GUI that allows the user to model the effects of mixed mobile and fixed multi-link radio network using this real-time channel simulator. The simulator should provide a visualization framework to view a subset of the time varying RF characteristics of interest (i.e. real-time coverage, link connectivity). The simulator should also support interface with live radios so that they can operate in-the-loop with the channel simulation.

DESCRIPTION: The Joint Tactical Radio System Program (JTRS) produces a family of multi-functional Software Defined Ratio (SDR) communications systems operating within the 2MHz to 2GHz range that provides the next generation of voice, video and data for Joint and Coalition Warfighter. A core design requirement of this family of radios is the capability to be integrated with existing military and civilian radios. By design, one JTRS radio can support multiple protocols such as UHF SATCOM, EPLRS, SINCGARS, LINK-16, HF SSB/ALE, V/U LOS, WNW, SRW, MUOS, etc. This scope presents a challenge to the development, test and deployment communities with respect to needing multiple channel emulation and channel simulation software solutions that covers (a broad spectrum and in some cases a large operational bandwidths (i.e 225-400 MHz) that emulate/simulate a multitude of environmental effects.

In order to measure the effectiveness of JTRS radio protocols, antennas or network layouts a real time channel simulator is necessary to characterize the effectiveness of these radios in the face of environmental impairments (i.e vegetation, terrain, seasonal conditions, atmospheric) in various environments (i.e urban, forest, open ocean, desserts). Factors that are of interest are, standard fading profiles, inter-symbol interference models characterized for the RF modulation techniques being used; the mobility impacts of hills, valleys, foliage, and vehicle speed; the altitude and speed of aircraft; antenna blockages due to host platform characteristics; and the presence of intentional and unintentional interference. When the final product is complete, the capability would allow lab users to specify propagation models, antenna/platform environmental effects, and have the simulator output a script-based scenario. The user could than use this script with a channel emulator to test dozens or hundreds of radios (this capability should be scalable to promote affordability) so that the effects of a mixed mobile, airborne, and fixed multi-link radio network could be emulated and measured in a lab environment. An added benefit is that this system could be used for network deployment analysis to rule out topologies based on environmental conditions.

PHASE I: Determine the feasibility of and develop a conceptual design for a modular RF simulation, prediction and visualization tool with the aforementioned environmental influences, which when connected to live radios can apply realistic channel effects to their communications.

PHASE II: Develop detailed designs for the Phase I modular RF channel simulator and develop a suitable proof of concept framework for use in a laboratory environment with live radios. Conduct preliminary testing demonstrating channel characterization capability for the 2 MHz to 2GHz range with the implemented channel modeling capabilities identified in Phase 1.

PHASE III: Transition the product into a supportable commercial product to be used in characterizing commercial cellular systems and government tactical systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The RF impairment simulator proposed within this SBIR is far reaching and can be used to test commercial cellular applications like GSM/GPR/EDGE, PCS, WCDMA, CDMA, 3GPP LTE, WiMAX.

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KEYWORDS: Radio Frequency; Real-time; Programmable; Multipath; Doppler

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N11A-T039 TITLE: New Process for Space Qualified Electronic Components

TECHNOLOGY AREAS: Electronics, Space Platforms

ACQUISITION PROGRAM: Mobile User Objective System (MUOS), ACAT I

OBJECTIVE: Develop a new design or manufacturing process to quickly produce electronic components that are reliable in the space environment.

DESCRIPTION: Space is a harsh environment. Spacecraft are subjected to high levels of radiation depending on the orbit. Spacecraft undergo extreme thermal cycles as they move in and out of direct sunlight. Temperatures range from -171C to 108C at geosynchronous orbit.

The electronics on spacecraft must be able to withstand the space environment to assure mission success. However, the aerospace industry orders relatively low quantities of "space qualified" electrical components, often at irregular intervals. This makes it a difficult business case for companies to keep a manufacturing line open just for space components. This leads space programs to rely on a very small number of suppliers, sometimes even a single source, which is highly undesirable.

New electronic component designs or manufacturing processes are needed to address this problem. If manufacturers could quickly and easily transition from producing mainstream items to space qualified components, competition would increase. Increased competition will reduce space program costs and improve availability and reliability of components.

Although desirable, a single process for multiple types of components is unlikely. Therefore, this topic will focus on resistors, specifically the RNC-70 class of resistors described by MIL-PRF-55182/6P. The resistors must be able to withstand greater than 8,000 thermal cycles as described above and continue to meet the standard.

PHASE I: Develop a new design or manufacturing process to quickly produce resistors that are reliable in the space environment.

Tasks under this phase could include:
• Apply new materials breakthroughs
• Develop a new design or manufacturing process for space qualified resistors
• Develop a process model
• Predict process yield and estimate the cost to implement it

PHASE II: Implement the new design or process and demonstrate its performance against expectations.
• Implement a new material
• Implement the new design or process
• Evaluate measured performance characteristics versus expectations and make design/process adjustments as necessary.

PHASE III: This phase will focus on manufacturing components required for Navy satellite systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: This technology can be applied to any space system, including space exploration, and commercial communications and imaging satellites.

REFERENCES:
1. MIL-PRF-55182/6P, http://assist.daps.dla.mil/quicksearch

KEYWORDS: Space-hardened resistors; space qualified resistors; pre-qualified space electronic parts

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