NAVY
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 N10-T001 through N10-T011, please contact the NAVAIR STTR Program Manager, Mrs. June Chan (june.chan@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 **23 February 2010**. Beginning **23 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 $70,000 and with the option not exceeding $30,000. The technical period of performance for the Phase I base should be 7 months and will commence on or about 01 July 2010. The Phase I option should be 3 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. ET, Wednesday, 24 March 2010**. 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 ELECTRONIC SUMMARY REPORT:

In addition to the final report required in the funding agreement, all awardees must electronically submit a non-proprietary summary of that report through the Navy SBIR/STTR Web site. It must not exceed 700 words and should include potential applications and benefits. 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". This summary will be publicly accessible via the Navy's Search Database.

PHASE II PROPOSAL SUBMISSION:

Phase II proposal submission is by invitation only. 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.

Under the new OSD (AT&L) directed Commercialization Pilot Program (CPP), the Navy SBIR/STTR program will be structuring more of our Phase II contracts in a way that allows for increased funding levels based on the projects transition potential. This will be done 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 currently existing phase II contracts, the goals of the CPP will primarily be attained through contract expansions, some of which may significantly exceed the $750,000 recommended limits for Phase II awards not identified as a CPP project. All projects in the CPP will include notice of such status in their Phase II contract modifications.

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.

PHASE II ENHANCEMENT:

The Navy has adopted a New Phase II Enhancement Plan to encourage transition of Navy STTR funded technology to the Fleet. Since the Law (PL 102-564) permits Phase III awards during Phase II work, the Navy may provide a one-to-four match of Phase II to Phase III funds that the company obtains from an acquisition program. Up to $250,000 in additional STTR funds for $1,000,000 match of acquisition program funding can be provided, as long as the Phase III is awarded and funded during the 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. The Navy will allow firms to include with their proposals, success stories that have been submitted through the Navy SBIR Web site at **http://www.onr.navy.mil/sbir**. A Navy success story is any follow-on funding that a firm has received based on technology developed from a Navy SBIR or STTR Phase II award. The success stories should be included as appendices to the proposal. These pages **will not** be counted towards the 25-page limit. The success story information will be used as part of the evaluation of the third criteria, Commercial Potential (listed in Section 4.2 of this solicitation) which includes the Company's Commercialization Report and the strategy described to commercialize the technology discussed in the proposal. The Navy is very interested in companies that transition SBIR/STTR efforts directly into Navy and DoD programs and/or weapon systems. If a firm has never received a Navy SBIR/STTR Phase II it will not count against them.

3. Any contractor proposing research that requires human, animal and recombinant DNA use is advised to view requirements at Web site **http://www.onr.navy.mil/sci_tech/ahd_usage.asp**. This Web site provides guidance and notes approvals that may be required before contract work may begin.

PHASE I PROPOSAL SUBMISSION CHECKLIST:

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

____1. Make sure you have added a header with company name, proposal number and topic number to each page of your technical proposal.

____2. Your complete STTR Phase I proposal (coversheet, technical proposal, cost proposal, Agreement between the Small Business and Research Institution, and DoD Company Commercialization Report) has been submitted electronically through the DoD submission site by 6:00 a.m. ET, Wednesday, 24 MARCH 2009. Note: If the above referenced agreement is not included within 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.

____3. After uploading your file and it is saved on the DoD submission site as a PDF file, review it to ensure that it appears correctly.

____4. The Phase I proposed cost for the base effort does not exceed $70,000. The Phase I Option proposed cost does not exceed $30,000. 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.

NAVY STTR 10.A Topic Index

NAVY STTR 10.A Topic Descriptions

N10A-T001 TITLE: Advanced Materials for the Design of Lightweight JP5/JP8/DS2 Fueled Engines for Unmanned Aerial Vehicles (UAVs)

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Develop a lightweight, efficient, and durable engine design capable of operating on JP5/JP8/DS2 fuels for use in unmanned aerial vehicles with a focus on advanced high strength to weight materials.

DESCRIPTION: Current Otto and Diesel cycle heavy fuel engines designed for UAVs are constructed of conventional materials (cast iron, aluminum, etc) that limit the power to weight ratio and/or durability. Innovative approaches to engine materials and designs are sought to enable UAV operation on low flash point fuels available in operational theater (JP5, JP8, DF2). Proposed approaches should focus on a significant increase in the power to weight ratio and durability through the development and use of high strength to weight advanced materials for key engine components, and shall meet the following goals:

- Power to weight ratio significantly higher than 1 hp/lb
- Minimum service life of not less than 600 operating hours
- Brake specific fuel consumption not to exceed 0.5 lb/hp-hr at all power outputs
- Capable of operating on JP5, JP8 or DS2 fuels
- Capable of operating at altitudes from sea level to 30K ft
- Capable of starting at temperatures of 0F and above
- Capable of operating at temperatures from -50F to 130F
- Modular or scalable to cover an output range from 2 to 150 shaft horsepower

PHASE I: Produce an engine design concept with analysis and proof of concept of advanced material construction.

PHASE II: Develop detail design(s) and running engine prototype. Demonstrate operation of the prototype engine in a laboratory environment or in flight.

PHASE III: Finalize system integration with major DOD end users and engine manufacturers and conduct necessary qualification testing.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Successful development of this technology could be used for enabling lightweight power generators, fire pumps, outboard motors, and portable air conditioning units to run on JP and Diesel fuels.

REFERENCES:

1. "Heavy Fuel Engine Technology Assessment", Interim Report TFLRF No, 331, Cynthia F Palacios, US Army TARDEC Fuels & Lubricants Research Facility, Edwin C. Owens, Southwest Research Institute, Charles D. Woods, CDW Engineering, DARPA Contract # DAAK70-92-C-0059, February 1998.

2. "UNMANNED AERIAL VEHICLE HEAVY FUEL ENGINE TEST FINAL REPORT", Joseph Lawton, Anthony Maggio, Robert Brucato, NAVAIRWARCENACDIVTRN- PE- 261 OCTOBER 1993.

Note: This document has been uploaded and is available in SITIS.

KEYWORDS: UAV; Small Engine; Heavy Fuel; Advance Materials; Power to Weight; Lightweight

N10A-T002 TITLE: Development of a Computational Method for Prediction of After-Burning Effect

TECHNOLOGY AREAS: Chemical/Bio Defense, Information Systems, Space Platforms, Weapons

OBJECTIVE: Develop a fully functional computational method for prediction of the after-burning effect of different fuels in a wide range of temperature, pressure, and turbulence regimes.

DESCRIPTION: After-burning munitions contain fuel that continues to burn following the initial detonation and provide additional energy to raise the temperature, raise the overpressure, and strengthen secondary shock waves. This "after- burning effect" can be especially pronounced in enclosed areas. In order to release energy, the after-burning fuel must convert to a combustible form (often achieved by phase change), mix with the available oxidizer, and then react. Therefore, in the design and development of after-burning explosives it is essential to connect the microstructural details of the explosive to the resulting spatio-temporal details of its macroscale dispersion of after-burning fuel, its turbulent mixing, and its volumetric energy release. While there are some computational tools that have validated models for specific fuels (e.g. aluminum) at specific conditions, there are no validated computational tools that can be used for multiple fuels (e.g. aluminum, magnesium, JP10) to predict the after-burning effect. In order to perform truly predictive simulations whose results can be trusted, it is essential to understand and accurately model the following microscale physics and incorporate them in mesoscale computational tools: (a) Mechanical and chemical response of the after-burning additives to condensed-phase detonation; (b) the complex mass, momentum and energy coupling between the rapidly expanding product of initial detonation and the particulates in the near-field of the detonation; (c) Role of compressible flow structures on the explosive dispersal of after-burning fuel; (d) Instability mechanisms of the gas and particle contacts and turbulent mixing; (e) Ignition, quenching and burn mechanisms (diffusion vs kinetic limited) of after-burn fuel, especially under truly representative conditions of elevated temperature, pressure and cross-flow.

PHASE I: Identify and define the generalized models to properly represent the after-burning effect for both solid and liquid after-burning fuels. Define the framework into which these models will be placed. Demonstrate the applicability of the mass, momentum, energy and burn-rate models to be used in the after-burning process at the temperature, pressure and turbulence levels present after an initial blast. Outline the steps needed to validate the models.

PHASE II: Develop, demonstrate and validate the after-burning models and incorporate them into a computational structure (CFD/Hydrocode). Validate the models against experimental data for multiple fuels.

PHASE III: Transition the developed method for use by weapons designers. Participate in the development and distribution of any new analytical or experimental processes that result from this research.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: This technology, if proven successful has direct application to commercial explosive applications. These types of explosives work well in enclosed spaces so mining would be possible. Also, understanding of particle laden deflagration to detonation could be used for safer construction of grain silos and mine shafts. Understanding of aluminum particle combustion at high turbulence levels could be used in underwater propulsion and propulsion in CO2 atmosphere (Mars).

REFERENCES:
1. V. Tanguay, A.J. Higgins, and F. Zhang, "A Simple Analytical Model for Reactive Particle Ignition in Explosives." Propellants, Explosives, Pyrotechnics, Vol. 32. (2007), pp. 371-383.

2. F. Zhang, S.B. Murray, and K.B. Gerrard, "Aluminum particles-air detonation at elevated pressures." Shock Waves, Vol. 15 (2006), pp. 313-324.

3. Q. M Liu, X.D. Li, C.H. Bai, "Deflagration to detonation transition in aluminum dust-air mixture under weak ignition condition." Combustion and Flame, Vol. 156 (2009), pp. 914-921.

4. T.A. Khmel' and A.V. Fedorov, "Interaction of a shock wave with a cloud of aluminum particles in a channel." Combustion Explosion and Shock Waves, Vol. 38 (2002), pp. 206-214.

KEYWORDS: After-Burn Effect; Enhanced-Blast Explosive; Thermobarics; Modeling and Simulation; Reaction Modeling; Turbulence

N10A-T003 TITLE: Characterizing the Impact of Control Surfaces Free-Play on Flutter

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop an efficient and accurate method of characterizing free-play in a control surface to assess its impact on flutter

DESCRIPTION: Free-play is the range of rotation about which a control surface freely moves without developing any resistance. All Navy aircraft are impacted by this free-play and yet each platform addresses only a small portion of the design space that is unique to its design. As joints wear in service, free-play increases and may exceed the maximum limit set during certification. If the free-play should increase past these set limits, the assets must be repaired, replaced, or new limits must be imposed on the aircraft mission capability. Free-play inspection schedules are required to periodically check compliance with the set free-play limit. Frequency of these inspections is increased as the limit is approached, adding to inspection costs.

No efforts have been made to gain a broad understanding of the impact of free-play on flutter. There is currently a very limited amount of test data available in the public domain. The current military specification limit for free-play is based on wind tunnel tests carried out in 1950-1960 at Wright Air Development Center (WADC). A review of this effort revealed that the tests performed covered all movable un-swept tails at subsonic speeds. The effort clearly did not cover the transonic and super sonic speeds at which the today's fighter/attack aircrafts fly. With the exception of a few researchers working in low speed wind tunnels, there has been no systematic study done to characterize the impact of free-play since the 1950s. In addition, a poor understanding of the influence of free-play on wind tunnel tests often leave the conclusions of these tests overly conservative.

It is practically impossible to design and manufacture a control surface with zero free-play. However, if a surface is designed well, the free-play could be small enough that it would not have any significant impact on operations. Military Specification MIL-A-8870 imposes limits on free-play for all control surfaces to preclude instabilities – flutter, limit cycle oscillation and buzz. The smallest of these limits is on the horizontal tail at 0.034 degrees on fixed wing aircraft. The UK defense standard, DEF-STAN, imposes a limit of 0.052 degrees on the horizontal tail. Many legacy aircraft have routinely exceeded these limits, some in blue print condition and almost all of them due to wear during service. This requires a designer to expand the free-play allowable by test and analysis.

Efficient and accurate methodologies and tools for the characterization of free-play in control surfaces are sought to enable the optimal design of control surfaces with no dynamic instabilities for new platforms, and the expansion of free-play limits with minimum additional flight tests for platforms already in-service.

PHASE I: Develop concepts for an efficient and accurate method of characterizing free-play in a control surface to assess its impact on flutter. Demonstrate the feasibility of the method by applying it to the all-movable un-swept horizontal tail used by WADC in the 1950s tests and comparing the results to the WADC data.

PHASE II: Further develop the method and demonstrate by applying it to control surfaces with variations in free-play, aspect ratio, hinge line location (chord), hinge line sweep angle, hinge line dihedral angle, air speed, and loop stiffness. Use current designs of military and commercial aircraft to determine the range of values used for each of the above parameters. Validate the method by carrying out wind tunnel tests. Use the method to develop a design space that is free of dynamic instabilities.

PHASE III: Optimize the method developed in phase II. Apply it to the specific control surface design including the specific actuator used in the aircraft supported by the sponsoring platform.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Free-play affects commercial aircraft as well. Advances made on military aircraft help the commercial aircraft industry to improve their maintenance, readiness, and life cycle costs on existing platforms and help designers in selecting parameters for future designs, such as for advanced supersonic transport.

REFERENCES:
1. Niles Hoffman and Irvin Spielberg, "Subsonic Flutter Tests of an Unswept All-Movable Horizontal Tail," WADC Technical Report 54-53, Wright Air Development Center, March 1954.

2. Dale Cooley and John Murphy, "Subsonic Flutter Model Test of a Low Aspect Ratio Unswept All-Movable Tail," WADC Technical Report 58-31, Wright Air Development Center, February 1958.

3. D. Tang et. Al, Duke University, “Nonlinear Response of Airfoil Section with Control Surface Freeplay to Gust Loads,” AIAA Journal, Vol. 38, No. 9, 2000.

4. T. O’Neal and T. Strganac, Texas A&M, “Aeroelastic Response of a Rigid Wing Supported by Nonlinear Springs,” J. of Aircraft, Vol. 35, No. 4, July-Aug 1998.

5. Carlton Schlomach, Lockheed Martin, “All Moveable Control Surface Free Play”, Aerospace Flutter and Dynamics Council, Spring 2009, NASA Langley Research Center, Hampton, VA.

6. Walter A. Silva, et. Al, NASA Langley Research Center, IFASD-US-39, “Identification of Computational and Experimental Reduced-Order Models,” International Forum on Aeroelasticity and Structural Dynamics, June 2003, Amsterdam, Netherlands.

KEYWORDS: Flutter; Aeroelasticity; Dynamic Instability; Divergence; Free-play; Control Surfaces

N10A-T004 TITLE: <u>Ambient Noise Interferometry for Passive Characterization of Dynamic Environments</u>

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop an innovative concept to demonstrate the feasibility of passive remote sensing of dynamic environments and determine which environmental parameters and types of targets can be effectively monitored through ambient noise interferometry.

DESCRIPTION: Daylight, as well as man-made lighting used in houses and in computer screens, is technically a diffuse electromagnetic field, that is, a combination of non-coherent waves propagating in various directions. Our eyes deal with diffuse radiation very efficiently. In everyday life, humans receive more than 90% of all the information that reaches the brain from processing diffuse electromagnetic wave fields. This is achieved through retrieving shapes, positions, optical densities, etc. of objects from their blocking, reflecting or refracting the background ambient light.

One can argue that the recent mid-ocean collision of British and French nuclear-powered submarines demonstrated rather convincingly that the passive acoustic detection techniques currently utilized by the submarines are woefully inadequate. We have identified a new approach, namely, correlation processing of diffuse noise fields recorded by spatially-separated receivers, which allows one to greatly increase the amount of information about a dynamic environment and a target (scatterer) which is retrieved from passive measurements.

Coherent processing of diffuse noise fields is no longer a controversial approach. Its validity and huge potential have been recently demonstrated by dramatic advances achieved in seismic and helioseismic passive tomography [1–3]. Another example is the precise localization and characterization of the Kursk submarine disaster, where more accurate results were obtained from the coda than from the ballistic waves [4]. Publications in the open literature reveal ongoing research work in Europe on passive detection, localization, and characterization of targets (scatterers) by cross-correlation of ambient noise.

Godin [5, 6] demonstrated theoretically that two-point cross-correlation function of ambient noise in an inhomogeneous moving fluid contains as much information about the environment, including the flow velocity field, as can be obtained with acoustic transceivers located in the two points. Obvious advantages of passive system include low cost (a receiver substitutes a technologically much more complicated transceiver), possibility of noninvasive measurements (in particular, avoiding any harm to marine life potentially associated with powerful underwater sound sources), and clandestine monitoring in denied areas. Less obvious advantages include exploitation of extremely broad bandwidth of ambient noise which exceeds by far the bandwidth of available non-explosive man-made sound sources used in remote sensing; much longer term of autonomous operation due to drastic reduction of power consumption; and increased spatial resolution of measurements due to greater number of paths along which the environment is probed, as compared to an active system with the same number of sensors.

PHASE I: Experimentally demonstrate feasibility of passive interferometric measurements of environmental parameters, including fluid velocity, through acoustic measurements in the atmosphere with traffic noise as "acoustic daylight". Determine optimal frequency bands, noise averaging times, and receiver separations for achieving desired accuracy and time resolution of passive acoustic measurements of environmental parameters. Characterize targets (scatterers), which can be reliably detected through interferometry of ambient noise and/or sources of opportunity in air. Consider the utilization of these interferometric techniques in the detection of very weak acoustic and/or hydrodynamic disturbances in an ocean environment.

PHASE II: Evaluate feasibility of passive acoustic and hydrodynamic characterization of underwater environment with discrete sensors. Characterize underwater targets (scatterers), which can be reliably detected through interferometry of ambient noise and/or sound sources of opportunity. Demonstrate feasibility of measurements of cross-correlation of electromagnetic ambient noise in the microwave band. Determine parameters of the ocean surface that can be reliably measured through cross-correlation of either thermal microwave radiation or longer electromagnetic waves.

PHASE III: Undertake engineering development to transition the technology to an existing Navy sensor system though collaboration with sensor and vehicle prime contractors.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The general techniques being explored under this STTR are applicable to the detection of a wide range of physical phenomena. Specific applications may include marine mammal detection, medical diagnostics and impurity or pollutant detection.

REFERENCES:
1. Rickett J. E. and Claerbout J. F.; "Calculation of the Sun's impulse response by multi-dimensional spectral factorization"; Solar Physics 192, 203-210 (2000)

2. Shapiro N. M., Campillo M., Stehly L., and Ritzwoller M.; "High resolution surface wave tomography from ambient seismic noise"; Science 307, 1615-1618 (2005)

3. Weaver R. L.; "Information from seismic noise"; Science 307, 1568-1569 (2005)

4. Sèbe O., Bard P.-Y., and Guilbert J.; "Single station estimation of seismic source time function from coda waves: The Kursk Disaster"; Geophys. Res. Lett., 32, L14308 (2005)

5. Godin O. A.; "Recovering the Acoustic Green's Function from Ambient Noise Cross-correlation in an Inhomogeneous Moving Medium"; Phys. Rev. Lett., 97, 054301, (2006)

6. Godin O. A.; "Retrieval of Green's functions of elastic waves from thermal fluctuations of fluid-solid systems"; J. Acoust. Soc. Am., 125, 1960-1970 (2009)

KEYWORDS: acoustic detection; hydrodynamic detection; passive interferometry; dynamic noise environments; coherent processing; cross correlation

N10A-T005 TITLE: Surface Reaction Modeling for C-SiC-SiO2-Rubber Composite Materials Exposed to High Temperature, High Pressure, Oxidizing Environments

TECHNOLOGY AREAS: Materials/Processes, Space Platforms, Weapons

OBJECTIVE: Develop and validate a highly detailed chemical kinetics reference model for the surface reactions associated with C-SiC-SiO2-Rubber composite materials exposed to high temperature, high pressure, oxidizing environments.

DESCRIPTION: Many materials falling into the C-SiC-SiO2-Rubber composite family of materials are commonly used on Navy weapons systems, where they are required to come into contact with high temperature, high pressure, oxidizing environments. Accurately modeling the behavior and response of these composite materials to the harsh environment is essential for developing an optimized weapon system with maximum performance.

Tools and methodologies currently used to analyze these C-SiC-SiO2-Rubber composite materials are not well suited to modeling this family of materials, and cannot accurately predict the response of these materials when exposed to high temperature, high pressure, oxidizing environments. Due to their high silicon content, these materials typically have multiple active species taking part in the surface chemistry reactions. However, the methodologies in existing analysis tools are limited to modeling the equilibrium chemistry of a single active surface species. Some tools are restricted to a single active surface species for a given state, but allow different species to be active at different states, while other tools require that the same, single species be active at all states. In either case, it is not possible to accurately model the complex chemistry that occurs with C-SiC-SiO2-Rubber composite materials.

The purpose of this STTR is to develop and validate new chemistry models that will make it possible to accurately model the complex reactions and phenomena that occur when C-SiC-SiO2-Rubber composite materials are exposed to high temperature, high pressure, oxidizing environments. The goal will be to create a highly detailed chemical kinetics reference model, as well as simplified equilibrium and reduced-order chemical kinetics models that could be easily incorporated into existing analysis codes. These models should address oxidation, melt, sublimation, and pyrolysis phenomena, and should be valid over the following parameter space: pressure: 0.1 – 350 atm; temperature: 500 – 5000 K; heat flux: 0 – 3000 W/cm2; shear: 0 - 1 psi. The regions of the parameter space where the simplified equilibrium chemistry and reduced-order chemical kinetics models can accurately replicate the behavior of the detailed reference model should be identified. Experimental data will be generated that will allow an exhaustive validation of the models developed. Methodologies will be evaluated upon the following criteria: innovation, generality, and robustness.

PHASE I: Identify suitable approach for developing the highly detailed reference chemical kinetics model. Develop and demonstrate the proposed modeling methodologies. Identify suitable approaches for obtaining appropriate experimental data that can be used to validate the reference model.

PHASE II: Based on the results of Phase I, develop, demonstrate, and validate a highly detailed reference model for the chemical kinetics associated with C-SiC-SiO2-Rubber composite surfaces (C, SiC, and SiO2 particles suspended in a generic rubber or polymer matrix), as well as appropriate simplified chemistry models. Obtain or generate experimental data for model validation. Fully document model development, reference and simplified surface reaction models, and validation data.

PHASE III: Integrate the developed chemistry models into a capability that can be used to support the development, acquisition, and integration of Navy rocket-propelled weapons systems. Demonstrate the new capability across DoD.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The results from this STTR could be used by a number of different industries. Silicon compounds are commonly used in refractory materials (such as furnace linings) that are used in many manufacturing industries. The models developed in this STTR could be used to analyze and develop these refractory materials. These chemistry models would also likely find practical application within the chemistry and chemical engineering industries. The models developed in this STTR could also be used by the construction and civil engineering industries to optimize the fire protective coatings used in buildings, providing increased public safety. Finally, the surface chemistry models would be applicable to insulation materials used in space launch applications and DoD systems.

REFERENCES:

1. Bartlett, E. P.; Kendall, R. M.; Moyer, C. B.; and Rindal, R. A.; "An Analysis of the Coupled Chemically Reacting Boundary Layer and Charring Ablator, Part 1: Summary Report"; NASA CR-1060; June 1968.

2. Milos, F. S.; and Chen, Y. K., "Comprehensive Model for Multicomponent Ablation Thermochemistry", AIAA 97-0141.

3. Williams, S. D.; Curry, D. M.; Pham; V. T.; and Chao, D.; "Analysis of the Shuttle Orbiter Reinforced Carbon-Carbon Oxidation Protection System", NASA Technical Memorandum 104792, June 1994.

4. Rosner, D. E.; and Allendorf, H, D.; "High Temperature Kinetics of the Oxidation and Nitridation of Pyrolytic Silicon Carbide in Dissociated Gases"; The Journal of Physical Chemistry; Vol. 74, No. 9; April 1970; pp. 1829-1839.

5. Gulbransen, E. A.; and Jansson, S. A.; "The High-Temperature Oxidation, Reduction, and Volatilization Reactions of Silicon and Silicon Carbide"; Oxidation of Metals; Vol. 4, No. 3; 1972; pp. 181-201.

KEYWORDS: Silicon; Rubber; Surface; Chemistry; Kinetics; Modeling

N10A-T006 TITLE: Innovative Approaches to Resource Virtualization over Ad-Hoc Wireless Networks

TECHNOLOGY AREAS: Air Platform, Information Systems

OBJECTIVE: Develop techniques, algorithms, protocols and architectures to enable resource virtualization across varied tactical platforms utilizing distributed ad-hoc wireless network systems. Proposed methods of resource virtualization must operate effectively over adaptive, highly-dynamic, lossy ad-hoc networks while maximizing security, scalability, re-usability and upgradability of distributed software applications.

DESCRIPTION: Current generation platforms employ monolithic, stove-piped software and data architectures. Effectiveness of these platforms is reduced by the lack of scalable, tactical wireless networks to support collaboration between platforms. Each platform attempts to perform its mission isolated from other platforms, unable to leverage resources from other platforms to solve war fighting problems. Innovative techniques, algorithms, protocols and architectures are sought to enable resource virtualization across varied platforms.

Over the last 15 years, resource virtualization concepts have been developed commercially and are heavily used to maximize application performance over the Internet as well as distributed computing applications. It allows applications to use all available processing resources, adapting the use of resources on the fly as necessary to maximize performance. Enabling commercial technologies include distributed computing, distributed network services, and virtualization of both network and computing resources. Supporting commercial concepts include content and context-based data management and behavioral security.

While these commercial technologies have been optimized for stable, fixed and wireless networks, considerable research is needed in order to extend and adapt these concepts to support highly variable, highly dynamic, unstable networks with little or no fixed infrastructure while simultaneously satisfying stringent security and timeliness constraints. Novel approaches are needed to develop protocols and model effects in military operations with highly dynamic constraints and topologies. As the speed of battlefield operations increases, there exists a need to rapidly add, remove, and utilize computing, storage, software application, and connectivity resources across multi-vehicle scenarios involving manned and unmanned aviation, ground, and maritime vehicles as well as human assets. Proposed concepts should place special emphasis on autonomous Unmanned Air Systems (UAS).

Resource virtualization concepts and protocols should be able to:
- Support scaling of collaborative applications from 2 to at least 50 local nodes with no degradation in performance, with further capacity through tiered multiple local node groups through backbone networks;

- Seamlessly scale while specific node-to-node communications bandwidth varies by at least three orders of magnitude (e.g. 10 kbps to 10 Mbps) over just a few seconds;
- Support local collaborative applications with timeliness requirements of a few milliseconds (with allowance for increasing latency with number of hops and distance).

PHASE I: Identify novel approaches and supporting algorithms, protocols, and architectures to effectively abstract resources over unstable networks. Demonstrate the feasibility of the identified resource virtualization approaches through modeling and simulation (M&S) tools which appropriately abstract the information and resource management problem.

PHASE II: Update models and simulations to appropriately represent real-world conditions and constraints based on the frameworks and component technologies proposed in Phase I. Evaluate the realized designs through real-time simulations and/or integration with real-time systems, with a focus on autonomous UAS. Use the results of real-time simulations, field and/or flight test data (in representative conditions) to verify model assumptions and determine effectiveness. At the end of Phase II, the resource virtualization framework should be fully described and its effectiveness supported by the results of the aforementioned experiments.

PHASE III: Transition the architectures and/or technology components into DoD and/or commercial systems. Demonstrate benefits of approach in real-world operations or exercises.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The technology will be compatible with a large class of distributed resource problems in commercial industry. Specifically, this research will benefit emerging commercial research in unstable networks, such as mobile cell phone tower installations. As commercial infrastructure is expanded from fixed tower to mobile, ad-hoc wireless networks, similar techniques will be needed to support virtualization.

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KEYWORDS: Distributed Computing; Distributed Network Services; Resource Virtualization; Service Oriented Architecture; Wireless Ad-Hoc Networking; Scalability

N10A-T007 TITLE: Self-Healing Non-Catalytic Multifunctional Composite Structure

TECHNOLOGY AREAS: Materials/Processes, Weapons

OBJECTIVE: Develop a self-healing non-catalytic multifunctional composite structure, so that when damaged the structure heals itself.

DESCRIPTION: Composite materials are the future structural material for missile systems as well as complex aero structures. These materials provide higher strength and less weight than traditional metal cases. Composite structures are usually made up of fibers such as carbon, glass, or Kevlar and the matrix materials may include epoxies, cyanate esters, polyimides, and bismaleimides. While composite materials are stronger and more lightweight than traditional metals, composite materials are susceptible to damage due to impact from handling accidents. Currently, if a composite structure is damaged it must be pulled out of service for repair. If composite materials are to be truly viable in the Navy, a self-healing composite is key.

As many composite structures may come in contact with flammable materials, proposed composites structure must employ a non-catalytic self-healing solution which could heal the damaged area of the composite structure to 85% of the original strength. Nano-fibers could be used as a delivery or strengthening method for the repair, although alternative non-catalytic methods of self-healing will be considered. Methods of repair may not include applied temperatures of above 160°F, and must be done from the exterior surface of the structure. Repair methods must also not extend past the bounds of the composite structure, due to presence of energetic material. Typical composite structures would include filament wound rocket motor cases, radomes, support structures, small UAVs, and other aero structures.

PHASE I: Conceptualize and design an innovative non-catalytic self-healing multifunctional composite structure. Demonstrate technical feasibility.

PHASE II: Develop, demonstrate, and validate two types of prototypes, filament wound structures and flat panel structures. Show via experiments and prototype fabrication a strength of 85% of the original strength of the structure. Complete component design, fabrication, and laboratory characterization.

PHASE III: Transition the self-healing multifunctional composite structure technology to a naval weapon system.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Self-healing multifunctional composite structure technology will make for better and more durable composite products. The life-span of many structures would increase as well as the durability of these structures. Also, the maintenance of composites would decrease as the structures would be able to heal themselves, allowing for longer periods between inspections. Wind energy, automobiles, and commercial aviation are all increasingly using composites and stand to gain from this technology.

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KEYWORDS: Self-Healing; Composite; Nano-Fiber; Rocket Motor Case; Filament Wound; Damage Repair

N10A-T008 TITLE: Adaptive Learning for Stall Pre-cursor Identification and General Impending Failure Prediction

TECHNOLOGY AREAS: Air Platform, Space Platforms

OBJECTIVE: Develop innovative computational tools for the analysis of performance and usage data to predict aircraft engine stall.

DESCRIPTION: Modern propulsion systems for Naval Aviation, full authority digital engine control [FADEC] systems, and supporting health management systems have the capability to collect and analyze large datasets of engine performance and usage information. This data offers the potential to detect impending failures and component performance degradation in flight and post-flight and flag these for compensation by the engine control system. This could also help to provide more timely maintenance attention which would positively impact operational availability, reliability, and safety. An example of a primary concern is intermittent gas turbine engine compressor stall (due to gradual component wear and fouling in service) that causes mission aborts and results in extensive troubleshooting at the flight line.

Innovative computational tools are needed for the analysis of performance and usage data to predict aircraft engine stall. These tools should allow time for control system software to take preemptive corrective action in order to avoid engine stall events, as well as identify and assess the state of the engine components causing this behavior and estimate the remaining useful life (RUL) of these critical engine components. Machine and adaptive learning techniques, effective searching algorithms of engine large data sets, statistical analysis methods, and adaptive neural networks are some of the tools seen to have promise for attacking this problem.

The proposed computational tools should be able to provide diagnostics and prognostics of aircraft engines, modules, subsystems, and components. The tools should also be able to: conduct failure mode and effects analysis to identify the failure modes and root causes and assess their impact; use machine learning techniques and neural networks to extract rules and knowledge underlying the available engine large data sets; predict impending engine stall events and other types of performance degradation, and estimate remaining useful life of the critical components driving the degrades engine performance; verify the performance and accuracy of the results against the available engine data sets; adaptively learn from newly generated engine data; inform engine maintenance staff and field engineers of imminent problems; interface seamlessly with the current engine FADEC and other hardware systems; and provide engine designers with field-data based feedback to enable them to improve the design of current FADEC systems and future propulsion systems.

PHASE I: Provide a proof of concept of a computational tool which can extract and analyze engine and field data to predict engine stall and identify the engine data indicators which led to that stall prediction.

PHASE II: Develop a fully functional prototype of the computational tools in the form of a software suite that is usable by OEM (original equipment manufacturer) maintenance personnel and design engineers. Demonstrate the accuracy of the tools, the prediction of the stall events, and the prediction of the current health and RUL of engine components. Test all against a FADEC controlled engine.

PHASE III: Commercialize the prototype and produce commercial-strength product. Integrate it with end users and engine manufacturers. Conduct necessary qualification field testing.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Successful development of these computational tools could be used for the prediction and prevention of engine stall and surge of commercial aircraft, greatly increasing engine life and engine time on wing of such aircraft.

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KEYWORDS: Data Mining; Data Fusion; Adaptive Learning; Neural Networks; Engine Stall; Stall Precursor

N10A-T009 TITLE: Dynamic Physical/Data-Driven Models for System-Level Prognostics and Health Management

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

OBJECTIVE: Develop a set of tools that will enable integration of distributed, heterogeneous data and models for system-level prognostics and health management.

DESCRIPTION: The field of prognostics and health management (PHM) has made significant advances in the ability to monitor and predict degradation and failure in structural and mechanical components. Unfortunately, similar advances have not been made with electronic components, especially in avionics. To date, results in electronic prognostics have been limited to small cases involving analog components and modules (e.g., power supplies) and material degradation of electronic components (e.g., delamination in integrated circuits). The computational complexity of existing PHM techniques makes it virtually impossible to apply them from a system-level perspective (e.g., monitoring across multiple avionic systems such as radar, GPS, and communications systems). Due to the rapidly emerging state of electronics-PHM and the desire to enhance existing test maintenance systems, the data modeling and ontology aspects of this field must be addressed. New methodologies and tools for PHM are sought to draw on multiple techniques in state estimation, fault and failure modeling, and prediction. Proposed methods must be capable of analyzing large amounts of data from distributed, heterogeneous sources.

At this stage, it is expected that the proposed e-PHM tools would be applied in an offline environment, utilizing information collected from data sources such as built-in test, automatic test systems (ATS), and other monitoring technologies. To minimize expense of system integration, such tools should focus on existing onboard monitoring systems and be integrated tightly with off-board ATS. The goal is to provide new analysis capabilities, consistent with the Navy's Conditioned Based Maintenance (CBM+) initiatives, with minimal impact on existing systems under test. Recent results in incipient fault detection and gray-scale health assessment, identification of requirements for CBM+, and interface standardization through the IEEE, potentially offer a foundation in developing system-level health-assessment prediction tools and supporting data management and analysis. In terms of interface standardization, the proposed tools should incorporate standards such as IEEE 1232 Artificial Intelligence Exchange and Service Tie to All Test Environments (AI-ESTATE), IEEE 1636 Software Interface for Maintenance Information Collection and Analysis (SIMICA), and IEEE 1671 Automatic Test Markup Language (ATML)), system monitoring (e.g., ISO 133374), and CBM technologies (e.g., Machinery Information Management Open Systems Alliance (MIMOSA) OSA-CBM, ISO 10303-239 PLCS, and Organization for the Advancement of Information Standards (OASIS) PLCS DEX).

PHASE I: Develop a desktop proof-of-concept for a small target system. The proof of concept should include electronic technologies and should incorporate a domain ontology and both physics-based and data-driven models and algorithms. Models should also incorporate system usage information. The proof-of-concept system should address existing and emerging standards in automatic test, system monitoring, and CBM technologies.

PHASE II: Develop a prototype modeling and analysis tool based on the demonstrated Phase I system. Fully implement appropriate standards-based interfaces. Evaluate the tool using real test articles and data. Implement a process for model maturation based on historical data. Continue to refine modeling methodologies and supporting algorithms, including development for real-time monitoring.

PHASE III: Refine and deliver algorithms and tool for system-level PHM, suitable for use in a maintenance shop. Transition the technology to various defense platforms.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Industries involved in large-scale, system level maintenance, such as the automotive, shipping, space, and aviation industries may benefit from the successful development of electronics PHM methodologies.

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KEYWORDS: Physics of Failure; Dynamic Graphical Models; Prognostics and Health Management; Standards; Automatic Test Systems; Avionics

N10A-T010 TITLE: Analysis and Modeling of Foreign Object Damage (FOD) in Ceramic Matrix Composites (CMCs)

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Weapons

OBJECTIVE: Develop and demonstrate a physics-based model for Foreign Object Damage (FOD) in continuous ceramic fiber-reinforced Ceramic Matrix Composites (CMCs).

DESCRIPTION: CMCs are currently being considered and used for aeroengine applications with a goal of increased specific power. Concerns exist regarding the degradation of CMCs due to life limiting phenomena associated with thermal, chemical, and environmental effects of those materials. Of particular concern is FOD by small objects such as sands, metallic or thermal barrier coating (TBC) particles loosened from components, and/or other objects ingested into engines. Since CMCs are brittle in nature and some sections of CMC components, such as airfoils, are in a thin configuration (around or less than 1/8") [1], the impact generates a varying degree of damage from localized surface damage to complete penetration, depending on the severity of impact events [2,3]. FOD in CMC airfoils can result in a premature component life and a loss of related functions. There are some on-going science and technology activities to assess FOD behavior [2,3] and to enhance FOD resistance of CMCs. However to date, no appropriate physics-based model exists to describe complex FOD phenomena of CMCs attributed to the complex nature of impact dynamics coupled with the materials' architectural/constituent complications. As a consequence, an emerging need exists to develop appropriate FOD model(s) so that FOD-resistant CMC materials can be better designed/tailored to enhance their affordability and durability and that overall component life can be better ensured. In general consideration, but not limited, target materials are gas-turbine grade, ceramic fiber-reinforced CMCs with various architectures, projectiles are metallic or ceramic with typical sizes of around 1/16" (1.6 mm) -1/8" (3.2mm), and impact velocity ranges from Mach 0.2 to 2.0.

PHASE I: Design and develop an initial concept model and demonstrate feasibility for the CMC material systems.

PHASE II: Fully develop and optimize the approach formulated in Phase I. Demonstrate the approach using pertinent data obtained from various materials systems together with different impact variables.

PHASE III: Perform validation and certification testing. Transition the approach to interested platforms and other propulsion applications.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: CMCs propulsion components have a great potential to transition to the civilian aeroengine applications. The resulting material development through appropriate modeling, albeit risky, could allow an eventually significant cost saving while the developed material could outperform the conventional CMC systems. The development will also open a new means of material fabrication and component designs.

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KEYWORDS: Foreign object damage (FOD); ceramic matrix composites (CMCs); impact; ballistic impact; FOD modeling; impact mechanics

N10A-T011 TITLE: Prediction of the Full-Scale Cook-off Response Based on Small-Scale Testing

TECHNOLOGY AREAS: Information Systems, Weapons

OBJECTIVE: Develop an innovative methodology that provides a modeling and simulation capability sufficient to predict the response of full-scale weapons systems to fast cook-off (FCO) and slow cook-off (SCO).

DESCRIPTION: Currently, assessment of ordnance items for Insensitive Munitions (IM) and Hazards Classification (HC) characterization requires full-scale testing. The testing of large diameter ordnance systems, such as a large diameter rocket motor, presents a considerable financial and logistical burden. For these tests, costs may range in excess of $30M for hazards testing. Also, ammunition presents a special problem in that no reliable sub or small-scale cook-off tests have been identified.

Innovative methodologies are sought to predict the response of full-scale weapons systems to FCO and SCO. It is thought that the use of small-scale test data such as thermal decomposition, radiant ignition and cinephotomicroscopy in the laboratory scale and controlled heat flux and cook-off pipe testing at the intermediate scale could be used to predict a full-scale response but there is no reliable understanding of scaling relationships for the phenomena responsible for controlling reaction violence. Key to this capability will be identifying and defining scaling relationships based on first principle chemistry and physics to predict full-scale cook-off which incorporates small to sub-scale testing. These scaling relationships should bridge the response of laboratory-scale tests (gram size) to small-scale experimental tests (1-10 kg size) to predicting a full-scale cook-off response. Proposed methodologies must address the experimental uncertainty and data sparsity which are found in most hazards tests. Resulting material models and advanced knowledge will be integrated and demonstrated in a computational simulation which will provide an efficient and accurate means to assess full scale munitions. If successful, proposed methodologies will enable assessment of advanced materials and technologies directed at improving conformance to IM and HC requirements for both legacy and future weapons systems.

PHASE I: Identify and define scaling relationships based on first principle chemistry and physics to predict full-scale cook-off which incorporates small to sub-scale testing. Identify the major technical factors leading to the response of a complex full-scale system. Show how these factors integrate and couple to provide a specific response. Demonstrate the feasibility of producing a full-scale cook-off prediction and outline the demonstration success criteria.

PHASE II: Develop, demonstrate and validate the scaling relationships described in Phase I. Identify the critical parameters controlling the cook-off hazard and perform the appropriate small-scale experiments, if needed, to support a full-scale prediction. If necessary and available, small to sub-scale cook-off data will be provided. Address computational and experimental error, along with techniques to overcome data sparsity.

PHASE III: Transition the methodology, experimental processes, and analytical tools for prediction of full-scale cook-off hazards for use in both Hazards Classification and Insensitive Munitions.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This technology, if proven successful, has direct application to the Department Of Transportation evaluation of hazardous energetics in the civil sector (all non-military energetics).

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KEYWORDS: Cook-off; Insensitive Munitions; Hazards Classification; Scaling; Reaction Violence; Hazards

N10A-T012 TITLE: High Efficiency Gain Media for Eye-Safer 1.55 µm Ultrafast Fiber Amplifiers

TECHNOLOGY AREAS: Sensors, Weapons

ACQUISITION PROGRAM: PE 0603925N Directed Energy and Electric Weapon Systems. PMS 405

OBJECTIVE: The goals of this program are (1) to develop novel erbium doped glass materials which maximize quantum efficiency (net conversion efficiency of pump power to signal power) for high energy eye-safer ultrafast fiber lasers pumped at 14xx nm, and (2) to demonstrate performance of the material(s) as a high power fiber amplifier in an eye-safer 1.55 µm ultrafast fiber laser system.

DESCRIPTION: The purpose of this topic is to develop a high efficiency erbium glass gain media optical amplifier to scale the average power of eye-safer ultrafast fiber laser sources. The results will enable solutions for applications of interest to the US Navy, including, but not limited to, directed energy weapons, InfraRed CounterMeasures (IRCM), and LAser Detection And Ranging (LADAR).

Fiber lasers offer many advantages for Navy applications: superior beam quality, compact form factor, and minimal optical alignment requirements. Single fiber lasers with average power up to ten kilowatts have been demonstrated, and even higher power levels have been obtained from arrays of such lasers. The key advantages of fiber lasers are direct diode pump configurations as well as beneficial geometry for thermal management.

There are aspects of the erbium fiber gain medium, however, that have limited its performance in chirped pulse amplification (CPA) systems with high energy, high average power, and moderate pulse repetition rate (< 10 kHz). In these scenarios, short fiber length, large mode area, and high gain are essential to generating sufficient power for applications while avoiding deleterious nonlinear optical effects, e.g. self-phase modulation. These same parameters, nonetheless, tend to reduce amplifier efficiency due to incomplete pump light absorption and parasitic losses in the form of amplified spontaneous emission (ASE), cooperative upconversion, excitation migration, and non-radiative gain quenching (excited state absorption). Despite the beneficial thermal management geometry of fiber, these conversion flaws impose large heat loads and power scaling limitations.

Improvements to the erbium glass gain medium may come from: novel dopant formulas to increase absorption and/or to inhibit parasitic losses; host glasses with greater erbium solubility; or advanced fiber fabrication techniques that reduce scattering losses and improve uniformity of both the waveguide index profile and the active ion distribution. With these improvements, it is expected that conversion efficiency of 14xx nm pump photons to ~1550 nm signal photons can be increased by a factor of four or more over the current state-of-the-art erbium fiber amplifiers used in CPA systems. Hence a proportional increase in the laser system power output at a given pump level is likewise expected. The successful result of this program will be demonstration of an eye-safer ultrafast fiber laser system with at least four times the average power of current industry benchmarks.

PHASE I: Conduct research and analysis of novel erbium glass gain media optimized for high efficiency, high energy, and high average power 1.55 µm eye-safer wavelength ultrafast fiber laser systems. The Phase I effort should include Chirped Pulse Amplification (CPA) system modeling and simulation results supporting performance claims. Demonstrate the proposed gain medium efficiency via testing. Develop the concept for integrating the proposed gain medium into an ultrafast laser amplifier implementation in the Phase II effort.

PHASE II: Evaluate the concept developed in Phase I for implementation of the gain medium in an ultrafast fiber laser system final stage high power amplifier pumped at 14xx nm. The amplifier in-band pulse train signal output should be at least 100 W average power with less than 1% comprising spontaneous emission when the pulse repetition rate is 5 kHz or less. Conversion efficiency of pump power to usable, in-band signal power should be 50% or better. Experimental demonstration should include end-to-end CPA system testing with closed-loop computer control of all stages

PHASE III: Develop a rugged, deployable fiber amplifier assembly suitable for deployment in both civilian and military applications. Specific requirements will be based on the specific application.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Ultrafast fiber lasers are a broadly enabling technology with a multitude of applications in the private sector, including manufacturing, medical technology, and life sciences. It is anticipated the fiber amplifiers developed under this program will help ultrafast laser vendors drive down manufacturing costs and enable broader market utilization.

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KEYWORDS: Ultrashort pulse laser; High efficiency amplifier; Erbium doped fiber; Laser gain media; High energy pulses; Compact fiber amplifier; Eye-safer fiber amplifier; Environmentally robust

N10A-T013 TITLE: Advanced Real Time Battery Monitoring and Management System

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

ACQUISITION PROGRAM: PMS399 SOF Undersea Mobility Program (JMMS ACAT IC), PMS-NSW (SWCS ACATIII)

OBJECTIVE: Develop and demonstrate a Lithium-Ion Battery Monitoring and Management System architecture that is capable of providing real-time indication of potential problems developing at the individual cell level, and can respond rapidly enough to prevent that developing problem from leading to cell venting, fire, or any other casualty.

DESCRIPTION: Lithium-Ion systems are more volumetric and gravimetrically efficient than other rechargeable battery systems that can provide cycle life in excess of 200 cycles and 5 years wet life. Unfortunately, energetic failure of a cell normally results in damage to adjacent cells, to battery hardware and to platforms, which can propagate throughout the system. The speed at which some of these conditions leading to cell failure can develop can be faster than the ability of current state-of-the-art battery monitoring systems to detect and respond to correct those conditions. The impact and severity of failure propagation increases with the size of the battery, with a corresponding increase in the likelihood and severity of collateral damage to peripheral assets.

The current state-of-the-art in Battery Monitoring and Management Systems require specific improvements to:
– Improve battery monitoring techniques to increase scan rates and to incorporate real-time diagnostics, predictive techniques, and control capabilities to detect and prevent impending cell failures before they happen,
– Incorporate Event-Driven architecture into battery status messages from the Battery Monitoring System, and
– Add redundancy in monitoring electronics.

This topic seeks innovative design architectures and electronic sensor and control components able to improve the inherent safety of very large scale Li-Ion batteries by being able to detect and respond to developing conditions in individual cells before they lead to cell venting, fire, or other casualties.
Additionally, these components need to be able to monitor the cell conditions and function without themselves adding significant waste heat that can accelerate aging of the battery and exacerbate a developing cellular failure and its hazards.

This solicitation seeks innovative improvements in cell level, module, string and battery monitoring and control technologies that can be incorporated into large-scale Lithium-Ion battery systems, which reduce the probability of a catastrophic cell failure from occuring. The system must provide near real-time monitoring capability of cell conditions. These safety modifications must be able to be made while still maintaining cell-level specific energy in the range of 150 to 200 Wh/kg and cell energy density in the range of 300 to 400 Wh/l. The system should be able to individually monitor multiple cells of sizes ranging from 10 Ah to 500Ah or larger, for a battery with a total capacity of 1.5 MWhs or greater, operating at a system level specific energy in the range of 140 to 160 Wh/kg and system-level energy density in the range of 250 to 350 Wh/l.

Assembly-level and system-level monitoring and control approaches should also be scalable to be able to monitor these high capacity systems when broken into multiple modular units (e.g. 50 to 100 kWh) which are installed inside pressure vessels for underwater use.

PHASE I: Conduct a feasibility demonstration of proposed innovative new battery monitoring and management system design concepts, that provide near-real-time (e.g. 1 second or less as necessary to provide the predictive capability desired) indication of developing conditions that may lead to lithium-ion cell failure, and respond in time to correct those conditions to prevent failure in any cell, in a laboratory environment. Demonstrate by engineering analysis that the materials and design concepts are scalable, and will improve the safety of large scale Li-Ion battery applications in high voltage (300 V) and high capacity systems (in excess of 1 MWh), without sacrificing performance significantly. Analyze these designs based on factors listed above, including reliability, efficiency, weight, heat generation by the monitoring system components, EMI considerations, size, and predicted cycle life, in addition to the inherent safety of the battery monitoring and management system itself.

PHASE II: Implement and verify the design and concepts from Phase I in full-size cells and full-scale multi-cell modules. Develop prototype battery monitoring and management system to safely regulate the cells during charge and discharge evolutions at varying rates, up to 100% charge. Build prototypes, and conduct proof-of-concept testing in a laboratory environment. This testing should include long term cycle testing and safety testing per reference 1 to assess the safety and performance of the new design. Validate efficiency and energy and power density storage of prototype systems. Develop final Engineering Development Models (EDMs) of a system for a single scalable battery module, capable of being tested in a real-world environment (note: real-world testing will be performed during Phase III).

Vendors shall submit a business plan for the commercialization of the technology developed under this topic. The Small Business Administration's web site www.sba.gov provides guidance, examples, and contact information for assistance.

PHASE III: Conduct shipboard testing and suitability analysis of the EDM systems, including shock, vibration, and EMI interference testing. The battery module with the associated monitoring and management system will be tested per references 1) and 2). Validate safety and efficiency of EDM Battery Monitoring and Management System in a true at-sea environment. Develop commercialization, and transition plans for full-scale shipboard implementation. Develop technical and user manuals, end-user training programs, logistics/ repair support plans, and troubleshooting and repair guides. Conduct initial end-user training and operator certification.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The safety of lithium batteries has long been a concern and use of the technology is limited because of the safety features. If this program is successful more platforms and commercial sectors, including the hybrid and electric car industry, airline industry, Unmanned Aerial and Undersea Vehicles, and the space industry could realize the benefits of the technology.

REFERENCES:
1) NAVSEAINST 9310.1b of 13 June 1991

2) Technical Manual for Batteries, Navy Lithium Safety Program and Procedures S9310-AQ-SAF-010 of 19 Aug 2004

KEYWORDS: battery; monitoring; management; control; Lithium; rechargable

N10A-T014 TITLE: Platform Li-Ion Battery Risk Assessment Tool

TECHNOLOGY AREAS: Ground/Sea Vehicles, Electronics

ACQUISITION PROGRAM: PMS399 SOF Undersea Mobility Programs (JMMS ACAT IC); PMS-NSW(SWCS ACATIII)

OBJECTIVE: Develop and demonstrate a Platform Li-Ion Casualty Risk Assessment Tool capable of assessing the probability of a Li-Ion battery cell-level casualty, and in the event a casualty does occur, determines the heat flux, pressures, and hazardous gasses produced, the likelihood of spreading to adjacent cells, and the total potential impact on the platform due to the casualty.

DESCRIPTION: Lithium-Ion systems are more volumetric and gravimetrically efficient than other rechargeable battery systems that can provide cycle life in excess of 200 cycles and 5 years wet life. Unfortunately, energetic failure of a cell normally results in damage to adjacent cells, to battery hardware and to platforms, which can propagate throughout the system. Currently, the Navy does not have quantitative and validated tools to model the heat flux, gasses, pressure pulses, or potential fragments produced during a cell-level casualty, in order to be able to predict the likelihood of that cell-level event propagating to other cells, and then to full modules, and ultimately to full battery strings.

This topic will develop a Platform Li-Ion Casualty Risk Assessment Tool that will be able to analyze any proposed Li-Ion battery design and assess the overall risk to the platform in the event a failure occurs in one cell.

The tool will include models of individual cell chemistry and designs based on laboratory destructive testing, that quantifies the potential likelihood of internal shorts and other failures developing, as well as the heat flux, combustion products, pressure pulses, and any particles released with the venting gasses, in the event such a cell-level failure occurs. Then, using those chemistry-specific models, the tool will assess the proposed battery design, including spacing between cells, cell geometry (e.g. prismatic or cylindrical, etc.), planned methods for removing waste heat, electronics, etc. to assess the potential likelihood the cell level event will propagate to adjacent cells. Finally, once the overall number of potentially affected cells is determined, the tool will assess the total heat flux, pressure, gasses, etc. would be produced in the battery string, and will allow an overall assessment of the potential impact on the platform on a system level.

The tool should include validated models of cells with a cell-level specific energy in the range of 150 to 200 Wh/kg and cell energy density in the range of 300 to 400 Wh/l, broken into multiple modular units (e.g. 50 to 100 kWh) which are installed inside pressure vessels for underwater use.

PHASE I: Conduct a feasibility demonstration of a conceptual risk assessment tool showing how cell-level casualty data may be projected to predict the overall impact on the battery and the platform. Demonstrate a prototype tool that will take one specific type of cell chemistry and battery layout and determine the full potential impact on the battery from a single cell internal short circuit.

PHASE II: Perform laboratory destructive testing of several common Li-Ion chemistry cell designs to measure the heat flux, pressure and gasses produced by that type of cell due to internal short circuits. Build a database into the tool for these different basic cell chemistry and designs. Extend the tools' analysis algorithms to be able to take that data and analyze multiple cell layouts to assess likelihood of cell to cell propagation. Implement and verify the design analysis algorithms to multi-cell modules. Validate predictions made by the tool against a single full-scale module of one design. (note: additional validation of the tool will continue during Phase III).

Vendors shall submit a business plan for the commercialization of the technology developed under this topic. The Small Business Administration's web site www.sba.gov provides guidance, examples, and contact information for assistance.

PHASE III: Continue validation testing of the Risk Assessment Tool's predictions against full-scale battery modules of different layouts and sizes. Develop commercialization, and transition plans for implementation. Develop technical and user manuals, end-user training programs, and troubleshooting and repair guides. Conduct initial end-user training and operator certification.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: This Risk Assessment tool can be used throughout the Navy (surface, carrier, sub-surface) wherever Li-Ion batteries are planned on being used. The tool can also benefit the UUV and UAV markets, as well as the commercial auto industry and NASA.

REFERENCES:

1) NAVSEAINST 9310.1b of 13 June 1991

2) Technical Manual for Batteries, Navy Lithium Safety Program and Procedures S9310-AQ-SAF-010 of 19 Aug 2004

KEYWORDS: risk;prediction;flux;lithium-ion;battery;propagation

N10A-T015 TITLE: Co-mingled E and B field antennas

TECHNOLOGY AREAS: Sensors, Battlespace

ACQUISITION PROGRAM: SEWIP Block 3; ACAT II

OBJECTIVE: The objective is to determine whether the mutual coupling between antenna elements which complicates antenna matching in array architectures can be weakened substantially by mixing electric and magnetic field antenna elements operating in their near fields.

DESCRIPTION: Two antennas are said to be mutually coupled when, because of their spatial separation, the currents flowing in one induces a field at the second that itself produces currents in that second. If one antenna is doing transmit and the other receive, this mutual coupling damages the RF isolation between these functions, generally degrading the reception. The magnitude of the mutual coupling is a function of the scan angle for an array and also influences the array's effective impedance. Thus if one is using an array to transmit/receive simultaneous signals in several different directions, mutual coupling strongly complicates the antenna matching problems. Very recently there has been work on magnetic field antenna (SQIF) which are believed to be very weakly coupled to one another due to their totally non-resonant character and small circulating currents. The question this topic raises is whether such magnetic field antenna would couple especially weakly to conventional electric (E) field antenna when spaced closer than lamda/2 apart, especially when their antenna patterns are also peaked along orthogonal directions.

PHASE I: In Phase 1, the performer should develop an initial simulation capability of both electric and magnetic field antennas in the near field. Utilize this modeling tool to determine the mutual coupling of a single E field transmitting element to a closely spaced array of B field receive elements and from this determine the isolation achieved. Compare that result to the case where all the elements are E field antennas and the spacing is unaltered. Numerically estimate whether the mutual coupling of the receive elements is dependent on the scan angle.

PHASE II: In Phase 2, the simulation tool should be refined by calibration of the model against experimental realizations of interferometer arrays for R with both single T elements and comingled T arrays. Optimize a design that can achieve over 40 dB of T/R isolation while still being electrically small.

PHASE III: In Phase 3, the finished improved isolation design should be fabricated and tested in a government owned anechoic chamber for use in a simultaneous transmit and receive system, then in a sea trial. Transition into a US government system doing comms in dense signal environments, EW, radar, or SIGINT.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The primary commercial market will probably be small directional antennas for mobile wireless systems, especially those for emergency workers who need the ability to geo-locate an emission source. Magnetic antennas are already established for very low frequency geophysical measurement systems (ore and oil deposit sensing) and for medical diagnostics (e.g. fetal heart). The proposed array sensors may offer better ability to localize the source of the emission of interest.

REFERENCES:
1) Superconducting quantum antenna United States Patent 7369093

2) arxiv.org/pdf/cond-mat/0608562

3) Appl. Phys. 92, 4751 (2002)

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5) http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=667043

KEYWORDS: Magnetic antennas; SQIF; mutual coupling; antenna phased arrays; T/R isolation; near field antenna patterns

N10A-T016 TITLE: External Pipe Sound Pressure Level Sensor

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: VIRGINIA Class Program Office (PMS 450)

OBJECTIVE: Develop a method to use external pipe wall sensors to measure the pipe wall "breathing mode" in order to infer the fluidborne sound pressure level in a pipe.

DESCRIPTION: If the motion (displacement, velocity or acceleration) of the n=0 radial "breathing" mode of a pipe can be measured accurately, and the pipe properties (material, ID, wall thickness) are known, the internal fluid sound pressure level in a pipe can be calculated. The challenge of this task is to develop an innovative technique and innovative sensors to measure the n=0 radial mode, and distinguish the n=0 radial mode from the other structural modes (n=0 axial, n=0 torsional, and n=1,2,3... higher order radial modes) in a noisy piping system at frequencies below 3 kHz. For pipes with a large thickness to diameter ratio (i.e. small diameter, high schedule number pipes), the radial motion of the n=0 mode is very small compared to the wall motion due to the other structural modes propagating in the pipe wall. Piezoelectric accelerometers that are small enough to fit on a small diameter pipe (e.g. 1-1/2-inch diameter), and not mass load it, do not have the sensitivity or low noise floor required to measure the n=0 mode for shipboard piping applications. A new technique with new sensors needs to be conceived and developed to accomplish this measurement. The developed sensor system and technique needs to be robust, applicable to a range of common pipe size sizes from 1-inch up to 16-inches diameter, and usable shipboard. The innovative sensor system should produce a single output (e.g. voltage) which is scalable to fluid sound pressure level.

PHASE I: Base: Develop a concept for an innovative technique and innovative sensors to externally measure the fluidborne sound level in a noisy piping system. The concept needs to be robust, applicable to a range of common pipe size sizes from 1-inch up to 16-inches diameter, and usable shipboard. The innovative sensor system should produce a single output (e.g. voltage) which is scalable to fluid sound pressure level. Use modeling and simulation to estimate the performance of the conceptual sensor system, and understand the characteristics of the sensor system that affect the accuracy of the sound pressure level measurement. Use modeling and simulation to determine if it is technically feasible with this concept to measure externally sound pressure levels as low as 80 dB rms re 1 microPA/Hz in a noisy piping system in (1) a 2.5-inch schedule 160 CRES 304 pipe (t=0.375-inches; id=2.125-inches), as an example of a small diameter, thick-walled pipe and (2) a 6-inch schedule 40 CRES 304 pipe (t=0.280-inches; id=6.065-inches), as an example of a larger diameter, thin-walled pipe. If measurement of 80 dB rms sound pressure level is not achievable, estimate the lowest sound pressure level measurable in these two pipe sizes. Use modeling and simulation to perform an error analysis of the performance of the concept.

PHASE II: Produce a prototype sensor system based on Phase I work. Demonstrate and validate the measurement performance of the prototype on two different sized noisy laboratory piping systems where the fluidborne pressure will be simultaneously measured at the same location with a pipe-wall hydrophone. Demonstrate the technique for making this sound pressure level measurement in the field. Validate models based on experimental results. Use validated models and simulations to produce performance estimates (minimum sound pressure level that can be measured) for common piping sizes and schedules (table to be provided by the government).

PHASE III: The expected transition is for the government to procure qualified, validated sensor systems for use by the Navy. The small business will either produce and sell the sensor systems to the government, or transition the technology to a manufacturer who will produce the sensors for the Navy.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The sensor system developed by this effort could be of interest in the private sector for any application where the fluid sound pressure level is desired with an external measurement. This could be used by pump manufacturers who are trying to make quiet pumps, quiet valves or any other quiet piping components. It might also be useful as a monitoring measurement for pump health.

REFERENCES:
1. "Vibration of Shells" by Arthur Leissa, published by the Acoustical Society of America, 1993. Particularly Chapter 2: Thin Circular Cylindrical Shells

2. "Sound and Structural Vibration" by Frank Fahy, published by Academic Press Limited, 1985.

3. Additional information relevant to STTR Topic N10A-T016 from TPOC, 2 pgs. (Uploaded in SITIS 2/12/2010.

4. Kenney, Debra M., A Short Water-filled Pulse Tube for the Measurement of the Acoustic Properties of Materials at Low Frequencies, NSWCCD-TR-97/029, West Bethesda, Md., 180 pages, September 1997. (Uploaded in SITIS 2/12/2010.)

5. Additional Information from TPOC: Plots of estimated level of n=0 radial mode acceleration for the two example pipe sizes described in the N10A-T016 (Navy) External Pipe Sound Pressure Level Sensor Topic Details. (Uploaded 2/17/2010.)

KEYWORDS: fluidborne; pipe; pressure; sensor; mode; noise

N10A-T017 TITLE: Optical Cooling of RF systems

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: SEWIP Block 3; ACAT II

OBJECTIVE: The objective is to determine whether optical cooling techniques can be used efficiently as a means of removing heat from RF apertures and especially power amplifiers.

DESCRIPTION: In optical cooling, thermal phonons are absorbed along with photons in order to cause the re-emitted photons to have higher energy than those absorbed, the anti-Stokes effect. Recently the efficiency of this process has been improved to the point where many lasers use it to maintain a viable operating temperature. Moreover, starting from room temperature, cooling of a single stage to 150K has been achieved. Moreover, confinement of the light to optical fiber may be feasible if efficient transfer of the relevant phonons from the object to be cooled into the fiber can be arranged. In such a system, the waste photons can in principle be piped substantial distances and expelled wherever the system designer wishes. The absence of cooling fins and fans or liquid coolant would be a substantial advantage in naval topside design.

PHASE I: In Phase 1, the performer should design a scheme for cooling a high power density (e.g. GaN) power amplifier using the anti-Stokes effect using light confined to optical fiber. Initial experimentation should prove a net cooling can be obtained and determine the general principles that apply to optimizing the design.

PHASE II: In Phase 2, experimentation on heat coupling and fiber materials optimization should continue. The desired end product is a clear understanding of the maximum efficiency achievable using the materials tested and of whether the approach will have general utility with these or other identified materials

PHASE III: In Phase 3, a cooling system for a real transmitter system should be designed and proven and productization started. Transition into US government systems doing high power transmitting such as radar is anticipated.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The primary commercial market will probably be broadcast transmitters and other concentrated radiators, plus systems such as laptop computers whose operation is currently limited by our ability to remove the waste heat. If the lasers can be made in compact form, small scale electronics could also benefit.

REFERENCES:

1) Optical Refrigeration: Science and Applications of Laser Cooling of Solids By Richard Epstein, Mansoor Sheik-Bahae, ISBN 978 3 527 40876 4

2) Optics Express, Vol. 17, Iss. 7 — Mar. 30, 2009, pp: 5466–5472

3) http://www.springerlink.com/content/55925141575031l8/

4) Optical Materials Volume 28, Issue 11, August 2006, Pages 1321-1324

KEYWORDS: optical cooling; fiber optics; anti-Stokes; fluorescence; thermal management; power amplifier cooling

N10A-T018 TITLE: Lightweight Layered Protection Systems for Missile Launchers and Canisters

TECHNOLOGY AREAS: Information Systems, Weapons

ACQUISITION PROGRAM: PEO-IWS, Standard Missile 6 (SM-6), ACAT 1

OBJECTIVE: Develop M&S tools to accurately predict and assess the performance of NEW state-of-the-art material systems as protection for high-value missiles deployed in their launchers or canisters.

DESCRIPTION: These material systems will likely be lightweight layered combinations of metals or non-metals and should include “non-traditional” designs, more complex than those currently used for ballistic protection in many weapon applications. M&S tools are needed to assess new layered combinations that have not been considered or evaluated against the more stressing threats that have emerged in recent years. Monolithic materials such as high-strength aluminum, armor grade steel and ceramics have been traditionally used as ballistic protection. The application of composites (layered high-strength materials, ceramics, polymers, etc.), layered low-density metals or ceramics or combinations of these with novel shapes (honeycombs, ribbed or embossed plates, etc.) are all candidates to be evaluated. Mature M&S tools must evolve for these assessments.

The primary focus, then, is to increase the protection against ballistic and fragment impacts and focused detonation hazards (specifically, RPGs) during operational use as well as during transportation in hostile areas. Predictive M&S and underlying damage and ignition response assessment capabilities will be used to:
• Characterize trade-offs in layered materials’ penetration and thermal resistance, optimize multi-layer, multi-material protection system design, and minimize experimental testing required to verify armor performance.
• Evaluate how design trade-offs in material selection, performance, weight and cost influence the sometimes opposing requirements on penetration and thermal protection.
• Quantify the uncertainty related to protection system parameters with respect to avoiding a violent reaction in the missile system’s energetic materials.

Missile systems are deployed in a variety of demanding environments that require not only protection of the missile’s functionality, but also protection against violent reaction of the energetic materials in the missile from mechanical and thermal insult. A layered, system-level approach to protection systems enables enhanced weapon survival across multiple operational and transportation environments. Introducing new protection materials can enhance ballistic protection and alter heat paths improving response to mechanical and thermal insult. A multi-layer, multi-material barrier sequentially interacts with the penetrator or thermal insult, taking advantage of material characteristics and geometry to elicit responses that then yield to the mitigating effectiveness of subsequent layers. Such barriers offer a path to defeat threats and thereby preserve the missile's functionality. This will mitigate overmatching threats to reduce and/or contain any resulting energetic material response and prevent sympathetic detonation of nearby missiles. Recent advances in analytical capabilities allow much broader and cost effective exploration of protection system design alternatives using metals, ceramics, composites, high strength polymers etc., either individually or in multi-layer designs through the application of advanced numerical methods to predict mechanical and thermal response, These advances provide the capability to analytically perform substantial design and optimization work to yield candidate designs that meet the various performance requirements and design constraints prior to committing to expensive prototype manufacturing and testing. The future application of high fidelity M&S tools to assess and predict the response of large rocket motors subjected to various combinations of IM hazard and threat stimuli will reduce (not eliminate) the number of development tests needed to assess and qualify weapon systems. This cost saving has a significant impact on the total life cycle cost burden and overall system affordability.

PHASE I: Conduct analysis of hazardous scenarios and evaluate the performance of existing and new concept protection systems versus emergent threats to establish a baseline level of protection. Identify candidate protection materials that have the potential, either individually or in combination, to meet performance requirements and design constraints. Fully characterize any novel materials that have demonstrated mitigation potential across the threat space. Use M&S tools to evaluate alternative designs relative to risk mitigation payoff versus weight, space, and cost of current technology alternatives. Determine the degree of protection offered by a lightweight layered system against a particular threat, where the degree of protection could range from an undamaged missile system (no penetration beyond protection) to breach of the rocket motor case with a penetration velocity that is below the expected threshold to induce a violent reaction in the energetic materials. Conduct analysis of the thermal (fast and slow heating) implications of protection solutions and perform a trade analysis of impact resistance against thermal characteristics of protection solutions. Select from the material list and optimize material thicknesses and layer stack-ups to yield the best penetration protection consistent with thermal threats and other environmental challenges. Evaluate the uncertainty associated with the protection system parameters with respect to avoiding reaction violence from the energetic materials. Compare the optimized armor performance against the baseline level of protection to evaluate the increased protection relative to cost, weight and other operational requirements.

The evaluation of candidate protection solutions could be initiated with a single component (canister protection or external ballistic transportation barrier) and evolve towards an integrated system solution as components are phased into operational service. Alternatively, multiple components could be assessed and designed simultaneously to optimize overall system performance.

PHASE II: Using the optimized design from Phase 1, build and evaluate both experimentally and numerically a sectional prototype against specific fragment and ballistic threats, particularly those specified by MIL-STD-2105. Evaluate the thermal response characteristics of the selected materials and prototype by building and testing a sectional prototype against specific fire scenarios, providing validation data for fire and thermal response models.

PHASE III: Support implementation of the protection design by the acquisition community.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The lightweight, layered protection approach for missile systems will have widespread applications to military, government, and private sector organizations for protection of fuels, energetic materials, and toxic or contaminating chemicals during operational use, transport or storage.

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2. DEPARTMENT OF DEFENSE TEST METHOD STANDARD, MIL-STD-2105C, "Hazard Assessment Tests For Non-Nuclear Munitions," 14 July 2003.

KEYWORDS: Rocket Propelled Grenade, Kinetic Threats, Lightweight Armor, Ballistic Effects Mitigation, Thermal Effects Mitigation, Insensitive Munitions, Modeling and Simulation

N10A-T019 TITLE: Multi-Modal Knowledge Acquisition from Documents

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop new knowledge acquisition technologies capable of extracting and representing multimodal knowledge derived from documents.

DESCRIPTION: Knowledge bases are at the core of intelligent systems for machine reasoning, planning, and decision support. Acquisition, organization and updating of knowledge bases, as well as representation of knowledge, particularly when obtained from multiple sources and modalities remain challenging tasks [1]. Documents are a vast source of human knowledge, yet, until recently, this source of knowledge has not been available in forms usable by computers. Research efforts in automated knowledge extraction from documents, has progressed to the point where this form of knowledge has been shown, quantitatively, to significantly enhance the performance of existing knowledge bases in problem solving. The study described in [2] is a good example of knowledge extraction from documents, however from text only. In many documents, however, knowledge may be conveyed in non-textual forms, e.g. images, figures, graphs, etc. Introducing a non textual element to a text may help in disambiguating natural language texts or significantly alter the content of the text itself. For example, authors may use images and figures to convey information better, as well as reduce the amount of text needed to convey that information [3]. Thus, presenting a diagram of engine components may be more efficient than having a lengthy textual description of how each of the components aligns spatially with the others in the engine. In these cases, engine components might be labeled with letters, or color coded, to enable easier reference within the text. To better understand these types of documents, knowledge extraction will be required not only from text, but also from non textual elements, like images, in the document. The resulting knowledge will need to be aligned, i.e., references made in knowledge derived from text will need to be mapped to the relevant knowledge derived from non textual components, and vice versa [4]. The aligned knowledge will need to share a common representation, to enable its use in reasoning. Moreover, the aligned knowledge may be complementary, i.e., aligned textual knowledge and non textual knowledge may combine to produce a richer common representation than each of the modalities can create on their own. For example, the document may contain a picture of a car, and its caption might provide information on the make and model. From the image, we might be able to derive additional features that were not explicitly stated in the caption, like the color of the car, or its location. Understanding the caption might also set expectations for non textual feature extraction. The mention of an automobile in the text may be used to cue the image based feature extractors to look for cars in the image. In some cases, cues derived from the caption might enable the system to learn an entirely new type of image feature detector. For example, the caption “White sheep grazing in a grassy field” coupled with some world knowledge on sheep, might allow the system to train an image feature detector to recognize sheep in other images. Proposers should develop multimodal knowledge extraction techniques capable of creating a common representation from multimodal knowledge. They should be able to quantitatively demonstrate that multimodal techniques produce superior representations than single modal approaches. Additionally, proposals should demonstrate that multimodal alignments can create new modal knowledge extraction methods.

PHASE I: Development of a theoretical framework for multimodal knowledge extraction and representation from documents. In this phase, we want to show (on a select set of cases) how textual and non textual features extracted from documents can be combined into a single common representation, and how multimodal knowledge can be used to boost the overall quality of the common representation.

PHASE II: Develop a prototype system capable of multimodal knowledge extraction, and demonstrate the advantage of multimodal knowledge acquisition over single modal acquisition over a defined data set.

PHASE III: Multimodal processing in large-scale online knowledge extraction for the cost effective, automated update of enterprise knowledge bases is important in many Naval/DoD and industry applications.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Multimodal processing in large-scale online knowledge extraction for the cost effective, automated update of enterprise knowledge bases is important in many Naval/DoD and industry applications.

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[2] http://www.noahfriedland.com/uploads/Moebius_Final_Report.pdf

[3] K. Forbus and J. Usher, "Sketching for Knowledge Capture: A Progress Report." In Intelligent User Interfaces. 2002.

[4] K. Barnard, et al., "Matching Words and Pictures." Journal of Machine Learning Research, Vol 3, pp 1107-1135, 2003.

KEYWORDS: Knowledge acquisition, documents, textual information, non textual information, knowledge representation

N10A-T020 TITLE: <u>Development of Magnetostrictive Energy Harvesting of Mechanical Vibration Energy</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Electronics, Battlespace

ACQUISITION PROGRAM: PMS 450: VIRGINIA Class submarine: ACAT I

OBJECTIVE: To explore and develop magnetostrictive (Terfenol-D or Galfenol) energy harvesting devices that provide modest amounts of power obtained from existing structure or machinery vibrations. For example, when combined with low power sensor / wireless network components, this would enable a low maintenance sensor network that monitors unoccupied shipboard spaces, reducing manning requirements.

DESCRIPTION: The concept of harvesting energy from a device's environment has gained popularity in recent years. There are several broad categories of such concepts. One is the development of long term surveillance acoustic or magnetic sensors that are deployed and obtain their power from wave, tidal or current sources. A second category is shipboard sensors for unattended low-maintenance monitoring that obtain their power by harvesting energy from the environment. This allows the energy source to be continually renewed and, in principle, removes maintenance issues like battery replacement. It is this second category that this topic addresses.

Substantial amounts of energy are available from ship structures while the ship is underway. The main driving force is the interaction of the propeller blades with nearby portions of the ship's structure. This interaction generates vertical forces of about 6 percent of the mean thrust and transverse forces of about 16 percent of the mean thrust.[1] Since an Arleigh Burke class destroyer has engines totaling 108,000 horsepower (75 MW), the forces are substantial. Estimates of the blade rate from published maximum engine RPM, reduction gearing and number of blades indicate that the maximum frequency from this source is about 20 Hz which goes down as the speed is reduced. Additional, higher frequency vibrations are expected to be present due to pumps, blowers and other mechanical devices. Exact details of vibration levels and frequencies are considered to be part of the ship's acoustic signature and are classified. However, maximum vibration levels are only part of the story. In reality, the ship does not spend all or even most of its time at full speed, and, in fact, it spends some time in port with the ship's engines off and power supplied by shore facilities. This means that an auxiliary source such as a rechargeable battery must be included to power the sensors while the ship is quiet. The energy harvesting device must supply enough energy not only to power the sensor, but to charge the battery while the ship is underway.

Magnetostrictive materials offer a unique capability to harvest the stray energy from high mechanical impedance sources such as ship structure vibrations. Referred to as the Villari Effect, magnetostrictive materials can convert mechanical vibrations into electrical energy, i.e. energy harvesting. Aboard naval vessels, the available vibration energy is from high mechanical impedance sources (high force, low displacement). There are two candidate magnetostrictive materials, Terfenol-D and Galfenol. Both of these materials are capable of supplying greater than 10's of milliwatts of power. Terfenol-D has a higher output than Galfenol, but it is brittle. For applications where the active material cannot be guaranteed to be kept in compression, the recently developed Galfenol alloys, are more steel-like and have unique mechanical properties which allow them to be used directly as part of the structure. As an example, Galfenol can be used under both tension and compression as mounts for heavy machinery, enabling it to harvest the machinery vibrations directly. Also Galfenol does not require additional components to protect it from shock loads, an issue with all other active materials, which are brittle.

This technology will directly benefit the US Navy in meeting its goals for future crew reductions while increasing the survivability of the fleet. It will also generate broader benefits in terms of energy conservation and environmental disposal issues associated with replaceable batteries.

PHASE I: Provide an initial development effort that 1) researches the available ship's structure vibrations, 2) demonstrates scientific merit and capabilities of Terfenol-D / Galfenol for energy harvesting and 3) Demonstrated devices at the laboratory scale.

PHASE II: Demonstration of the capabilities of a Terfenol-D / Galfenol energy harvester on large scale platforms. In this phase the design and optimization of the magnetostrictive energy harvester should be addressed for the platforms of interest.

PHASE III: Produce magnetostrictive energy harvesters suitable for shipboard application. Since some of the basic energy harvesting designs resemble an actuator, the energy harvesting device could be switched to active vibration electronically. Phase III would include a demonstration of vibration cancellation using the magnetostrictive energy harvester.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Successful development of a magnetostrictive energy harvester would enable design engineers the ability to optimize the design criteria to harvest energy from any platform of interest. Structural health monitoring of critical infrastructure will also benefit from this work. Magnetostrictive material's affinity for high force, low strain excitations make them a perfect match for remote wireless sensors able to provide real-time monitoring of the nation's bridges and power plants to detect flaws before they lead to structural failure.

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KEYWORDS: energy harvesting, magnetostrictive materials, Galfenol, Terfenol-D, vibration, structures

N10A-T021 TITLE: Wideband Metamaterial Antennas Integrated into Composite Structures

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

ACQUISITION PROGRAM: PMS-408 JCREW/EOD Program Office

OBJECTIVE: Develop methodologies and manufacturing processes for integrating the antenna's conductive elements and devices directly into the composite structures of the platform such as ship topside superstructure or Marine Corps vehicles.

DESCRIPTION: The objective of this effort is to develop the manufacturing processes and antenna designs needed to integrate a wideband metamaterial antenna within the composite materials of Navy platforms, such as ship superstructure or Marine Corps vehicles, through analysis, modeling, testing, and prototyping. The technical challenge associated with this effort is to maintain antenna performance when it is embedded within composite materials, without compromising the ballistic performance of these structures. Ideally, the metamaterial antenna should be capable of operating over frequencies from the mid-LF band up to 8 GHz and tunable to the specific frequency (or if possible frequencies) of interest for communications. Different metastructures/antenna and distributed inductive/capacitive material manufacturing concepts (for low loss and dispersion) will be evaluated and down-selected for full-scale fabrication and testing.

PHASE I: In phase 1, the performer should focus on material/component-level modeling and experimental assessments of integrated wideband antenna concepts. This includes characterization of the electromagnetic properties of host composite materials, RF design studies, modeling/experiments to assess the mechanical performance of composite structures with an integrated wideband antenna. Phase I will result in one or more candidate designs for a wideband antenna integrated within a composite structure.

PHASE II: In phase 2, sub-scale components will be fabricated to validate the modeling and soundness of the integration methodology, RF design, mechanical performance, etc. Phase II will result in the selection of one or more candidate designs for fabrication of a full-scale prototype.

PHASE III: In phase 3 the performer will fabricate, test and evaluate a full-scale prototype (i.e., full-scale antenna integrated into a sufficiently large structure to be representative of the platform of interest) of the proposed concept. The evaluation will focus on how well the prototype can meet the established operational requirements of RF performance, mechanical performance, size, weight, power, etc. as well as the manufacturing cost/complexity of the prototype system.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The technology developed could be applied to a wide range of commercial vehicles (e.g., cars, trucks, ships, aircraft) and structures (e.g., buildings) with requirements for low profiles.

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KEYWORDS: Metamaterial, Metastructure, Wideband, Tunable, Antenna, Composite Structures, Materials, Manufacture

N10A-T022 TITLE: Low Loss High Power Current Lead for Cryogenic Applications

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

ACQUISITION PROGRAM: PMS501, PMS320, PMS502

OBJECTIVE: Develop an ambient-to-cryogenic temperature current lead for a superconducting power cable while minimizing heat leakage and joule heating for use in a Navy shipboard environment.

DESCRIPTION: In order for the Navy to advance and develop a superconducting power distribution system for ship power requirements, efficient yet compact terminations need to be developed. The Navy has various programs supporting the development of superconducting motors and generators. To fully utilize these systems large amounts of power on the order of megawatts will need to be transferred from ambient temperatures to cryogenic temperatures.

The Department of Energy (DOE) is funding the development of superconducting power cables which have been spliced into substations through various termination designs. These designs typically make use of a liquid cryogen such as liquid nitrogen (LN2) to provide cooling at the termination as well as act as a dielectric providing the necessary electrical insulation from the outside environment. This design type may not be ideal for use onboard navy ships due to the presence of a liquid cryogen which is a gas at ambient temperatures and poses health risks to sailors in the event of a breach.

The needs of the Navy include transferring power to and from electrical generators and motors, as well as other shipboard systems with power rates on the order of 40 megawatts. The current leads must handle voltages from 1V-15kV and 100-100,000A (both AC and DC). The transition from regular conductor to superconductor will require a cryogenic environment however a liquid cryogen which can present an asphyxiation risk must be avoided. The leads should also require little to no maintenance and be small in size.

Novel ideas and approaches to a solution for a low loss high power current leads are sought. Current lead designs that could support the Navy's future superconducting architecture and distributed power systems must be compact, highly reliable, and require little to no maintenance.

PHASE I: Based on an assessment of current leads derived from various superconducting cable architectures, explore novel conceptual designs of currents leads for use within superconducting cables, motors, and generators. Identify and define the basic requirements for practical naval applications based upon lead size and heat leakage. Rank the conceptual designs for performance and practicality.

PHASE II: Develop and demonstrate a full scale prototype of the current leads. Using lessons learned from the prototype, create a conceptual design with cost estimates for high power current leads for use onboard a Navy ship.

PHASE III: Transition this technology to commercial and military cryogenic and superconducting power applications.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Low loss high power current leads will enable the use of superconducting wire in superconducting power cables. As superconducting power cables move from demonstration to field use, reliable, safe, and efficient current leads will be vital to a successful product. The outcome of this research could be directly applicable to the power cable programs funded by the Department of Energy.

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KEYWORDS: cryogenic, current leads, superconductor, HTS, power electronics, electrical distribution

N10A-T023 TITLE: Development of High-Efficiency, High Power Electron Beam Accelerator Technologies

TECHNOLOGY AREAS: Sensors, Electronics, Weapons

ACQUISITION PROGRAM: FEL INP

OBJECTIVE: To develop technologies supporting the development of a megawatt (MW) class electron beam accelerator.

DESCRIPTION: The advanced accelerator technologies targeted in this topic are directly relevant to developing high power, compact, lightweight, robust Free Electron Lasers that will be used for fleet ship-self defense. Accelerator technologies such as high average current injectors, accelerating modules and high power RF tube technologies are desired. Research will focus on novel strategies for designing and developing high quantum efficiency (>5%), long life cathodes for use in high duty factor DC, normal conducting RF and Superconducting RF guns. Injector and cathode designs to produce high average current, high quality, high charge per bunch electron beam are desired. Approaches may include alternative cathode technologies such as thermionic and field emission cathodes, alternative materials to improve current cathodes or new materials for existing designs. It is important to have close coupling between theory, simulation and experiment. Coupled with the development of the injector technology, modeling of electron beam injectors include cathode emission, space charge and RF effects is needed. Any codes developed should be anchored to definitive experiments. Research in the area of compact, high-current superconducting RF acceleration modules for injectors and linear accelerators should focus on high accelerating gradient and low heat loss designs with high instability thresholds, high order mode HOM power management and MW level compact RF power coupling.

PHASE I: Develop a design that includes conceptual drawings for both the accelerator components and associated test equipment.

PHASE II: Develop a detailed design of a prototype system of the proposed accelerator technology component/s. Perform detailed calculations (modeling and simulations) to prove feasibility.

PHASE III: Successful development of a compact, high-power accelerator will make possible numerous commercial applications due to the availability of an inexpensive high current, high power, bunched electron beam.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Applications include: high energy x-ray sources, Compton x-ray sources, high power microwave and THz sources, materials processing and e-beam welding, and FELs.

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KEYWORDS: electron particle accelerators, energy recovery, free electron laser, RF power couplers

N10A-T024 TITLE: Enhanced Riverine Drifter

TECHNOLOGY AREAS: Sensors, Battlespace

ACQUISITION PROGRAM: NAVOCEANO

OBJECTIVE: Drifting or minimally powered river sensors are sought that both increase spatial sampling for river currents and bathymetry and also reduce the tendency for drifters to run aground on river bars. Such "smart" drifters might incorporate power sources to move the drifter from a purely drifting trajectory, make use of interdrifter communications, or other techniques to enhance spatial coverage of the river environment. Proposed solutions should explore the tradeoffs between power, economy, computational resources, number of drifters and deployment strategies, among other variables, that result in optimal spatial description of the riverine environment.

DESCRIPTION: Existing river surface drifting sensors provide useful flow velocity, bathymetry and other environmental information in river environments that may be difficult or dangerous to access. Such drifters may be deployed by hand from bridges or from underway boats or even aircraft. A single drifter typically traces a single along-river trajectory along which river current, depth, etc. are measured. Unfortunately, the use of multiple drifters deployed across the river width to more effectively map river characteristics is hindered by the tendency of drifters trajectories to merge with increasing distance downstream, so that after a relatively short distance all drifters trace similar trajectories. While an autonomous sensor/vehicle could overcome such difficulties, the challenge is to provide an autonomous, economical (ideally expendable), compact, energy-efficient river measurement sensing solution that provides significantly more data than a freely drifting sensor.

PHASE I: Develop a preliminary design for an enhanced riverine drifting sensor system that provides, at a minimum, current speed and water depth. The system design should offer clear advantages in spatial coverage over a freely drifting sensor. Provide the theoretical predictions of the system and develop a technology development plan for Phase II. The deliverable should be a preliminary design of the system. If the design or components of the design are 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 three prototype sensors and complete laboratory and development tests. Conduct one demonstration in a riverine environment.

PHASE III: Redesign the riverine sensor system using lessons learned from prototype development during Phase II. Fabricate a production system for government testing. Develop documentation of the system for transition into an acquisition program.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Federal, state and local civilian agencies and commercial boat operators who must transit rivers lacking bathymetric maps, or known rivers after floods, volcanic eruptions, chemical spills, or other significant environmental disturbances can use a riverine drifter system to assess environmental conditions including currents and water depth with minimal human exposure to danger before deploying vessels for reconnaissance or rescue operations.

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KEYWORDS: riverine; drifter; autonomous; bathymetry; current; GPS

N10A-T025 TITLE: Development of Refractory Coatings on High Strength, High Conductivity Substrates

TECHNOLOGY AREAS: Materials/Processes, Space Platforms, Weapons

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

OBJECTIVE: To explore and develop coatings of Mo, Ta, or their alloys on high strength, high electrical conductivity alloys to enable damage resistant electromagnetic launcher (electric railgun) rails with a shot life exceeding 1000 rounds.

DESCRIPTION: The US Navy is pursuing the development of an electromagnetic launcher (also known as a railgun) for long range naval surface fire support. An electromagnetic launcher consists of two parallel electrical conductors called rails, and a moving element, called the armature. Current is passed down one rail, through the armature, and back up the other rail. This causes strong magnetic fields, high temperatures, chemical interactions and strong lateral forces on the rails and armature in the launcher bore.

A pair of electrically conductive rails act to transfer the power supply current down their length and through the moving armature creating an accelerating Lorentz force. These rails also provide lateral guidance to the armature. The properties of the rails must be such that they can support the coating on the surface in the presence of high mechanical loads due to armature contact, armature balloting, and heating. At the same time, the rails must conduct current to the armature at levels approaching 6 MA. High strength copper alloys are preferred for the base material due to their combination of strength and electrical conductivity. The surface of the rail must be able to withstand sliding electrical contact with an aluminum armature and polymer bore rider materials at velocities up to 2.5 km/sec, and concurrent balloting loads. In order to survive these conditions, the rail contact face must be electrically conductive, resistant to high transient temperatures, possess high hardness and yield strength and retain these properties after thermal transients, must accommodate balloting loads, and survive exposure to molten armature metals. The material is required to resist thermal breakdown and interaction in the presence of plasma due to high current electrical arcing and shocked gas. The material must eventually be manufacturable at length of several meters, and in non-planar geometry. Molybdenum, tantalum, and alloys based on these materials have shown promise, but monolithic refractory sections typically do not possess the required toughness or elongation limit to resist fracture during railgun operation. Therefore, a coating of a refractory alloy on a high strength, high conductivity base alloy is an attractive approach for increasing rail life.

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

PHASE I: Develop a rail material/coating and process approach to manufacture electrically conductive bore materials. Conduct any necessary subscale tests needed to show that the proposed process is suitable for Phase II demonstration. Create sample rail coupons for static or small scale testing and verification, such as coating adhesion, strength, erosion resistance, and conductivity versus temperature from ambient to 500 degrees C.

PHASE II: Produce samples of electrically conductive rail materials of at least 1 m length that meet the needs of the EM launcher environment. Demonstrate that the material provides the required material property characteristics described above. Further develop and demonstrate the fabrication or joining processes for creating longer sections. Also demonstrate fabrication technology to create non-planar contact surfaces facing the bore. Produce a prototype set of coupons 1.5 m long and of full rail cross section, for testing in a small scale EM launcher. The EM launcher test facility may be provided as a government furnished asset, or via a teaming relationship with other EM launcher test sites. Potential test sites include various scale railguns operated by Universities and Defense contractors. The results of testing may be classified. The Phase II product may become classified.

PHASE III: Develop full length (7 – 12 meters) rails with final design dimensions in other axes. The materials process developed by the Phase II effort will be applied to Navy railgun proof of concept demonstration and design efforts in the lab as well as industry advanced barrel contractors. Successful rail materials solutions will be transitioned to the ONR EM Railgun INP Program Office for testing within designated laboratories and test facilities as deemed appropriate.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The materials and processes developed could be applied to any electro-mechanical applications particularly under conditions of high heat, stress, and/or current requiring both the beneficial thermal and high current aspects of conducting metals combined with the need for higher toughness and hardness with traceability to relatively long sections. Example applications could be high-speed mag-lev contacts, electrical generation facilities, high current switches and sections for re-entry protection of space-craft.

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KEYWORDS: railgun; rail; electromagnetic; conductor; wear; launcher; refractory

N10A-T026 TITLE: Tactical, Energy Efficient, 4K Pulse Tube Cryocoolers

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: SSEE

OBJECTIVE: The objective is to evaluate the leading technology pathway toward a 4K base temperature cryocooler and determine if it will with high confidence work reliably in a high vibration, non-negligible roll/pitch environment. This would enable the tactical use of cryogenic electronics.

DESCRIPTION: In order to be fielded on a wide spread basis by the US military, electronics which requires a low temperature (4K) operating environment will have to be packaged on a high reliability tactical grade cooler capable of functioning for many years in a high imported vibration setting that is unstably positioned in the earth's gravitational field. Unfortunately such a cooler does not exist today commercially or in the MOTS arena. The total absence of cold moving parts in pulse tube designs makes this class of machine an obvious candidate. A first prototype 4 stage pulse tube cooler (~40 mW of continuous heat removal from (lift at) 4K) with space heritage was successfully demonstrated by Lockheed Martin for Hypres in 2008, but its energy efficiency has not yet been optimized and a factor of 5-20 more lift is desirable. More importantly, the issue of the independence of the lift achieved on orientation of the unit relative to G was not considered in this first design. This topic seeks to address that issue and determine how well the energy efficiency (lift/power from wall) achieved when the cooler is stationary and vertical is maintained when it is rocked around the vertical.

PHASE I: In Phase 1, the performer should develop an initial 3D numerical simulation capability sufficient to allow the energy efficiency of a multi-stage pulse tube cooler design to be evaluated. The inclusion of the possibility of a separate 3He working fluid in the lowest temperature stage (and 4He in higher temperature ones) is desirable. Utilizing this design software and previous experience, design a nominally 200mW at 4K lift cooler expected to be more independent of orientation. Evaluate for it the efficiency impact of a set of stationary tilted orientations. Extrapolate in the phase 2 proposal to a prediction of what efficiency can be expected from a continuously rocking installation.

PHASE II: In Phase 2, the design concept should be refined by calculation, constructed and tested to validate the simulation software, and then the design reoptimized in terms of the efficiency performance. 30 degree rocking on a 10s-1 minute time scale should also be included. If funding permits, efforts to minimize the volume of the complete cooler are also desirable. By the effort's conclusion, an iterated and tested prototype should be available for delivery to a follow-on project, achieving TRL3

PHASE III: In Phase 3, the prototype unit should be integrated with an electronics payload and the resulting system tested for fielded applicability to a US government system doing comms in dense signal environments, EW, radar, or SIGINT.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The primary commercial market will probably be that of laboratory test instrumentation. The high price of He is forcing university researchers to move their laboratory testing from boiling cryogen to closed cycle refrigerators. The requested 4K base temperature is cold enough that thermal noise is much reduced compared to room temperature and all technologically relevant superconductors are already transitioned by this temperature. 4K is also cold enough to be a useful heat sink for dilution refrigerators and other lower temperature cryocoolers essential for research on quantum computing and communications and other low temperature physics topics. For some of these commercial uses, it may be necessary to use the simulations to design in features that make those models inappropriate for tactical applications in order to satisfy ITAR restrictions.

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KEYWORDS: Cryocoolers; pulse tube coolers; real gas properties; tactical environments; helium gases; energy efficiency

N10A-T027 TITLE: Three Dimensional Imaging Diagnostics for Dense Sprays

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: Air platforms, PMA (275), PEO (W)

OBJECTIVE: Develop techniques to image three dimensional structures of dense sprays with improved spatial and temporal resolution.

DESCRIPTION: Complete and stable combustion of fuel in the combustion chamber provides maximum combustion efficiency and specific thrust that are of great significance for Naval Unmanned Combat Air Systems, Versatile Advanced Affordable Turbine Engines, ADaptive VErsatile ENgine Technology and other air platform programs. The efficient combustion in propulsion devices critically depend on the fuel-oxidizer mixing process, which typically involves liquid breakup and atomization in dense sprays. Being optically thick, dense sprays pose tremendous diagnostic challenges, and the understanding of the governing processes in dense sprays remains far from complete. Hence, innovative techniques are to be developed to resolve the 3D structure of dense sprays. The proposed techniques may be innovative in different perspectives: it may be a completely new technique, a significant enhancement of an existing technique, or an innovative application of an established technique which has never been applied to dense sprays. Examples of techniques in the second and third categories include ballistic photon imaging and synchrotron X-ray radiography. However, these emerging techniques, as well as other more established ones (e.g., Shadowgraphy, Planar Laser Induced Fluorescence, and Mie scattering), all have application restrictions. For example, ballistic photon imaging only provides spatial resolution in one direction and cannot fully resolve the 3D structure of sprays. X-ray radiography suffers an additional disadvantage for field applications. Ideally, the proposed techniques should be able to overcome such limitations, and be capable of resolving structures of dense sprays with full 3D resolution and rapid temporal response. Further, it would be advantageous if the diagnostic equipment can be packaged for transportation to in-situ field applications.

PHASE I: Design approaches for imaging 3D structures of dense sprays that are optically thick. Develop a plan to validate the proposed approaches via computation and/or small scale tests. Determine the best approach that provides maximum temporal and spatial resolutions.

PHASE II: Complete the experimental and theoretical development of the best measurement approach chosen from Phase I and perform parametric studies in laboratory scale combustion rigs. Obtain diagnostic measurements in dense sprays under realistic operating conditions.

PHASE III: Design, build and calibrate work-horse type diagnostics to use in real combustor development programs, and provide the technology base for atomization in propulsion (e.g., rocket engines, gas turbines); power generation; spray diagnosis, control, and health management.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Successful development of this diagnostics technology will yield payoffs in designing the next generation injectors and/or combustors for commercial aviation engines, power generation, transport vehicles, and prognostics/health management.

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KEYWORDS: dense sprays; laser diagnostics; 3D imaging; spray diagnostics; fuel-oxidant mixing; combustion, propulsion

N10A-T028 TITLE: Probabilistic Prediction of Location-Specific Microstructure in Turbine Disks

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Develop probabilistic modeling and simulation methods that predict location dependent microstructure and bulk residual stresses in nickel-base superalloy turbine disks.

DESCRIPTION: Advanced turbine engine cycles will benefit from disks that can run hotter and faster than that which is possible using today's materials and processes. Future propulsion systems for both Naval aircraft and marine gas turbine engines will require compressor and turbine disks with an increased material temperature capability of up to 150°F over today's state of the art technologies. The ultimate benefit to the Navy from this increased disk temperature would be significant increased capabilities such as increased power or payload or reduced fuel consumption that could be utilized for increased loiter time or increased range.

PHASE I: Establish a primary probabilistic modeling and simulation approach that enables prediction of location-specific microstructure, life-limiting features and bulk residual stresses due to processing and fabrication. Validate the model using published data for titanium or superalloy components with dual microstructure.

PHASE II: Apply validated model to optimize the processing technology to produce complex gas turbine engine components with controlled microstructures, defect populations and satisfactory mechanical properties. In coordination or collaboration with an appropriate original equipment manufacturer, establish and execute mechanical test plan that will provide sufficient database for preliminary assessment of design allowables for critical and relevant design requirements.

PHASE III: Adoption of model by an original equipment manufacturer for further maturation to develop the tools to manufacture complex engine components. Produce a small component showing complex properties.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: There is an increasing need for commercial airlines to reduce fuel consumption for better profitability and reduced emissions and thus the technology will be applicable to the design of more fuel efficient commercial engines.

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KEYWORDS: Location specific properties, microstructure models, dual microstructure, turbine disk, residual stress, titanium alloys, Ni-base superalloy, gas turbine

N10A-T029 TITLE: Information System for Uncovering Deception in Unstructured Data

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: PM Intel

OBJECTIVE: The objective of this research is to develop information technology to discover acts of deceptions in unstructured communications. Unstructured communications of interest include internet postings, audio transcriptions and conventional voice and print news media. Due to the growth in importance in open source intelligence, a critical need exists now to develop advanced algorithms and decision aids to detect deception more effectively. Methods to automatically discover camouflaged messages, author misrepresentations, and sophisticated messaging are needed. Automated detection of the out of place words, phrases or themes would help as would methods to automatically discover changes in an author’s normal content or style. Illegal activities are often conducted through acts of deception. It is hypothesized that this can be countered through the development of novel applied natural language processing.

DESCRIPTION: Deception falls under the military domain of information operations [1]. Deception is the act of convincing another to believe information that is not true or only part true. Dissimulation consists of concealing the truth, or in the case of half-truths, concealing parts of the truth, like inconvenient or secret information. There are three dissimulation techniques: camouflage (blend into background), disguise appearance (alter perception) and obfuscation (misdirection). Deception can be used to hide communication or as part of sophisticated attempts to sway thought or opinion. The commercial world has long been worried about this form, deception in unstructured text, of information operations [2].

Deception detection can be considered in the realm of pattern analysis. Normalcy patterns for communications can be developed over time provided detailed metadata about each communication is recorded. Deception could be discovered as exceptions to these normalcy patterns. Deception could also be discovered by finding known patterns such as the use of unsubstantiated quotes, out of place words or distortions of facts. A deception engine that fuses over these and perhaps other independent techniques will be required to achieve useful true and false positive detection rates.

The scope of the topic includes both text corpus preprocessing and the development of a deception detection engine. Measurement of error rates against a truthed data set is an important metric. Offerors may extensively use open source natural language processing tools.

The Department of the Navy is interested in innovative R&D that involves technical risk. Proposed work should have technical and scientific merit. Creative solutions are desired.

PHASE I: Complete a feasibility effort that provides an analysis framework design for text corpus pre-processing and deception detection. Conduct a proof of concept demonstration against a data set with known ground truth. The data set can be created by the offeror. Show how the proposed algorithms and architecture can be matured during follow on phases. Demonstrate the retirement of technical risk.

PHASE II: Produce a prototype system that is capable of detecting deceptive documents automatically with tactically relevant error rates. The prototype should be capable of processing in real time a stream of documents. The system should be automated and capable of alerting operators in a timely manner. Prototype should accept a variety of common document formats. In this phase, the system should be tested on samples of tactically relevant data and show statistically significant event detection accuracies. Open architecture and standards is encouraged. An initial capability should provide a probability of detection above 80% and false alarm rate below 25%.

PHASE III: Produce a system capable of deployment and operational evaluation. The system should operate on real time streams of thousands of documents per hour. Further improvement on error rates should be made. The system should be deployable to an operational unit for a field user evaluation.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Successful development of the prototype capability would be of great interest to law enforcement as well as to political scientists. Presently, there is a strong military need to extract credible information form unstructured data. Deception practices can turn these exploitation efforts into vulnerability. The provide sector faces a similar challenge.

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1. Joint Publication 3-13 Information Operations (IO) 2006, Information Warfare (IW) JP 3-13.1 2007, Military Deception JP 3-13.4 2006.

2. Deception at Work by Michael Comer and Timothy Stevens, (Chapter 8) published by Gower 1994.

3. Counterdeception Principles and Applications for National Security by Edward Waltz, and Michael Bennett, 2007.

KEYWORDS: Deception, obfuscation, unstructured data, data fusion, automated alerting, military, security

N10A-T030 TITLE: Powder Reactant Delivery System for Air Independent Fuel Cell

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PMS 403

OBJECTIVE: Develop and demonstrate a powder storage and delivery system to supply reactants used in an air independent fuel cell. The platforms utilizing the proposed fuel cell could be either an Unmanned Undersea Vehicle (UUV) or an Unmanned Distributed Network System (UDNS). The delivery system should be capable of startup and shutdown and be capable of operating over a wide range of delivery rates. The storage component of the system should be capable of being reloaded via a penetration in the shell without requiring the separation of the UUV hull sections. This system should be amenable to replenishment under submarine and surface ship operating conditions. This approach can also address safety issues; using powder reactants and refueling will be easier and safer to handle than cryogenic liquids and high pressure gases.

DESCRIPTION: Underwater vehicles will serve as key elements in the integrated operations of future surface ships and submarines, providing a range of support functions including autonomous surveillance, mine counter measures, and special forces transport. However, current power sources for these vehicles (rechargeable silver-zinc batteries or high-energy primary batteries) do not meet the energy requirements for future missions, or they impose a tremendous logistics burden on the host vessel. Fuel cells offer a viable option for meeting mission energy requirements, and at the same time, they can reduce the host vessel logistics burden if the fuel and oxidizer can be stored in a high energy density format.

Fuel cells operating on hydrogen and oxygen are attractive as underwater power sources because they are efficient, quiet, compact, and easy to maintain. The total energy delivered by a fuel cell system is limited only by the amount of fuel and oxygen available to the fuel cell energy conversion stack. Unlike ground and air transportation fuel cell systems that only require an onboard fuel, underwater vehicles must carry both the fuel and the oxygen source because the oxygen concentration in the ocean is insufficient to meet vehicle power requirements. The underwater vehicle's fuel and oxygen source must possess both a high hydrogen and oxygen content (both weight and volume based) to accommodate the weight and volume constraints of the vehicle design and be amenable to safe handling and storage onboard submarines and surface ships.

Solid-state fuel sources such as sodium borohydride (NaBH4) and calcium hydride (CaH2) have been shown to be reliable fuel sources for both PEMFCs and SOFCs respectively. The systems employ a decomposition reactor in which the raw fuel source is decomposed to generate the pure fuel source (i.e., hydrogen for a PEMFC). In order to increase the energy density of these fuel sources a system in which the fuel is stored in a compact dry state is desired. However the use of a solid-state fuel source (i.e., powdered NaBH4) requires a novel method of refueling when hull separation is not amendable to the operating environment.

Therefore, an innovative comprehensive approach to solid-state fuel storage, delivery, and refueling through the hull is sought. The solid-state fuel may be fed to the decomposition reactor as a solid or in a carrier fluid (preferably water) as a slurry or a solution. To meet nominal undersea vehicle power requirements, throttleable fuel delivery rates should be sufficient to power a typical fuel cell stack from 50 W to 5 kW. For example, a PEMFC operating on solid NaBH4 would require 500 g/hr of NaBH4 at a power of 2 kW. Fuel storage capacity should be scalable to provide a minimum of 40 hrs of power generation. The available fuel capacity should be maximized on a total system weight basis (i.e. weight percent fuel), while maintaining a high volumetric density for the overall system.

PHASE I: Demonstrate the use of a refuelable solid state system to store and deliver a solid-state fuel (e.g. NaBH4) to a decomposition chamber with an output stream suitable for use in a fuel cell. Demonstrate rapid startup and shutdown capabilities and continuous operation greater than 8 hours.

PHASE II: Construct and evaluate a comprehensive solid-state (e.g. NaBH4) fuel source for a nominal 2-3 kW fuel cell system. The system should have the capability to store dry fuel, deliver the fuel to the decomposition reactor, store the decomposition byproducts, and demonstrate an efficient suitable through hull refueling concept. The effort should demonstrate controlled fuel generation rates, start/stop/restart capabilities, and fuel source recharge or replenishment capabilities. The system should be made available for attachment to a fuel cell system for Naval Laboratory testing.

PHASE III: Design and construct a fully integrated, comprehensive solid-state fuel system for operation in a Navy-designated undersea vehicle powered by a nominal 2-3 kW fuel cell for at least 40 continuous hours.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Fuel cell use in marine applications and ocean mapping.

REFERENCES:
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KEYWORDS: Hydrogen; Fuel Cell; Underwater; Power; Energy; NaBH4; CaH2

N10A-T031 TITLE: <u>High-rate Manufacturing of Electronic Systems-on-Film</u>

TECHNOLOGY AREAS: Materials/Processes, Electronics

OBJECTIVE: Develop a high-throughput, low-cost enabling manufacturing technology for the production of electronic systems-on-film. Address all technical issues related to system-on-film design, materials development and synthesis, and high-rate processing for flexible electronics.

DESCRIPTION: Electronic systems-on-film or hybrid flexible electronics is an emerging technology [1,2] that involves the functional integration of organic, inorganic and bio-inspired materials on a flexible backplane permitting new functionalities and performance. True flexibility is achieved by the introduction of organic semiconductors, conducting polymers and electro-biological materials, which are inherently flexible and compatible with flexible substrates, such as, plastic, fabric, and paper. This permits the production of electronic devices, which can be conformable, foldable, stretchable, rollable and deformable, which are capabilities of particular interest to the Navy and DoD. Electronic systems-on-film has many potential applications, such as flexible displays, flexible lighting, e-paper, solar cells, batteries, sensors, actuators, radio and antenna. Additionally, more than one device can be placed on the flexible backplane to achieve full functionality, e.g., full color video display, sound, sensing, etc. Electronic systems-on-film products can be interactive, energy-efficient and ultra-low cost (throwaway). For electronic systems-on-film to be successful, new material discoveries and high-rate, affordable processing and manufacturing methods are needed.

PHASE I: Develop proof-of-concept high-rate (e.g., roll-to-roll), solution- or vacuum-based processing for the design, modeling and manufacture of electronic systems-on-film. Develop consumables (e.g., printing inks) for tighter control of feature size and resolution. Develop processing technologies (e.g., printing) that have greater flexibility in materials and features. Develop cyber-enabled tools for automated in-line registration and in-plane substrate deformation monitoring and control in real-time. Develop tools for high-speed integrated optical, electronic and mechanical quality assurance. Demonstrate production of a full-function electronic system-on-film, considering applications such as threat detection, health monitoring, communication and others.

PHASE II: Fabricate a specific electronic systems-on-film prototype and demonstrate its utility and performance. Potential Navy/DoD applications are tape sensors for monitoring of traumatic injuries, tagging-tracking-locating (TTL), CBNRE sensing and warning, photovoltaics for energy-harvesting, antennae and displays for communications.

PHASE III: Transition the electronic systems-on-film 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 electronic systems-on-film manufacturing system would be useful for a variety of commercial applications. Electronic systems-on-film will impact all industrial sectors – electronics, energy, aerospace, defense, consumer, IT, healthcare, biomedical. Electronic systems-on-film has the potential to surpass silicon in electronic device applications in 20 years [3]. Its affordability and versatility will result in new businesses and industries, and high-value jobs.

REFERENCES:
[1] See Materials Today issue on “Bend and Flex”, Volume 9, Issue 6 pp. 1-56 (June 2006).

[2] See Scientific American issue on “The Future Looks Flexible”, (February 2004).

[3] WTEC Report, “Assessment of International Research and Development on Flexible Hybrid Electronics and Systems,” (2009), to appear.

KEYWORDS: Electronic Systems-on-Film; Hybrid Flexible Electronics; Organic and Inorganic Materials; High-rate Manufacturing; Printing; Cost Reduction

N10A-T032 TITLE: Insert ear-probe assembly for high-quality otoacoustic-emission (OAE) measurements in adults

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Otoacoustic-emissions (OAE) are sounds produced by the inner ear that are measured in the ear canal with a special microphone and indicate the activity of outer hair cells in the cochlea. Normal-hearing ears produce OAEs, while noise-damaged ears produce smaller OAEs or none at all. This research will develop an otoacoustic emission (OAE) ear probe with companion software that is robust, durable, inexpensive, easy to fit, easy to clean, easy to use, with advanced acoustical properties including low noise, low artifact, wide and flat frequency response, good impulse response, and low cross-talk between channels.

DESCRIPTION: Hearing loss is the biggest compensable injury to the U.S. military forces. The Noise Induced Hearing Loss (NIHL) Program at the Office of Naval Research (ONR) provides cross-service leadership for the development of science and technology aimed at reducing hearing loss in U.S. military forces. This STTR topic represents an expansion of the NIHL Program.

Hearing conservationists need effective schemes to determine whether their hearing-conservation programs are successful. Currently, these goals cannot be achieved due to the lack of tests that allow audiologists to catch hearing loss before it becomes clinically significant. Thus, prevention of hearing loss may be greatly enhanced by early, sensitive measurement and recognition of noise-induced inner-ear damage. OAE probes can be used to measure inner ear function. Current probes have suitable low noise floors (ultimately limited by internal biological noise), but their frequency range is limited. Specifically, the Otodynamics ILO system produces clicks with an upper frequency cutoff of about 5 kHz. The Etymotic Research Inc. (ER10B+, ER2, and ER10C probes) produce stimuli with upper frequency cutoffs of about 10 kHz (without laboratory modifications and while maintaining good calibration), and cross-talk can also become problematic at higher frequencies.

The intended use of this probe is for measuring OAEs in military populations. When sailors and soldiers are exposed to hazardous levels of noise (shipboard and blast), OAEs show the accumulated damage to the inner ear before hearing loss shows up in an audiogram. Moreover, diminished OAEs are predictive of subsequent hearing loss if the sailor or soldier remains in the noise-hazardous environment.

The OAE measurements may include both tonal and click/chirp stimuli, and stimulus levels that often will be below those used for typical hearing-screening scenarios. The lower stimulus levels need to be achieved with signal-to-noise ratios above noise floor/artifact levels within a clinically feasible timeframe. Thus the probe system must have low internal noise and low artifact for all the stimulus types. At high frequencies, it is desirable to have a transducer capable of putting out relatively high acoustic power in the higher frequency ranges, as the middle ear acts as a bandpass filter, creating inefficient passage of high frequencies into the middle ear. At these higher frequencies, the internal probe system noise (including microphone, loudspeaker, A/D – D/A converters, etc.) may be of more importance than it is for lower frequencies. In any case, the proposed technology should perform better than the current set of available probes (e.g., ER10C and ILO probes).

Target specifications are (not in order of importance): 1. Microphone flat frequency response from 0.5 – 20 kHz optimal; 1-16 kHz acceptable. 2. Loudspeaker flat frequency response range from 1-16 kHz optimal; 1-12 kHz minimal. 3. Thevenin parameters must be stable over time. 4. Output levels for loudspeakers: 85 dB SPL desirable; 75 dB SPL acceptable. 5. Dynamic range as large as possible. 6. Linearity superior to current probes. 7. Impulse duration: ringing should be around 1 ms. 8. All noise sources must be addressed—microphone, loudspeaker, amplifier, probe case, and cable vibration, with total noise comparable or better than what the ER10-C can achieve in the same test time (must be able to measure OAEs down to -20 dB SPL). 9. Low harmonic and intermodulation distortion (e.g., at 2f1-f2) in loudspeakers, microphones, and amplifiers, equal to or better than the ER10C. 10. Electrical cross-talk must be 50 dB below the real signal, and acoustical cross-talk must be 20 dB below the real signal. 11. Good seal and stability in the ear canal for a clinical setting with minimally trained users. 12. Earplug: must be stable in the ear canal and easy to fit a range of adult ear-canal sizes and shapes. 13. Must be capable of withstanding high-volume use in a clinical setting. 14. Affordable as to enable widespread military and commercial use. Trade-offs among some of these specifications may be necessary, but should be well documented.

PHASE I: Demonstrate the technical merit and feasibility of the proposed device. Provide schematics including size, weight, maintainability and ruggedness. Estimate performance parameters of the proposed device and provide a comparison matrix with current probes (e.g., ER10C and ILO).

PHASE II: Demonstrate and validate prototype technology in the laboratory and in limited human tests, to include comparisons between the new probe and the ER10C and ILO probes. Coupler data are required, but human data (on ears that do and do not have OAEs) must also be furnished. At a minimum, the following performance data should be reported: maximum output level (output sensitivity at 1 kHz (Pa/volt), output sensitivity as a function of frequency), nonlinearity (total RMS level re: the intended output level as a function of level, 2nd and 3rd harmonic distortion as a function of frequency and level), monotinicity (acoustic output level vs. electrical input level as a function of the input level); cross-talk (dB down for electrical and acoustical cross-talk as a function of frequency); electrical impedance (ohms and inductance at electrical input), acoustic impedance (equivalent volume); physical dimensions; weight; cost (in volume), specification of connections, and temperature specifications. For the microphone, the following information must also be provided: sensitivity (mv/Pa at 1 kHz and as a function of frequency, linearity, vibration sensitivity, e.g., touch the wire to measure the mic output). Introduce final prototype(s) for use at the Naval Submarine Medical Research Laboratory. Conduct a thorough market analysis for commercial and government use.

PHASE III: Develop production capacity to support potential research and clinical demand. Introduce the product for additional testing and clinical use by audiologists at DOD medical facilities and in academia.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Otoacoustic emissions are measured in thousands of clinical and research settings in the United States alone. Initially, every OAE researcher will want this probe. As the usefulness of high quality OAE measurements is realized, standard clinical practice will demand these new probes as well. This technology will be particularly useful for hearing conservation programs in military and civilian settings, as well as monitoring for drug ototoxicity.

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KEYWORDS: hearing loss; instrumentation; otoacoustic emissions; OAE probe; OAE measurement; high-frequency OAEs

N10A-T033 TITLE: Development of Electronic Controlled Fuel Injector and Pump Suitable for 5-20 Horsepower Diesel Cycle Engines

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Space Platforms

ACQUISITION PROGRAM: PMA 263

OBJECTIVE: To develop a small electronic controlled high pressure fuel injector and pump suitable for use with diesel cycle engines in the 5-20 horsepower range.

DESCRIPTION: Modern fuel injection technology has focused almost exclusively on larger capacity (100 hp and above) diesel engines. For these larger engines, advances in technology have migrated the required high pressure fuel delivery systems away from mechanical injection and mechanical timing to electronically controlled and actuated systems. These electronic systems can respond across a broader range of engine operating conditions, providing optimized performance beyond a single operating point. While improving fuel economy with faster combustion, larger diesel engine electronic fuel injection systems were also developed to increase engine performance, operating range, and reduce emissions. Smaller engines have not received significant attention from the commercial market generally due to restrictive purchase costs, diminished return on fuel cost, and exemption from emission standards. Additionally, an electronic controlled fuel injection system can adjust injection timing and compensate for the different cetane values of JP5, JP8, and diesel. Conversely, a mechanical injection system must be timed for the higher cetane fuel to prevent engine damage thus reducing performance when operating on lower cetane fuels. To meet current and emerging requirements, the Navy and other services are seeking small lightweight power plants that can operate reliably and efficiently on heavy fuels, (JP5, JP8, and diesel), in a broad spectrum of environments (ground and air) with minimal smoke, and noise.

To improve performance and capability of small ground based and UAV engines, the Navy is interested in developing a small electronically controlled fuel injector and pump suitable for diesel cycle engines operating in the 5-20 horsepower range. Injector and pump should be capable of interfacing with and exploiting the features of a modern common rail style controller, namely multiple injections, variable timing, and variable injection duration. Injector and pump should be designed to address the challenges specific to small diesel engines operating in the field; specifically, accurate metering of small fuel quantities, proper atomization, small combustion chamber dimensions, reduced spray length, an ambient environment of -40F to 130F, and an altitude range from sea-level to 15,000 feet. Injector and pump system must be compatible with JP5, JP8, and diesel.

PHASE I: Perform trade and feasibility studies on conceptual injector and pump design. Identify controller and interface requirements. Develop injector and pump design and conduct initial risk reduction effort. Conduct initial performance analysis and estimates.

PHASE II: Conduct detailed design of injector and pump. Manufacture prototype injector and pump. Demonstrate operation of injector, pump, and selected controller in laboratory environment.
Option 1: Install and demonstrate operation of injector, pump, and selected controller in a commercially available diesel engine.

PHASE III: Integrate injector, pump, and controller with commercial available engine or GSE engine for testing in a representative environment.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: It is doubtful that electronic injection control would be commercially viable in the near future for sub-20hp engines. However, diesel engines in the 40hp and above range could not only benefit from electronic control but engine usage, purchase cost, and expected operational life could justify the development of these systems. As the EPA and state regulatory agencies increase emission requirements and fuel costs increase, electronic injection could assist the overall engine system is meeting those emerging emission requirements and mitigate fuel cost by increasing fuel economy.

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[2] Effects of Fuel Injection Rate on Combustion and Emission in a Direct Injection Diesel Engine SAE 981929; August 1998; Terukazu Nishimura - Isuzu Advanced Engineering Center LTD.

KEYWORDS: Fuel Injector; Fuel Pump; Common Rail Fuel System; Direct Injection; Diesel Engine; Emission Control

N10A-T034 TITLE: Naval Special Warfare (NSW) Underwater Secure Text Messaging and Diver Locater

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

ACQUISITION PROGRAM: PMS NSW/NSW GRU3

OBJECTIVE: Provide Naval Special Warfare (NSW) operators a way to communicate between each other and provide a diver locater capability to know the location of each diver during a NSW waterborne insertion and extraction.

DESCRIPTION: Naval Special Warfare (NSW) operators need a way to communicate between each other and provide a diver locater capability to know the location of each diver during a NSW waterborne insertion and extraction. Much of this capability is currently resident in the 40 lb Mk 107 Mod 0 Hydrographic Mapping Unit (HMU) the SEALS use for hydrographic reconnaissance missions. The HMU serves a variety of functions in that mission, but it is too large to carry in situations where only the communication component is required. A much smaller, wearable unit is needed to enhance capability and ensure diver safety in a wider variety of waterborne insertion / extraction missions.

The diver locator function is increasingly constrained by data from relative positions between divers (nodes); however, increased numbers of nodes will reduce the BW available for each node and/or increase the probability of collision. A successful secure text messaging/diver locater system should support at least six communication nodes at ranges up to 1000m separation and incorporate code, time, or frequency division multiplexing, as required to enhance the probability of reception and reduce errors.

PHASE I: Design and demonstrate through simulation or limited testing the potential to develop a secure text messaging/diver locater for divers. This phase may or may not include actual hardware testing.

PHASE II: Demonstrate a secure text messaging/diver locater system in a realistic environment. This phase will include development of hardware. A completely functional prototype is not required; however, the feasibility and the expected performance of a fully operational messaging system should be clearly evident within the demonstration.

PHASE III: A successful secure text messaging/diver locater system has the potential to transition into the PMS NSW Diving Program of Record. SECRET clearance may be required for Phase III.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Teledyne RDI already offers the MapTac Diver Navigation and Mapping Console, designed to assist commercial divers in reconnaissance and mapping applications. The market for adding a text messaging capability to this type of product clearly exists and could well expand into recreational and instructional diving.

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1. Colucci, Frank - Diver Navigation (Available at: http://www.special-operations-technology.com/sotech-archives/167-sotech-2008-volume-4-issue-3/1524-diver-navigation.html).

2. Teledyne RD Instruments Navigation Capabilities Guide (Available at: http://www.rdinstruments.com/app_notes/trdi_nav_bro_0507_lr.pdf)

KEYWORDS: Diver; Acoustic; Communication; Navigation; locater; messaging

N10A-T035 TITLE: Mathematically Rigorous Methods for Determining Software Quality

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop mathematically rigorous methods for determining the quality of software modules when the system implementation of the code is not well known, i.e., input parameter values are unlimited. Of particular interest is the ability to independently determine software vulnerabilities that can be intentionally exploited or unintentionally triggered.

DESCRIPTION: Accreditation of software systems is currently possible only on a system-basis in the operational environment it is to be used. NOTE: the intent of this topic is to manage general cases that don't meet type accreditation methodologies. A fundamental understanding of software vulnerabilities does not exist including, but not limited to loops, recursive algorithms, access to memory registers, trap doors, interface with the operating system, and routine calls. This fundamental understanding is necessary to develop tools to have provable software performance with out knowing input parameter ranges and implementation of the software module.

Statistical methods have proven to be too coarse for the required level of analysis. Model-based methods offer promise, but again, can only offer performance equivalent to the granularity of the model. Preferred approaches would be mathematically rigorous, or highly detailed analytic methods.

PHASE I: Develop the mathematical or analytic-based software quality determination technique. Validation of selected software modules would be a plus.

PHASE II: Develop computer algorithms based on the basic Phase I work. Validate the algorithms is several test scenarios with software modules of known quality.

PHASE III: Analyze commercial and military software modules. Commercialize the computer algorithms. Determine the extensibility of the module-based approach through comparison with current system-based methods.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Commercial industry has needs similar to the military in protecting computer information systems and the critical infrastructure which they monitor and control. Cost effective, provable methods for software quality are also important to the commercial sector.

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KEYWORDS: software reuse; commercial software; operating system; software vulnerability; software accreditation; software validation

N10A-T036 TITLE: Mitigation of USV Motions via Wave Sensing and Prediction

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors

ACQUISITION PROGRAM: PMS403

OBJECTIVE: To develop a system for mitigating the motion of an unmanned surface vehicle (USV) in a seaway.

DESCRIPTION: A boat's coxswain visually reads the waves before they get to the boat and adjusts the course of the boat to mitigate its motions and reduce the chance of capsizing. There is a significant predictive component in the coxswain's control decisions. Unmanned surface vehicles (USVs) do not have the benefit of a coxswain reading and predicting oncoming waves - existing autonomous control systems are not aware of the wavefield. This makes the USV susceptible to excessive motions, which may degrade mission performance, or capsizing. A system that is capable of emulating the coxswain's actions: visualizing oncoming waves, evaluating a set of possible courses and choosing the course that best mitigates the motions, would increase the operating envelope of the USV.

The Navy seeks approaches for reducing the motions of a USV in rough seas. The proposed solution should: (1) rely on prediction or anticipation of the waves for an appropriate time into the future given the typical speed of a small boat (10-40 kts) and the necessary reaction time; (2) rely only on sensors and computation that resides on-board the USV; (3) be compatible with operation on a small (<40 ft length) boat in terms of space, weight, computational requirements, compatibility with the maritime environment and susceptibility to boat motions, shock and vibration; (5) be integrable with an existing USV control system. The proposed solution should consist of sensor(s) and algorithms that allow the USV to sense and predict waves prior to their interaction with the USV and enable the USV to follow a course that minimizes the wave-induced motions. Proposed solutions should incorporate a sensing modality for waves. The wave information would be provided to the USV control system to influence its navigation to mitigate the USV motions. A number of prior efforts, include previous SBIRs, have focused on synchronizing relative ship/USV motion during recovery operations [Ref 1] , placed a wave sensor on the host ship and not the USV during recovery operations [Ref 1], or on reactive (not predictive) motion sensing and mitigation systems onboard the USV [Ref 2]. None of these efforts have focused specifically on development of a wave sensing and prediction capability that resides entirely on-board the USV.

The Navy will only fund proposals that are innovative, address science and technology, and involve technical risk. Proposals that address hullforms or that seek to develop new USV control systems are not within the scope of this Topic. General information regarding the US Navy's vision for USV can be found in the USV Master Plan [Ref 3].

PHASE I: Develop a conceptual design of the proposed solution. Demonstrate scientific merit and capabilities of the proposed solution. Demonstrate proof-of-concept. Describe how the concept would interface with the USV (physically, electrically and logically). Identify areas of highest risk and how those risks would be managed.

PHASE II: Fabricate a prototype system that could be integrated onto a USV in Phase III. Test prototype system on a platform of opportunity, which could be a manned boat.

PHASE III: Integrate and test on a USV.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The system developed under this Topic has application to unmanned surface vehicles supporting many maritime industrial areas including; oceanographic survey, off-shore oil exploration and salvage ships, shipping industry, Coast Guard and the Border Patrol. In addition, this system has application to manned craft.

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2. F. Khorrami. http://www.imicro.biz/articles/IMI%20MSNS%20Brochure%204-29-07.pdf

3. USV Master Plan, http://www.navy.mil/navydata/technology/usvmppr.pdf

KEYWORDS: unmanned surface vehicles, usvs, motion mitigation, wave sensing and prediction

N10A-T037 TITLE: <u>Low-Cost Ball/Air/Magnetic Hybrid Bearing System for Extended-Life Micro Gas Turbine Engines</u>

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Space Platforms

ACQUISITION PROGRAM: PMA 263

OBJECTIVE: To develop a low-cost, long-life bearing system for micro gas turbine engines, which employs passive magnetic or air bearings to augment the thrust load capacity of grease-lubricated ball bearings.

DESCRIPTION: For small unmanned air vehicle (UAV) propulsion and portable power generation, miniature gas turbines (<~30 kW) could offer numerous advantages over internal combustion (IC) engines, including higher reliability, longer life, less noise and vibration, smoother torque output, and superior heavy fuel (JP5/JP8) compatibility. Their poor fuel efficiency has been an obstacle to deployment, but emerging ultra-compact recuperator and high-temperature materials technology can solve this problem. Furthermore, recuperation reduces the cycle pressure ratio at which fuel efficiency peaks, allowing a reduction in engine shaft speed. The use of multistage turbomachinery can further reduce the shaft speed while simultaneously improving the compressor and turbine efficiencies [1]. This combined strategy can enable the use of grease-lubricated bearings. Compared to present systems, which require a mixture of fuel and oil to be sprayed on the rolling elements, greased bearings would confer major improvements in simplicity, weight, and logistics. The main remaining weakness of ball bearings is a limited capacity to resist axial loads, which exceed 100 N in miniature turbine engines with 8mm-bore bearings, resulting in a typical bearing life of 25 hours.

Magnetic bearings and air bearings have been proposed as alternatives, and have many appealing features. However, passive magnetic bearings are inherently unstable when used to support radial and axial loads simultaneously, so closed-loop control systems and electromagnets must be used, which are undesirably complex, heavy, and expensive. Air bearings are used in land-based microturbines, but while they are non-contact at full speed, they rub on the shaft during startup and shutdown, and can clamp down on the shaft if operated at off-design temperatures. Radial air bearings also introduce new vibration modes due to their out-of-phase restoring force, making the design of high speed shafts supported by radial air bearings a complex task, in which subtle problems can be extremely difficult to predict in advance. Finally, air bearings are generally custom-designed for specific applications, whereas rolling element bearings are available off-the-shelf at low cost in a wide range of sizes.

A better solution might be to use greased bearings to support radial loads only, and passive-magnetic, air, or combined types to resist thrust loads. The U.S. Navy is interested in supporting the rigorous scientific analysis and testing of an innovative hybrid bearing system of this type. The preferred result would be a commercially available, low-cost, non-contact thrust bearing, capable of supporting bidirectional thrust loads in excess of 200 N, suitable for application in a miniature turboshaft/turboprop engines with an 8mm diameter main shaft. The bearings should have a service life in excess of 1,000 hours when operated at a speed of 100,000 rpm.

PHASE I: Conduct an initial development effort that demonstrates the scientific merit and capabilities of the proposed design. A lab-scale prototype thrust bearing should be tested at high speed to validate the concept.

PHASE II: Fabricate and characterize a complete prototype hybrid bearing system. Perform extended-time durability testing with rotor mass and inertia representing typical small engines, under an axial load of 200 N. Incorporate the bearing into a miniature gas turbine engine, and perform a second durability test.

PHASE III: Produce and supply non-contact thrust bearing systems for miniature turbine OEMs.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Successful development should enable design engineers to develop miniature gas turbines for combined heat and power (CHP), residential natural gas backup power systems, and miniature generators for recreational vehicles and boats. Small, quiet, efficient microturbines with minimal maintenance requirements would be exceptionally attractive in these markets.

REFERENCES:
[1] Vick, M.J., Heyes, A.L., and Pullen, K.R., "Design Overview of a Three-Kilowatt Recuperated Ceramic Turboshaft Engine", GT2009-60297, presented at ASME Turbo Expo 2009, Orlando, FL.

[2] Wilson, D.G., and Korakianitis, T., 1998, The Design of High-Efficiency Turbomachinery and Gas Turbines, 2nd. Ed., Prentice Hall, Upper Saddle River, NJ, pp. 564-565.

[3] Heshmat, H., Tomaszewski, M.J., Walton, J.F., 2006, "Small Gas Turbine Engine Operating with High-Temperature Foil Bearings", ASME Paper GT2006-90791, presented at ASME Turbo Expo 2006, May 8-11, Barcelona, Spain.

KEYWORDS: Microturbine; Turboshaft engine; Bearings; Portable Power; UAV Propulsion; Heavy Fuel.

N10A-T038 TITLE: Translation of Mission Directives to Behaviors Including Thresholds in Autonomous Undersea Search Sensor Elements of Distributed Sensing Systems

TECHNOLOGY AREAS: Information Systems, Sensors, Weapons

ACQUISITION PROGRAM: PEO IWS, Under Sea Warfare Decision Support System (USW DSS), ACAT IV

OBJECTIVE: Develop an actionable methodology by which to translate a "mission control directive" resulting from a warfighter's selection of a course, one that represents both the relevant information and operational priorities, into a set of rules by which to control the thresholds for the execution of the set of behaviors available to it in response to the discrete events, not completely knowable in advance, which occur during the execution of that mission.

DESCRIPTION: Autonomy has meaning in the context of some purpose in which a trusted agent is granted authority to locally make discrete decisions, including explicitly the expenditure of resources, in order to achieve some agreed upon purpose. It is reasonable that such a working definition that is applied to warfighters and to S&T managers alike should apply also to the robots themselves. In the case of undersea sensors operating at a severe disadvantage in latency in both data exfiltration and receipt of operational guidance, there is a great need for methods to reduce the amount of information which must be transmitted to and from a central command and control authority. The guidance from the central control authority should be the minimum required to maintain field-level group performance characteristics. The data and information from the autonomous sensors nodes should be the minimum necessary to provide some requisite level of confidence that the expected field level performance is being achieved and to make reports that demand action. An important measure of performance will be the effectiveness of individual node adaptation relative to the amount of information transmission required.

PHASE I: Identify a viable concept for the specification of a mission level control directive in a manner which both captures the reasonable expectations of the warfighter relative to the competing performance objectives and does so in a manner that allows the automata to adaptively and locally manage the thresholds for actual behavior set available to it. Perform modeling and simulation necessary to validate the efficacy of the proposed approach. Include a method by which to compare actual achieved performance to the a priori expectation of achievable performance for the course of action defined by the control directive.

PHASE II: Develop, demonstrate and validate an algorithmic approach based on Phase I work. Demonstrate the utility of the methods to the closely related problem of defining the actual set of behaviors that should be made available to the autonomous sensor. Implementation will be in the form of a service or set of services suitable for subsequent incorporation within a use case in open-services architectures. The warfare application specific data associated with the Phase II demonstration might be classified.

PHASE III: The algorithmic approach will be developed and validated within actual ASW and/or MIW autonomous sensor systems in a manner consistent with the command and control system that issues the control directives. Particular emphasis will be paid to providing feedback to the operator that either confirms that the expected level of performance has or is being achieved or the information necessary to understand the most likely sources of that performance mismatch.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Coast Guard searches, like MIW and ASW searches, frequently start by simply dividing the area to be searched into separate areas and then allocating resources to best "mow the grass" in the areas. This rigid enforcement of such a narrow set of behaviors fails to take advantage of important relevant prior information.

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KEYWORDS: autonomy; adaptive; distributed; sensor; control; search

N10A-T039 TITLE: Autonomous Landing at Unprepared Sites for a Cargo Unmanned Air System

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Sensors

ACQUISITION PROGRAM: AACUS Candidate INP and Potential Support of future Marine Corps Cargo UAS

OBJECTIVE: To develop autonomous control systems for safe and robust autonomous vertical landing at unprepared sites with terrain slopes of up to fifteen degrees at potential landing sites. The system should be robust to environmental conditions and minimize the cost, weight, volume, and power requirements for sensing. It should also minimize the amount of ground equipment that is required and the manning requirements to operate the system safely and robustly.

DESCRIPTION: There is currently interest in a Cargo Unmanned Air System that could be used to transport supplies to Marines at remote and unprepared sites. Some system capabilities that are of interest include: (1) Operate autonomously, beyond line-of-sight, (BLOS), (2) capable of command and control with remote terminal control capability at a site BLOS from the original launch site, (3) terminal control cargo delivery accuracy within ten meters, (4) cargo lift operations at a 12,000 ft DA, (5) 150 nautical mile round-trip range, (5) operate in all-weather conditions, comparable to Marine Corps CH-47, (6) operate at night with overt and covert lighting, (7) capability of en-route re-programming to alter delivery points, (8) capable of carrying a standard pallet sized load, (8) Be able to launch the Cargo UAS within 45 minutes of receiving tasking from the Marine Corps. There are a number of systems that have been developed to allow for autonomous vertical landing of unmanned air systems. However, these systems are typically designed for landing on flat surfaces and may have significant limitations in terms of robustness to disturbances and their ability to compensate for any obstacles around the site. Further, these systems may require significant hardware at the ground location and/or operators with a high degree of skill and training to enable the system to be used safely and robustly.

The goal of this topic will be to develop the integrated control algorithms and sensing system to enable autonomous landing at unprepared sites with terrain that may include slopes of up to 15 degrees at potential landing sites. Users at the landing site may provide some support. However, a goal should be to minimize the amount of hardware required at the landing site and minimize the amount of skill/training required by users to utilize the system. Further, the goal of this effort is to develop platform or sensor hardware and existing hardware or hardware from other programs should be used to the greatest extent possible. .The approach should be robust to environmental factors and minimize the sensing requirements to enable such a system including cost, weight, volume, and power. Another important goal of the effort will be to ensure any approach is not a point design suitable only for a single type of configuration, but can be applied to a broad range of unmanned air vehicles including future designs. Finally, analysis and certification techniques to ensure the approach is safe and reliable will be important, and must be considered in the design of the approach.

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

PHASE I: Phase I will provide initial development of the control and sensing algorithms and experimentation using a limited-fidelity simulation or inexpensive hardware testing, if feasible. Simulation should include models of a platform, the sensing approaches, and the relevant environmental phenomena at a reasonable level of complexity and uncertainty (although not necessarily a high degree of fidelity). Phase I should also develop a set of sensing requirements for the particular approach and estimate the cost, weight, volume, and power requirements of the sensing approach and of the processing power required to run all on-board algorithms. Relevant metrics for the simulation proof of concept may include the probability a hard landing relative to different environmental conditions and touchdown dispersion. Manning issues should also be taken into account.

PHASE II: Phase II shall allow for further development of the algorithms and testing using a combination of higher fidelity nonlinear 6- Degree-of-Freedom aircraft model with sufficient complexity for a proof of concept and hardware in-the-loop or flight testing using inexpensive surrogates. This should include some operator in-the-loop testing. Phase II will also allow for refinement of sensing requirements.

PHASE III: Phase III will develop a software package for use by government and industry to apply the proposed algorithms to a wide range of air systems. Phase III may also allow for experimentation on a larger UAS and/or integration with an existing software system.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: This technology would be relevant to a wide range of civilian uses of unmanned air systems including first responders, environmental monitoring, law enforcement, and park service.

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KEYWORDS: unmanned air system; autonomous control; autonomous landing

N10A-T040 TITLE: Complex Event Detection in Video and Communications

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: PM Intel

OBJECTIVE: The goal is to investigate the potential for automated threat warning of complex events using Complex Event Processing (CEP) techniques against video and communication streams. Near real-time monitoring of multiple events can be achieved through CEP technology. Warfighters combating terrorism could benefit from capability for detecting and tracking at-risk individual and group behavior and was able to alert units in time to disrupt threats. In particular, video and communications data streams contain a great deal of information and need to be sorted quickly. The objective system would be able to detect and warn against a complex event based on a series of individual behavior detections in both video and communications data. Recent experimentation at Empire Challenge (Green Devil) clearly demonstrated the potential of enhanced cross domain analysis.

DESCRIPTION: Achieving actionable intelligence requires rapid response by operators. Navy and Marine Corps personnel need to anticipate terrorist actions. Threatening complex behavior is a hostile act that requires a series of human actions be taken in advance. For example, an assault on a specific place can involve planning and logistics activity as well as the coordinated movement of multiple actors. CEP could automate complex event monitoring and speed response. Capability is needed to detect, sort, store and prioritize complex events using heterogeneous data sources and in a Service Orientated Architecture (SOA). Individual video detections may include (but not limited to) the detection of a meeting, coordinated movement, speed and/or track anomalies. Individual communication anomalies may include (but not limited to) network flow or volume changes. The desired CEP engine needs to ingest a stream of anomalies from multiple cameras and network analysis utilities and reliably find instances of threatening complex behavior. In a SOA, data and functionality are exposed as reusable services described using common standards for transport (e.g. HTTP, JMS, etc.), discovery (e.g. UDDI) and access (e.g. WSDL). It is important to have applications sufficiently described so they can be used in conjunction with other applications as orchestrated services.

Making sense of evolving situations requires event processing technology and domain specific expertise. Complex events can be inferred from simple events. Similarly, activities and thought processes can be inferred from observed sequences of behaviors. A sliding window can be used to capture streaming data, CEP used to detect events, and rules used to determine activity patterns of significance. Technology developed should support real time data streams, build event relationships and handle uncertainty [1]. Recently, several CEP engines have been released and assessment of applicability to this problem domain is necessary [2]. A CEP framework should be flexible, independent of workloads, neutral of engine used, offer correctness checks, and be scalable.

Business Process Management (BPM) can be used to optimize information workflows needed for collection and processing. An Event Driven Architecture (EDA) can be used for loosely coupled services with event emitters (agents) and consumers (sinks). EDA supports asynchronous data flows in a SOA environment. SOA, BPM, EDA and CEP are complimentary [3]. It is hoped that these or other methods taken will reliably detect state changes indicative of terrorist actions and/or attacks. The topic challenge is to provide a real time predictive tool relevant to processing large Imagery and Communications data streams.

The Navy is interested in innovative R&D that involves technical risk. Proposed work should have technical and scientific merit. Creative solutions are desired.

PHASE I: Complete a feasibility effort that clearly retires technical risk. Select one or more complex behaviors that can be observed in streams of video and communications data to show a proof of concept. Demonstrate how a CEP process could be used for monitoring data streams in order to alert operators of threatening complex behavior. Provide an architecture that supports the maturation of a fieldable system.

PHASE II: Produce a mature prototype system that is capable of ingesting and processing large data streams (individual event streams from many video and communications feeds) in order to provide the warfighter advance notice of a hostile complex behavior. The system should be automated and capable of alerting operators in a timely manner. In this phase, the device should operate in a simulated environment and use CEP to detect specific sequences of activities and predict attack locations and times. An initial capability should have a probability of activity detection of 90% and false alarm rate below 10%. Option efforts should result in a successful test in a relevant environment, which will probably require processing classified data.

PHASE III: Produce a system capable of deployment and operational evaluation. The system should address threats to a specific operational environment (e.g. attacks on roadway convoys, checkpoints or ports). It should operate in a distributed SOA environment, handle multiple data streams, use CEP with rules sets, and be intuitive with little training required. Evaluation of accuracy of alerts and false alarm rates will be made by system operation in an exercise or field environment suitable for the product application.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Commercial applications of CEP include stock market trading, credit card fraud detection, business activity monitoring, and network security monitoring. Businesses can benefit from CEP for activity monitoring, performance management and quality assurance to detect event exceptions in real time. Law enforcement can benefit by CEP for sensor monitoring to protect civilians and public facilities from criminal activity. Transportation can benefit by use of CEP for monitoring air, ground, or land traffic, identifying disruptions due to congestions, accidents or weather events and rerouting traffic. For all applications, effectiveness is enhanced and cost savings gained by modular and net-centric designs.

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KEYWORDS: complex event processing, counter terrorism, cognitive science

N10A-T041 TITLE: <u>Fracture Evaluation and Design Tool for Welded Aluminum Ship Structures Subjected to Impulsive Dynamic Loading</u>

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

ACQUISITION PROGRAM: PMS-385 "Joint High Speed Vessel" and PMS-501 "Littoral Combatant Ship"

OBJECTIVE: Develop an efficient fracture analysis and design tool to characterize dynamic failure of welded aluminum ship structures in the presence of material anisotropy, rate dependence, material heterogeneity, and multisite damage. Transition the resulting analysis capabilities into design and certification processes for improved aluminum ship performance and reliability.

DESCRIPTION: Weight and performance needs for the current and future U. S. Navy demand optimal lightweight aluminum ship structural systems. High-speed, multi-hull aluminum vessels experience high strain rate loading resulting from extreme loading events such as the wave slamming. The presence of material heterogeneity, reduced HAZ strength, crystallographic texture induced material anisotropy, rate dependent properties, and arbitrary crack initiation and propagation patterns make the current commercial off-the-shelf numerical simulation tools intractable. The US Navy is facing great challenges in the selection of appropriate design codes and analysis tools and adequate experimental validation procedures to assure performance and integrity of the aluminum ship structure in the presence of unexpected extreme loading events. The test driven design and certification approach is costly and reduces the ability to achieve an optimal design. A new analysis tool combined with an experimental validation protocol is needed to accurately characterize the dynamic response and fracture behavior of welded aluminum ship structures subjected to extreme loading events.

The goal of this effort is to develop an explicit dynamic failure prediction toolkit for fracture assessment of welded thin-walled aluminum structures. To efficiently characterize a large size ship structure, innovative modeling techniques using fractured shell elements are needed along with a mesh independent crack insertion and propagation capability. In addition to innovative crack simulation in a shell structure, advanced constitutive models have to be implemented in the toolkit to capture the rate dependence and anisotropy in strength, plastic flow and ductility. Developing and demonstrating novel damage simulation and fracture prediction methods has significant potential impact on design and operation of current and future Navy welded aluminum, ship structural systems.

PHASE I: Demonstrate feasibility of the analysis approach applicable to arbitrary crack insertion and dynamic fracture simulation in thin wall, welded aluminum ship structures. Evaluate the efficiency and accuracy of the failure path prediction using dynamic fracture data of welded aluminum panel. Propose a conceptual design for a prototype software/toolkit to perform explicit dynamic response and fracture of large scale aluminum welded structures.

PHASE II: Implement and integrate analytical solution modules into a toolkit that can be commercialized. Fully develop all the solution modules including texture-based polycrystal yield surface and flow rule, rate dependent stiffness and strength characterization module, mesh independent fractured shell representation, mesh independent crack propagation, and user-friendly interface for damage insertion and display of fracture pattern and fracture parameters. Perform a through validation at subcomponent and component level for multi-bay stiffened aluminum panels in the presence of flaws/damage subjected to dynamic loading.

PHASE III: Demonstrate implementation and integration of an analytical solution toolkit that can be commercialized. Development of the resulting toolset may require further investment to meet specific and various user-base requirements requirements in application for design and analysis in cases of dynamic loading for welded aluminum structure. Ship-type application component fracture prediction validation should be sufficiently met via Phase II supported development, with follow-on Phase III investment targeted at ship hull (system-level) structural fracture evolution evaluation .

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Dynamic fracture in welded aluminum structure is not unique to high speed naval vessels; it is equally prevalent in the commercial marine industry, and pipe and auto industry. The innovative analysis tool developed in this program can have great potential for civilian sector to improve aluminum structure performance and reliability under extreme loading events.

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KEYWORDS: welded aluminum panel; mesh independent method; dynamic fracture; debonding; anisotropy; rate dependence

N10A-T042 TITLE: Advanced Data Processing, Storage and Visualization Algorithms for Structural Health Monitoring Sensor Networks of Naval Assets

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Sensors

OBJECTIVE: To develop a minimalistic, yet powerful, distributed network of sensors and actuators together with innovative mathematical and computational algorithms to process, store and visualize massive amounts of data generated from said system to enable quantitative structural health monitoring of Naval assets (ships and aircraft). The objective is to develop a complete and detailed assessment of the material/structure condition well before any visible signs of deterioration develop by using a permanently installed network of sensors and actuators and interrogating them only during scheduled stops or during scheduled maintenance intervals. The goal of the project is not computational speed but material state accuracy.

DESCRIPTION: A highly reliable, minimally invasive system for materials state awareness of Naval structures (ships and submarines) as well as next generation weapon systems is critically needed. Our inability to test new material systems (or even exiting materials systems) under all possible structural geometries or configurations, under all loading conditions (static or dynamic), under all sea state conditions, and under all environmental conditions (temperature, humidity, pH) implies that it is virtually impossible to predict degradation in structural performance or when a component or structure will fail. As a result the Navy has traditionally assigned large margins of safety to its structures in order to guaranty operational viability, often negating or crippling the reasons for using such materials in the first place. A material state awareness system could mitigate such a situation.

The goal of this program is to develop a minimalistic, yet powerful, distributed network of sensors and actuators that is highly reliable (will last the operational life of the platform), has built in some degree of redundancy (sensors and actuators will not be repaired, or replaced) and has minimum wiring requirements. The equipment required for powering the network and collecting the sensor data will be stowed away all the time except during scheduled stops or during scheduled maintenance. The aim is to minimize alterations to the structures (opening sealed hatches, paint or coating removal, surface preparation) by having a network of sensors and actuators in place, but having the possibility of interrogating the system when needed using advanced data acquisition systems combined with powerful mathematical, computational and visualization tools. The key to success is high data quality combined with powerful mathematical and computational tools.

The expected outcome of this STTR project is a reliable actuator/sensor network with minimal wiring requirements that when combined with powerful excitation/deconvolution equipment and advanced data processing, storage and visualization techniques allows the precise material state condition specification before any visual sign of damage develops.

PHASE I: During the phase I the contractor will develop a lab bench prototype material state awareness distributed network of sensors and actuators. The network will be mounted on a large 36"x72"x¼" aluminum panel with a doubler on the center of the panel and across its entire width. The doubler will be mechanically fastened to the main panel with two rows of fasteners separated 1” apart (between rows and fasteners). This will allow for the introduction of damage in the fastener holes and in the faying surfaces with relative ease. The contractor will also develop mathematical tools to analyze, store and visualize the panel material state. It is anticipated that the system will need to monitor the temperature and the strain of the structure being interrogated.

PHASE II: During the Phase II the contractor will scale up the system to enable interrogation of structures with much greater size and with much more diverse structural details such as structural ribs, stiffeners and bulkheads as well as complex composite construction such as sandwich core or rib stiffened structures. The ability to assess welded joints both in-plane and T-joints as well as to identify fatigue crack initiation and growth should be included. The contractor will need to demonstrate that the system is ruggedized, showing that it is capable of surviving the ship or aircraft environment, such as is identified in MILSTD 810 which can be used as a guide. The contractor will also optimize the mathematical and computational tools that demonstrate the ability to accurately identify and locate various forms of damage and damage precursors or material state. The contractor will determine and demonstrate the sensitivity of the system by inspecting representative structural applications with varying levels of damage. Finally, the contractor will determine the reliability of the system, including the attachment method (following MILSTD 810) by installing the system on a representative Navy application. This will include the demonstration of the reliability of the mathematical and computational tools to assess the state of the material/structure.

PHASE III: A material state awareness system of this nature could be installed in many DoD platforms (including destroyers, cruiser, amphibious ships, submarines, fighter, patrol and transport aircraft) which have key structural components (such as pressurized bulkheads, rudders, propellers, superstructures and wing attachment point) that require damage evolution monitoring. The contractor will need to demonstrate that the system is fully functional and capable of surviving the ship or aircraft operational environment, which will included large temperature variations, high moisture, high g-loading from maneuvering and/or underwater shock .Significant cost savings could be achieved by the installation of such a system and therefore, performing maintenance at longer time intervals or only when the system indicates that it is required. The contractor, in collaboration with the Navy monitoring team, will seek a potential military application and/or demonstration during Phase III

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The commercial shipping industry would benefit significantly from a system of this nature as well. The same problems that exist in Naval platforms (ships, subs and aircraft) are also found in commercial platforms. For example, wide spread area fatigue damage has been determined to be a major source of problem for commercial aviation.

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KEYWORDS: Sensors, Mathematical Algorithms, Material State Awareness, Structural Health Monitoring, SHM

N10A-T043 TITLE: Miniature, Portable, Device to Detect and Monitor Coagulopathy

TECHNOLOGY AREAS: Materials/Processes, Biomedical

ACQUISITION PROGRAM: FNC Force Health Protection

OBJECTIVE: To develop a device that will detect coagulopathy and monitor the effectiveness of blood product replacement therapy.

DESCRIPTION: Blood loss through a traumatic injury presents unique challenges to caregivers. Perhaps the biggest challenge is the development of coagulopathy (failure of blood to clot appropriately) in patients with severe trauma. Correction of coagulopathy is done largely though administration of blood components such as plasma and blood platelets (all of which are essential to clot formation) and this management strategy is termed blood component replacement therapy). Component replacement therapy can be guided by the use of thromboelastography (TEG), which is a technique that measures, in vitro, the viscoelastic properties of blood as it is induced to clot. TEG provides information on changes in shear-elasticity which allow determination of the kinetics of clot formation as well as the strength and stability of the formed clot. The kinetics determine the adequacy of factors available to clot formation (primarily in plasma) while the strength and stability of the clot (a function of platelets) provides information about the ability of the clot to perform the work of hemostasis. The TEG data can provide a quantitative basis for administration of components (which are currently administered as ratios). Current TEG devices are large (table top) and delicate. Therefore, the need is for a low cost, portable, ruggedized device to detect coagulopathy and to monitor the effectiveness of replacement therapy at Level II and III medical treatment facilities (MTFs).

PHASE I: Demonstrate the scientific and technical merit and feasibility of the proposed miniature device for the detection and monitoring of coagulopathy. Provide schematics for proposed device. Effectiveness, size, weight, simplicity of design, maintainability and ruggedness are main performance characteristics.

PHASE II: Demonstrate and validate technology. Bench top demonstration of technology for initial validation occurs in Phase II. Validation will entail testing of blood samples from a coagulopathic animal model and results must not be statistically different from those obtained from currently accepted laboratory diagnostic protocols.

PHASE III: Produce ruggedized prototype device, conduct market analysis, and obtain FDA 510k approval for device.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Successful development of the highly effective portable device will present a new and affordable approach for the detection of a medical condition where blood no longer clots as required (coagulopathy). This product can be used in military, emergency medicine, and all other medical fields associated with trauma.

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KEYWORDS: Thromboelastograph; hemorrhage; coagulopathy; blood clotting; replacement therapy; TEG-like

N10A-T044 TITLE: Adaptive Fleet Synthetic Scenario Research

TECHNOLOGY AREAS: Information Systems, Sensors, Battlespace, Human Systems

ACQUISITION PROGRAM: SPAWAR PEO C4I PMW-120 Ships Signals Exploitation System (SSEE)

OBJECTIVE: Investigate algorithms and human interfaces to automatically generate multiple-source (communications, imagery, tracking) training scenarios that are realistic for a mission, easy to modify, compose, and regenerate.

DESCRIPTION: Scenario development for synthetic fleet training is highly complex and involves a great deal of human effort and domain knowledge. Similar past programs typically use scenarios that are used to train a particular mission within an area of responsibility. Platforms, multi-source events and associated data feeds that augment the scenarios with realism are tediously hand edited using different tools and simulators. This expense and tedium makes the developed scenario expensive and discourage potentially important modifications for various situations and current-day problems.

Multi-source training adds even greater complexity because many tools and simulators are written with special purposes in mind. They are good at what they do, but suffer from an inability to operate or regenerate their scenarios based on what other special purpose simulators have done. The special purpose simulators are important but they need an ability to see outside their domain and adapt to other specialized processes. The more the ability of cooperative production is hampered the more human involvement is required to overcome the impairment. These problems are readily apparent in today's Fleet Synthetic training.

The topic will search for an innovative way of developing correlation algorithms to fuse data sources in the creation of real world scenarios. The algorithms must contain knowledge of reasonable realism across information domains while at the same time use a framework that supports a service-oriented architecture (SOA).

The topic's technical goals are to create correlation and fusion algorithms that derive scenario generation across many data sources (communication, imagery, tracking), minimize the need for user scenario creation interaction and create a presentation layer that makes the scenarios to be easily managed by the end user. The new capability will provide support for multi-dimensional missions and reduce the cost and speed at which realistic and hyper-realistic scenarios are created and tailored. The composite operational picture will be driven by processes that create, recreate and adapt their scenario generative capabilities based on what other scenario generative processes are doing. As stated before, past research has been done from the software architecture, communication, and federation aspects, such as the High Level Architecture and the Runtime Infrastructure. This STTR will focus on the research for making the process of generating scenarios more automated and realistic which will reduce the time, manpower and cost for Navy Programs of Record that would benefit from this technology.

PHASE I:
• Research techniques to make auto generative processes that ease the ability of creating highly realistic scenarios with less tedium. These generative aspects must be easily tailored by the operator, be mission relevant, and may be deterministic or stochastic in nature.
• Illustrate that these processes can be hooked into a scenario creation toolset, to create an easy to use environment.

PHASE II:
• Create a series of algorithmic processes that understand each data source and provide building blocks to minimize user interaction.
• Create a generic data framework to allow the algorithms to operate on.
• Create a set algorithms which can be weighted based upon a data importance and relevance to other data sets.
• Create an easily useable web interface which provides the scenario creation tool.
• Test across a select group of multi-source event data such as communications, imagery and tracking.

PHASE III:
• Support transition to a PEO C4I PMW-120 program of record.
• Tailor to train a larger set of multi-source products and provide wider reaching scenarios across various PEO C4I domains (communications, imagery, networks).

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:

Homeland security and first responder scenarios can greatly benefit from better scenario based training.

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KEYWORDS: Training Exercises; Skill Acquisition; Team Training; Tailored Training; Live, Virtual & Constructive Training; Distributed Mission Training

N10A-T045 TITLE: Development of Navy Wave Rich Collaboration for Command and Control

TECHNOLOGY AREAS: Information Systems, Sensors, Human Systems

ACQUISITION PROGRAM: Global Command and Control System - Maritime (GCCS-M)

OBJECTIVE: Design and develop a Navy distributed Maritime C2 collaboration capability ("Navy Wave") that applies emerging Google Wave protocol standard. Design a solution that models the Google Wave collaboration framework to create an equivalent capability, including the three plug-in interfaces: Robots, Gadgets, and Embed APIs. Extend the Navy Wave framework through decoupled components, using the plug-in APIs as needed to meet Navy-unique purposes, constraints, and the doctrine (NWP 3-32) of Decentralized Execution and Self-Synchronization to support the Commander's Control Actions: (1) Counter the Enemy, (2) Adjust Apportionment, (3) Maintain Alignment, (4) Advance the Plan, (5) Comply with Procedure, and (6) Situation Awareness of all of the above among the subordinate commands and units.

DESCRIPTION: Navy warfighters at the Operational Level of War (OLW) and echelons below are constantly engaged in widely distributed missions. These missions require collaboration between operators ashore and afloat, over communication channels that are often disconnected, intermittent, and limited (DIL). Though modern communications technologies provide some ashore and large deck afloat platforms tools like video teleconferencing and voice-over-IP (VOIP), many Navy operators do not have the required bandwidth. And the bandwidth required for voice and video may not be available in a time of crisis. Therefore, users still rely on standard text chat and file transfer. Text and files are also searchable, and can be scanned quickly, unlike video and audio. However, current tools for chat and file sharing (such as Collaboration at Sea – CAS and Net-Centric Enterprise Services – NCES Collaboration) are inadequate for maintaining context. In addition, technical underpinnings of today's chat and file sharing tools are nearing obsolescence, meaning increased lifecycle costs to maintain, and a lack of agility when it comes to integrating with other modern technologies.

Industry leader, Google, has recently launched a groundbreaking technology called Google Wave, which promises to offer a new paradigm for Internet collaboration, combining the best capabilities of XMPP collaboration, instant messaging, email, Wiki documents, and file sharing. Wave is also two-way interoperable with the web in that Waves can be embedded in web pages, and web content can be embedded in waves through gadgets. Knowledge context can be maintained with complete version tracking (even with embedded gadget state), with support for playback and rewind. And Waves can be enhanced with Robots that monitor and interact with a Wave upon request, for simple text enhancements, or theoretically to offer more sophisticated knowledge agent capabilities, i.e., to monitor potential needs based on the conversation, and suggest available information or resources. Google has announced it will open source the Google Wave client and server technologies, and is submitting the Google Wave XMPP-based protocol specification for industry standardization.

Innovation is required to develop an equivalent capability for use in a high operational tempo, high demand environment with limited communications. The open source baseline for Google Wave may be able to be tailored to a Navy C2 network to create a "Navy Wave" federated implementation, with specific application extensions and procedures for Navy-specific problem domains. Google Wave is a new concept, with extreme promise for knowledge management and context, and this topic will explore all features of Google Wave to develop practices and extensions to support Navy C2 processes including collaborative problem analysis, collaborative planning, knowledge sharing, knowledge awareness (searching and registering for critical information requirements), knowledge context (including versioning as well as embedding waves in web documents, and C2 apps inside Waves), instant messaging, status monitoring, and query-and-response applications (such as to learn the readiness status of a Navy platform). Performance should approach that of standard IRC and XMPP Chat services used by the Navy today in varying network states, including the ability to maintain context during network outages, and continue the conversation Wave when the link is restored.

PHASE I: Evaluate open source Google Wave software, and assess the feasibility of building a Navy-specific implementation based on the open source version of Google Wave (a.k.a., "Navy Wave") server and client. Determine if and how a Navy Wave implementation could be extended with Google Wave-compatible Robots, Gadgets, and Embed APIs. Develop a whitepaper that explores how a proposed Navy Wave implementation can be deployed, federated, extended, and used to enhance Navy C2 knowledge management and C2 processes. Evaluate the Google Wave protocol (based on XMPP) performance and bandwidth usage.

PHASE II: Implement and demonstrate a federated, multi-server implementation of a Navy Wave prototype. Simulate Disconnected, Intermittent, and Limited network connectivity issues, and demonstrate the ability to adapt to these conditions, without losing critical messages. Develop and/or integrate examples or mockups of likely C2 tools and processes using Wave Robot and Gadget interfaces. Develop enabling web pages, processes, and organizational tools to assist in registering interest in, discovering, and publishing knowledge as Waves. Assess and address potential security vulnerabilities.

PHASE III: Work with Navy C2 Program of Record sponsor—PMW 150 GCCS-M Program Manager—to expand prototype and prepare for transition of Navy Wave server and client into the Navy C2 architecture for eventual fielding at ashore and afloat locations. Analyze and address Information Assurance Certification & Accreditation requirements. Demonstrate Navy Wave prototype in a Sea Trial experiment and evaluated for military utility. The experiment shall be deployed on a US Navy Secret network, with at least one ashore instance, one command ship, and two or more subordinate afloat units with limited communications.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Google Wave is expected to be adopted by enterprises for enhanced collaboration. A successful implementation of a Navy Wave variant, and C2 extensions for knowledge management, planning, monitoring, and assessment should yield a technology foundation that can be similarly applied to other distributed enterprises. These Navy processes are unique only in their application domain. The technology should be adaptable to corporate environments, other Government agencies, or any other organization that manages a distributed workforce. The technology and know-how developed by the provider will support a private sector business model if desired.

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KEYWORDS: Google Wave; Federated Collaboration; Knowledge Management; Navy Command and Control; Planning, Execution, and Assessment; Chat