

**NAVY**  
**SBIR FY11.1 PROPOSAL SUBMISSION INSTRUCTIONS**

The responsibility for the implementation, administration and management of the Navy SBIR Program is with the Office of Naval Research (ONR). The Director of the Navy SBIR Program is Mr. John Williams, [john.williams6@navy.mil](mailto:john.williams6@navy.mil). For general inquiries or problems with electronic submission, contact the DoD Help Desk at 1-866-724-7457 (8:00 am to 5:00 pm ET). For program and administrative questions, please contact the Program Managers listed in Table 1; **do not** contact them for technical questions. For technical questions about the topic, contact the Topic Authors listed under each topic prior to **10 December 2010**. Beginning 13 December 2010, the SITIS system (<http://www.dodsbir.net/Sitis/Default.asp>) listed in section 1.5c of the program solicitation must be used for any technical inquiry.

**TABLE 1: NAVY ACTIVITY SBIR PROGRAM MANAGERS POINTS OF CONTACT**

<u>Topic Numbers</u>	<u>Point of Contact</u>	<u>Activity</u>	<u>Email</u>
N111-001 thru N111-005	Mr. Paul Lambert	MARCOR	<a href="mailto:sbir.admin@usmc.mil">sbir.admin@usmc.mil</a>
N111-006 thru N111-030	Mrs. Janet McGovern	NAVAIR	<a href="mailto:navair.sbir@navy.mil">navair.sbir@navy.mil</a>
N111-031 thru N111-061	Mr. Dean Putnam	NAVSEA	<a href="mailto:dean.r.putnam@navy.mil">dean.r.putnam@navy.mil</a>
N111-062	Mr. Steve Stachmus	NSMA	<a href="mailto:stephen.stachmus@navy.mil">stephen.stachmus@navy.mil</a>
N111-063 thru N111-082	Mrs. Tracy Frost	ONR	<a href="mailto:tracy.frost1@navy.mil">tracy.frost1@navy.mil</a>
N111-083 thru N111-085	Ms. Summer Jones	SPAWAR	<a href="mailto:summer.m.jones@navy.mil">summer.m.jones@navy.mil</a>
N111-086	Mr. Nick Olah	NAVFAC	<a href="mailto:nick.olah@navy.mil">nick.olah@navy.mil</a>

The Navy's SBIR 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 SBIR Program can be found on the Navy SBIR website at <http://www.onr.navy.mil/sbir>. Additional information pertaining to the Department of the Navy's mission can be obtained by viewing the website at <http://www.navy.mil>.

**PHASE I GUIDELINES**

Follow the instructions in the DoD Program Solicitation at [www.dodsbir.net/solicitation](http://www.dodsbir.net/solicitation) for program requirements and proposal submission. Cost estimates for travel to the sponsoring activity's facility for one day of meetings are recommended for all proposals and required for proposals submitted to MARCOR, NAVSEA, and SPAWAR. For NAVSEA proposals, a recommended proposal template can be found at <http://www.navysbir.com/navsea>. The Navy encourages proposers to include, within the 25 page limit, an option which furthers the effort and will bridge the funding gap between Phase I and the Phase II start. Phase I options are typically exercised upon the decision to fund the Phase II. **The base amount of the phase I should not exceed \$80,000 and 6 months; the phase I option should not exceed \$70,000 and 6 months.**

The Navy will evaluate and select Phase I proposals using the evaluation criteria in section 4.2 of the DoD solicitation in descending order of importance with technical merit being most important, followed by the qualifications, and followed by commercialization potential. 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.

One week after solicitation closing, e-mail notifications that proposals have been received and processed for evaluation will be sent. Consequently, e-mail addresses on the proposal coversheets must be correct.

The Navy typically awards a firm fixed price contract or a small purchase agreement for Phase I.

## **PHASE I SUMMARY REPORT**

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

## **PHASE II GUIDELINES**

Phase II proposal submission is by invitation only. If you have been invited, follow the instructions in the invitation. **Each of the Navy Activities has different instructions for Phase II submission. Visit the website cited in the invitation to get specific guidance before submitting the Phase II proposal.**

The Navy will invite, evaluate and select Phase II proposals using the evaluation criteria in section 4.3 of the DoD solicitation in descending order of importance with technical merit being most important, followed by the qualifications, and followed by commercialization potential. 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 does NOT participate in the FAST Track program.

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

All awardees, during the second year of the Phase II, must attend a one-day Transition Assistance Program (TAP) meeting. This meeting is typically held in the summer in the Washington, D.C. area. Information can be obtained at <http://www.dawnbreaker.com/navytap>. Awardees will be contacted separately regarding this program. It is recommended that Phase II cost estimates include travel to Washington, D.C. for this event.

The Navy typically awards a cost plus fixed fee contract for Phase II.

## **PHASE II ENHANCEMENT**

The Navy has adopted a Phase II Enhancement Plan to encourage transition of Navy SBIR funded technology to the Fleet. Since Phase III awards are permitted during Phase II work, the Navy may match on a one-to-four ratio, SBIR funds to funds that the company obtains from an acquisition program, usually up to \$250,000. The SBIR enhancement funds may only be provided to the existing Phase II contract. If you have questions, please contact the Navy Activity SBIR Program Manager.

### **PHASE III**

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

### **ADDITIONAL NOTES**

**The Navy will NOT accept Phase I proposals that require the use of Human, Animal, or Recombinant DNA. The Phase I effort is a feasibility study and should not require the use of such research.** If you are proposing human, animal and recombinant DNA use under a phase II proposal, you should view the requirements at <http://www.onr.navy.mil/About-ONR/compliance-protections/Research-Protections.aspx>. This website provides guidance and notes approvals that may be required before contract/work can begin.

Proposals submitted with Federal Government organizations (including the Naval Academy, Naval Post Graduate School, or any other military academy) as subcontractors will be subject to approval by the Small Business Administration (SBA) after selection and prior to award.

## **PHASE I PROPOSAL SUBMISSION CHECKLIST:**

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

\_\_\_1. Include a header with company name, proposal number and topic number to each page of your technical proposal.

\_\_\_2. Include tasks to be completed during the option period and include the costs in the cost proposal.

\_\_\_3. Break out subcontractor, material and travel costs in detail. Use the “Explanatory Material Field” in the DoD cost proposal worksheet for this information, if necessary.

\_\_\_4. The base effort does not exceed \$80,000 and 6 months and the option does not exceed \$70,000 and 6 months. The costs for the base and option are clearly separate, and identified on the Proposal Cover Sheet, in the cost proposal, and in the work plan section of the proposal.

\_\_\_5. Upload your technical proposal and the DoD Proposal Cover Sheet, the DoD Company Commercialization Report, and Cost Proposal electronically through the DoD submission site by 6:00 a.m. ET, 12 January 2011.

\_\_\_6. After uploading your file on the DoD submission site, review it to ensure that it appears correctly. Contact the DoD Help Desk immediately with any problems.

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 N111-081 Stealth and Real-time Program Execution Monitoring  
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## NAVY SBIR 11.1 Topic Descriptions

N111-001

TITLE: Active Laser Protection System

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors, Human Systems, Weapons

ACQUISITION PROGRAM: Pm Advanced Amphibious Assault (PM AAA) (ACAT 1)

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

OBJECTIVE: Develop innovative technology approaches to protect vehicle crewmen eyes from frequency-agile lasers.

DESCRIPTION: The proliferation of threat lasers possessing multiple wavelengths present a significant danger to ground vehicle crew members looking through direct view optics (vision blocks/unity periscopes). The present mitigation strategy to protect vehicle crewmen against fixed frequency threats is to filter lasers through narrow band spectral line rejection at the threat laser wavelengths, attenuating incident laser energy at these wavelengths, thus preventing laser radiation from damaging the eyes. The current state-of-the-art approach used to protect against frequency-agile lasers relies on nonlinear optical materials (nonlinear absorbing dyes, nonlinear scattering suspension, etc.) which must be located at the focus of an optical system in order to obtain high fluences necessary to trigger the nonlinear mechanism. Direct view optics carries with them a host of limitations and integration issues that make incorporation of nonlinear mechanisms impractical (field of view, image quality, space claim, cost and complexity, etc.). This SBIR topic solicits new, innovative approaches to provide frequency-agile laser eye protection throughout the visible spectrum. The proposed technology should allow ample transmission of ambient visible light and be of high optical quality so as not to significantly degrade normal vision. It should have a fast response time when exposed to dangerous fluence levels, sufficient to react to and block incident laser pulses to a high optical density. The technology must have a broadband response; blocking any visible wavelength (i.e. 400-700 nanometers) which has sufficient irradiance to damage eyes. The concept should be capable of changing from a high transmission state to a very low transmission state within sufficiently short time to block nearly all of the light contained in a light pulse emitted from a Q-switched laser. When harmful radiation is no longer incident, it must recover to a high transmission state in a short amount of time so that the user's vision is not interrupted or significantly degraded after exposure. The proposal should discuss in detail the spectral transmittance in the attenuating state, activation threshold, response time, optical density in the attenuating state, and recovery time of the technology, as well as any other important technical details. If the technology is capable of exceeding any of the above requirements, the proposal should note this as well. Likewise, the proposal should note any limitations inherent to the proposed technology.

PHASE I: Develop a laser protection concept designed to meet the requirements stated. Identify critical technologies for realizing this concept. Conduct theoretical analysis and limited laboratory testing on sample materials or devices to prove the feasibility of the concept. Phase I deliverables will be monthly progress reports, a final technical report, a final review and sample materials or devices.

PHASE II: Develop and demonstrate a laser protection prototype system. Prototype should be built in the form, fit and function of, or integrated for use in conjunction with, common periscopes or vision blocks on ground combat vehicles. This prototype shall be tested for laser protection performance and degradation to optical system performance in a laboratory environment. Factors to be considered include, but are not limited to, optical density upon laser illumination, response time, recovery time, linear optical properties under normal daylight illumination, manufacturability, and environmental stability. Phase II deliverables will include a prototype laser protection system, interim sample materials (if applicable), test data, monthly progress reports, semi-annual progress reviews, a

final review, and a final report. Depending on the work performed, the Phase II may become a classified program.

PHASE III: The most likely Phase III transition path is integration of this technology into the unity vision periscopes of the Expeditionary Fighting Vehicle.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This system could be applied to other military platforms as well as the commercial and private airline industries as a defense against real world terrorist threats.

REFERENCES:

1. Standards for Hardening U.S. Army Sensors Against Antisensor Lasers, 27 April 2008
2. Periscope, Tank, MIL-PRF-62420A(AT), 23 January 1997
3. Filter, Laser Hazard Protection, MLMIL-PRF-62422B(AT), 27 February 1997

KEYWORDS: Lasers, wavelengths, energy, frequency, hazardous, optics

TPOC: Craig Harvey  
Phone: (703)780-2458  
Fax: (866)651-1128  
Email: harveyct@efv.usmc.mil  
2nd TPOC: Patrick Hart  
Phone: (703)492-3342  
Fax: (703)492-5141  
Email: hartpa@efv.usmc.mil

N111-002 TITLE: Modular Anthropomorphic Test Device (ATD)

TECHNOLOGY AREAS: Ground/Sea Vehicles, Biomedical, Human Systems

ACQUISITION PROGRAM: PM Advanced Amphibious Assault (PM AAA) (ACAT 1)

OBJECTIVE: Research, develop and build a modular Anthropomorphic Test Device (ATD).

DESCRIPTION: The current ATD's are specifically designed to measure lateral accelerations in automotive crashes. Available ATD's are limited in the information they provide when evaluating injuries sustained in a ballistic event. It is desired that a new ATD which incorporates a frangible skeletal system and an outer covering more closely representing human construction be developed. It must be capable of measuring vertical acceleration such as would be found in an explosive/blast event and take into consideration the short impulse duration associated with an explosion. The construction must be modular and relatively inexpensive. Damaged parts are to be disposable with the exception of insertable instrument packages that can be easily installed into the new modular component. In addition to modular construction the materials used should be able to represent deep tissue injuries sustained from blunt trauma.

PHASE I: The contractor shall conduct research and generate options for a modular ATD for use in vehicle testing. The contractor shall down select to one approach and create a conceptual design, including estimated weight, cost and performance characteristics. The contractor shall conduct a Kick-off and a Final Review meeting at the Program Office in Woodbridge, VA. Monthly reports are required.

PHASE II: The contractor shall manufacture test articles representative of the modular ATD and conduct ballistic testing to validate their design meets specified performance level and characterize the performance. The contractor shall design and manufacture a prototype modular ATD for vehicle testing. The contractor shall conduct a Kick-off, 3 Semi-Annual Reviews and a Final Review meeting at the Program Office in Woodbridge, VA. Monthly reports are required.



PHASE III: Transition technology into production via sales to the US Marine Corps and US Army.

Private Sector Use of Technology: Successful development and characterization of a modular ATD has direct application to a wide variety of requirements for uses in various military and commercial land and sea based vehicles. This technology is also applicable to the evaluation of protection requirements of body armor. This technology is directly applicable to all combat vehicle tests.

REFERENCES:

1. Blast Injury Translating Research into Operational Medicine
2. Blast Headform Development
3. Development and Calibration of a Frangible Leg Instrumented for Compression and Bending
4. MIL-STD-662F V50 Ballistic Test for Armor
5. TR-HFM-089 Test Methodologies for Personal Protective Equipment Against Anti-Personnel Mine Blast
6. Review of Methodologies for Assessing the Blunt Trauma Potential for Free Flying Projectiles Used in Non Lethal Weapons
7. TR-HFM-090 Test Methodology for Protection of Vehicle Occupants against Anti-Vehicular Landmine Effects
8. RTO-MP-090 Occupant Safety in Vehicle Mine Protection
9. AEP-55 Vol 2 Ed. 1 Procedures for Evaluating the Protection Level of Logistic and Light Armoured Vehicles Volume 2 for Mine Threat
10. ITOP 4-2-508 Vehicle Vulnerability Tests Using Mines

KEYWORDS: Materials; Anthropomorphic Test Device; ATD; Survivability; Crash Test

TPOC: Craig Harvey  
Phone: (703)780-2458  
Fax: (866)651-1128  
Email: harveyct@efv.usmc.mil  
2nd TPOC: Subodh Prasad  
Phone: (703)490-8272  
Fax:  
Email: PrasadS@EFV.USMC.MIL

N111-003 TITLE: Integrated Multi-Spectral Sensor

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: Common Laser Range Finder Refresh - ACAT-IV

RESTRICTION ON PERFORMANCE BY FOREIGN CITIZENS (i.e., those holding non-U.S. Passports): This topic is "ITAR Restricted." The information and materials provided pursuant to or resulting from this topic are restricted under the International Traffic in Arms Regulations (ITAR), 22 CFR Parts 120 - 130, which control the export of defense-related material and services, including the export of sensitive technical data. Foreign Citizens may perform work under an award resulting from this topic only if they hold the "Permanent Resident Card", or are designated as "Protected Individuals" as defined by 8 U.S.C. 1324b(a)(3). If a proposal for this topic contains

participation by a foreign citizen who is not in one of the above two categories, the proposal will be rejected.

**OBJECTIVE:** Develop a single integrated Multi-Spectral sensor that incorporates day and night vision and multi-spectral laser spot imaging into a single sensor package.

**DESCRIPTION:** This integrated technology will enable Forward Air Controllers (FACs) to see the target area and simultaneously see the laser energy from pointers, designator/markers, and rangefinders with one integrated device. Currently, imaging laser pointers and designator/markers is accomplished with multiple devices which together weigh over 14 lbs, a significant load on a FAC whose full load of equipment is 166 lbs. There is no currently fielded device which can see the laser spot from eye-safe laser range finders. The weight and set up time (boresighting) of these devices is substantial. Further, the available InGaAs technology that is available is too expensive and not operationally viable. Similarly, available silicon devices are not practical for field use.

The Integrated Multi-Spectral Sensor must be a visible light day imager capable of simultaneously detecting and tracking the laser energy on a target from the following three sources simultaneously and displaying them in context with the surrounding scene:

- 1540-1560 nanometer (nm), laser class 1 from an eye safe laser range finder (either single pulse or correlation of multiple pulses, each as low as 1 microjoule) , at a range of up to 5km
- 1064nm, laser class 4 from a laser designator (30-90 millijoule per pulse, 20 nanosecond pulse width, 10-20Hz pulse rate) at a range of up to 5km
- 860nm, class 4, 1 Watt continuous IR laser pointer, at a range of up to 5km.

The laser energy will be no larger than a 3.5m circle at a range of 5km and linearly reduce at closer ranges. The sensor shall be of a size, weight, and cost commensurate with a military handheld laser range finder.

The addition of IR imaging in the form of SWIR, MWIR, or LWIR would be of considerable benefit but does not eliminate the need to image with visible light.

**PHASE I:** Develop a concept for the sensor, including the selection of appropriate sensor technology, that enables the detection of the laser spot from the three color lasers. The concept must either include imaging in both day and night, or include the approach to fuse the laser spot location with the data acquired from a co-boresighted thermal imager.

**PHASE II:** Develop the prototype sensor and demonstrate compliance with performance goals for laser spot detection of all three laser colors and image fusion with a thermal imager, if the sensor cannot be used as a thermal camera.

**PHASE III:** The expected transition product is a TRL level 6 prototype three color laser spot sensor and software/hardware required to replace the day camera in the Common Laser Range Finder refresh program, and the software required for image fusion with the thermal imager if the sensor cannot image in the IR band. Upon successful transition, the Program Office will utilize RDT&E funding for a Phase III effort. This effort will require completion of a production representative design for the Common Laser Range Finder Refresh Program that satisfies the performance, cost, logistical, and schedule goals of the Common Laser Range Finder Refresh program.

**PRIVATE SECTOR COMMERCIAL POTENTIAL:** This technology has application to first responders, search and rescue, medical, law enforcement, customs and border patrol, and any other application that requires utilizing a laser pointer to cue others to a particular area.

**REFERENCES:**

**KEYWORDS:** laser, imager, IR, designator, fusion, handheld

**TPOC:** Bryan Freeman  
**Phone:** (703) 432-4259  
**Fax:**  
**Email:** bryan.freeman@usmc.mil  
**2nd TPOC:** Michelle Winston

Phone: (703) 432-4109  
Fax:  
Email: michelle.winston@usmc.mil

N111-004 TITLE: Advanced Celestial Azimuth Sensing Technology

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: Common Laser Range Finder Refresh - ACAT IV

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

**OBJECTIVE:** Develop a celestial azimuth sensor capable of operating under less than ideal weather conditions, including clouds and precipitation, day and night.

**DESCRIPTION:** Current celestial based systems are capable of determining azimuth under clear sky conditions but cannot operate under lightly overcast conditions or during any precipitation and take considerable time to compute azimuth. The best systems can determine azimuth when there is enough daylight to see your shadow in the daytime and under equivalent atmospheric conditions at night. The proposed sensor is to determine the observer to target azimuth to an accuracy of 2 mils within 2 seconds and operate day and night, and to operate under greater cloud cover than existing sensors can today, with the objective of operating under total cloud cover and under light precipitation. The total sensor package must weigh under 0.5 pounds, be of a size and cost compatible with handheld laser rangefinders. The focus of this effort should begin with analysis of available celestial light at the wavelengths considered, followed by effects of atmospheric attenuation, scintillation, and scattering based on the wavelengths and composition of air molecules and size of water and ice vapor and precipitation droplet size under different weather conditions, optical filters, optical losses, sensor sensitivity and noise, electronic noise, and processing gain. A multispectral sensor coupled with carefully selected optical filters at wavelengths of high transmission will increase the signal to noise such that celestial objects can be viewed under non-ideal atmospheric conditions.

**PHASE I:** Identify appropriate wavelengths of light to maximize the percentage of time the sensor will provide an azimuth solution. Perform modeling and simulation that determines the conditions under which the sensor will meet the performance goals, and what percent of time the sensor will operate when considering worldwide annual weather patterns.

**PHASE II:** Develop a prototype sensor based on the sensors, optics, filters, and processing selected in Phase I that maximize the conditions under which the sensor will satisfy the performance requirements. Perform tests under simulated and/or real weather conditions that demonstrate sensor performance.

**PHASE III:** The expected transition product is a TRL level 6 prototype celestial azimuth sensor. Upon successful transition, the Program Office will utilize RDT&E funding for a Phase III effort. This effort will require completion of a production representative design for the Common Laser Range Finder Refresh Program that satisfies the performance, cost, logistical, and schedule goals of the Common Laser Range Finder Refresh program.

**PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:** An azimuth determination sensor system that operates under a broad variety of weather conditions has vast commercial applications. It would be useful for ship and aircraft navigation, search and rescue operations, and any general purpose navigation that currently uses a magnetic compass.

REFERENCES:

KEYWORDS: Targeting, Azimuth, Celestial, Sensor, Laser, Rangefinder

TPOC: Bryan Freeman  
Phone: (703)432-4259  
Fax:  
Email: bryan.freeman@usmc.mil  
2nd TPOC: Michelle Winston  
Phone: (703)432-4109  
Fax:  
Email: michelle.winston@usmc.mil

N111-005 TITLE: MEMS Azimuth and Navigation Sensor

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: Common Laser Range Finder Refresh - ACAT IV

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

OBJECTIVE: Develop and demonstrate a MEMS sensor based azimuth determination and navigation sensor.

DESCRIPTION: The sensor must determine the angle from the optical axis of a handheld laser range finder to true north to an accuracy of 2 mils or less within 120 seconds. The proposed sensor must weigh less than 0.5 pounds and be of a size and cost compatible with handheld laser range finders. Additionally, the sensor must maintain the ability to measure observer to target azimuth measurements to an accuracy of 4 mils or less over a period of 20 minutes. During this time, the user must be able to hand carry the rangefinder to different observation points and use the rangefinder handheld, without the use of a tripod or other support system. This will require a gyro with the following minimum parameters: ARW  $\leq$  0.003 deg/rt-hr, Bias Instability  $\leq$  0.02 degrees/hr, and bias drift  $\leq$  0.068 degrees/hr. This will also require accelerometers with the following minimum parameters: Bias  $\leq$  2 ug, Bias drift  $\leq$  6 ug. Accelerometers of this quality are commercially available. Achieving a better gyro ARW will result in a faster convergence to the azimuth solution, which is highly desirable. State of the art inertial sensor based azimuth determination systems use heavy and bulky ring laser gyroscopes or fiber optic gyroscopes, and are very expensive. Existing MEMS gyroscopes do not have adequate angle random walk, angle white noise, and bias stability to meet sensor accuracy requirements. The main focus of this effort is to develop suitable MEMS gyroscopes and accelerometers capable of meeting sensor requirements.

PHASE I: Develop a conceptual MEMS gyroscope and accelerometer design that is capable of meeting sensor requirements. Develop a model for overall sensor performance, identifying trade spaces in gyroscope and accelerometer designs as well as a sensitivity analysis of the design which includes anticipated manufacturing tolerances, as well as overall azimuth and navigation performance of a sensor built with these MEMS sensors. This model should include environmental, wind vibrations, and user motion inflicted upon the sensor that will occur when it is used with a handheld laser range finder.

PHASE II: Produce prototype MEMS gyroscopes and accelerometers and perform measurements of performance over time and temperature. Develop a prototype azimuth and navigation sensor based on the selected MEMS sensors

and conduct performance tests of the sensor over time, temperature, and motions anticipated by a user carrying the sensor while attached to a handheld laser range finder.

PHASE III: The expected transition product is a TRL level 6 prototype MEMS based azimuth and navigation sensor. Upon successful transition, the Program Office will utilize RDT&E funding for a Phase III effort. This effort will require completion of a production representative design for the Common Laser Range Finder Refresh Program that satisfies the performance, cost, logistical, and schedule goals of the Common Laser Range Finder Refresh program.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Such a sensor is useful for any application requiring accurate determination of azimuth that doesn't depend on a magnetic compass or the GPS constellation. Applications include ship and aircraft navigation, search and rescue operations, surveying, and any general purpose navigation that currently uses a magnetic compass.

REFERENCES:

KEYWORDS: MEMS, Azimuth, Navigation, Targeting, Laser, Rangefinder

TPOC: Bryan Freeman  
Phone: (703)432-4259  
Fax:  
Email: bryan.freeman@usmc.mil  
2nd TPOC: Michelle Winston  
Phone: (703)432-4109  
Fax:  
Email: michelle.winston@usmc.mil

N111-006 TITLE: Optimized Real-Time Mission Planning Tool for Expeditionary Warfare

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

ACQUISITION PROGRAM: PMA281, Strike Planning and Execution Systems

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

OBJECTIVE: Develop a tool to optimize manned and unmanned utilization in prosecution of pre-planned and ad hoc air requests, with easy access for the warfighter whether in combat or elsewhere.

DESCRIPTION: A tool that is capable of performing real-time decision making is needed to provide collaborative command and control (C2) of aircraft assets with regard to emergent tasking supporting both manned and unmanned aircraft. The desired decision theoretic planning tool should be able to tailor and perform intelligent filtering of various data sources and air support requests initiated from users in combat or elsewhere (shipboard, etc.). It should also select the most appropriate available aircraft, including weapons and load capabilities and other information required in support of the mission to include all concurrent or nearly-concurrent sorties. The tool should automatically deconflict requirements and make the most efficient use of aircraft. There are multiple criteria to consider for choosing a particular aircraft, such as timeliness of response, geographic location, and current payload. In addition, new situational data will be provided to this automatic decision theoretic planning tool in real-time for current and forward locations so that flight plans can be adaptively changed based on the most up-to-date data. In

this way, the tool will reduce data overload, reduce uncertainty and improve decision making. The output flight routes should minimize time and risk, avoid hostile airspace and deconflict with friendly operations.

The final software tool will be integrated with existing systems such as Joint Mission Planning System (JMPS) and Tomahawk Cruise Missile Autorouter System (CMARS). The tool will be used to support write-once/read-everywhere access to time critical data for the Marine Air Ground Task Force (MAGTF) and Carrier Air Wing (CVW) and support integrated Assault Support Board (ASB) and Aircraft Planning Board vetting processes.

PHASE I: Determine the feasibility of developing a real-time mission planning tool for managing emergent air support requests, scheduling aircraft to satisfy the requests, and managing the execution of the operation. Demonstrate the technical merit of the proposed solution.

PHASE II: Develop and demonstrate a prototype of the innovations developed in Phase I.

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

PHASE III: Mature the prototype capability for automated machine-to-machine (M2M) integration with all present and future real-time Air Tasking Order (ATO) management software packages and suites. Formalize the Application Programming Interface (API) for user developed applications to be developed ad hoc by subject matter experts in the active forces. Transition the technology to the fleet.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: All route scheduling applications in the civilian market are potential targets for this technology. Given the increasingly “just-in-time” nature of our economic models, it will be ever more important that business managers have access to technologies proposed in this topic. Furthermore, the technology can be applied to any domain where logistic schedules have to be quickly modified, e.g. homeland security and law enforcement applications.

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2. Farhoodi, F. & Fingar, P. (1997). Developing Enterprise Systems with Intelligent Agent Technology, Distributed Object Computing. [http://home1.gte.net/pfingar/docmag\\_part2.htm](http://home1.gte.net/pfingar/docmag_part2.htm)
3. Blythe, J., (2009). Decision Theoretic Planning. AI Magazine. <http://www.isi.edu/~blythe/papers.html>

KEYWORDS: Air Tasking Order (ATO); Theater Battle Management Core System (TBMCS); Computer Modeling; Route Deconfliction; Ad Hoc Flight Schedule Simulator; Information Fusion

TPOC: (301)757-6153  
2nd TPOC: (301)757-6179

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

N111-007

TITLE: Low Cost, Low Drift, High Accuracy, Miniature Inertial Navigation System (INS)

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

ACQUISITION PROGRAM: PMA-264, Air Anti-Submarine Warfare Systems; ACAT IV

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

OBJECTIVE: Develop new innovative devices and methods to create a miniature, low cost, low drift, high accuracy inertial navigation system (INS).

DESCRIPTION: Currently available, high grade, high performance INS are costly, upwards of \$200k per unit, bulky, 5 to 10 pounds, power hungry at 20 to 50 watts and have unaided drift rates of miles per hour. The high altitude antisubmarine warfare (ASW) mission has imposed the requirement for buoy systems to report their own location over the course of many hours in global positioning system (GPS) denied areas and therefore require INS. The increasing number of UAVs and pod or turret mounted sensors also requires very compact, low power INS attitude and position data without sacrificing accuracy to achieve their peak performance. These sensor systems may be required to operate in GPS denied environments and therefore require VERY low drift inertial systems to maintain position and attitude awareness. The proliferation of these sensor systems also requires that the INS unit cost be drastically reduced while maintaining performance to achieve reductions in overall program costs.

The best INS systems in use today couple high grade GPS receivers with large and expensive laser ring gyro or fiber optic gyro-based inertial measurement units. The real-time processed and filtered data products from these INS achieve 0.01 degree attitude errors (one sigma) and approximately one (1) meter position errors (one sigma) in standalone mode (no differential GPS aiding) at high update rates. The lower cost and much smaller approaches available commercially do not meet the performance needs for Navy systems. Also, in a GPS denied environment, both high grade and low grade INS lose their precise position and attitude accuracy within minutes and are completely lost within hours. Today's sensor systems require position accuracies on the order of tens of meters in GPS denied environments over the course of many hours.

The availability of new micro electromechanical systems (MEMS), fiber optics, nano materials and embedded processors has the potential to improve the current performance to the point where small low cost approaches are viable. For example, one component of the INS is a 3-axis accelerometer. With MEMS technology, an enormous number of accelerometer triads could be made in a very small space with opposing temperature and noise sensitivities to self-compensate. The over-redundant accelerometer system could be filtered and averaged to drastically reduce drift rates. Current MEMS accelerometer triads use a single device per axis and suffer high drift rates.

PHASE I: Demonstrate the feasibility of the proposed approach. Perform preliminary bench-top testing to verify the performance of the components or algorithms.

PHASE II: Develop and demonstrate a working bench-top design. Sufficiently harden bench-top design for testing and demonstration in a dynamic environment. Design and develop a prototype based on the results of the bench-top device.

PHASE III: Complete prototype development and document the design. Transition the units to a Navy system.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Private sector commercial applications for low cost, miniature INS include small aircraft such as Cessna's and turret mounted imaging systems, such as video cameras. Also long-life scientific sea buoys and underwater autonomous vehicles would greatly benefit from low drift, low power INS. Only the largest commercial aircraft currently have the ability for autonomous landing. The successful result of this SBIR could bring autonomous landing to a smaller class of

aircraft.

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KEYWORDS: Inertial; Inertial Navigating System (INS); Inertial Measurement Unit (IMU); Global Positioning System (GPS); Attitude; Micro Electromechanical Systems (MEMS)

TPOC: (301)342-2034

2nd TPOC: (301)757-5735

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

N111-008                      TITLE: Common Unmanned Vehicle Control Procedures Trainer for Airborne and Sea Based Unmanned Systems and Sensors

TECHNOLOGY AREAS: Air Platform, Information Systems, Human Systems

ACQUISITION PROGRAM: PMA 205, Aviation Training Systems

OBJECTIVE: Create innovative, common unmanned aerial vehicle (UAV) training that adequately emulates the major components of all UAV systems operated by the Navy and naval elements of special teams.

DESCRIPTION: Training exercises ensure that troops deployed to support Naval Unmanned Aviation are capable of executing the mission in every aspect. The Navy is undergoing a transformation in how products are procured resulting in a return to the Navy as the prime integrator of major systems with the prime doing the manufacturing and delivery of the product. To date though, many stove pipe UAV control stations have been produced. Each stove pipe system requires unique training to be done on unique hardware. This is very costly and removes actual fielded systems from service to conduct training. An innovative, open architecture training system that would allow training for multiple Unmanned Vehicles from a single system such as Service Oriented Architecture (SOA) is needed to reduce costs and logistics, provide platform portability, and provide an easily modifiable trainer. The architecture should allow an easy upgrade path to add unmanned vehicles or capabilities.

The system must be cross platform compatible (Windows and Linux) and provide Standardization Agreement (STANAG) 4586 (this standard establishes a common protocol to facilitate the interoperability of various, heterogeneous vehicles from a common control station and is an effective standard for both military and emerging commercial unmanned vehicle applications) and Joint Architecture for Unmanned Systems protocol for data communications.

PHASE I: Demonstrate the technical feasibility of designing and demonstrating an innovative, common open control station software suite and define its key elements.

PHASE II: Develop a prototype software training environment that covers the Tier 1-3 fixed-wing vehicles. The prototype should operate in the same fashion as the proposed control stations except that it will operate on either Linux or Windows systems, and will use simulation grade hardware devices (hand controllers, payload control and displays, etc). Develop a vehicle specific module (software adapter for each vehicle type). Aircraft Interface Control Document (ICD) data will be provided by the Government.



PHASE III: Transition the packaged system onto a Windows-based operating system hardware set.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The proposed work will result in development of a powerful technology that will be effective and efficient in providing training methods for a wide range of coming commercial UAVs such as law enforcement and homeland security.

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KEYWORDS: Common; Open Architecture; Source Code; Unmanned Air Vehicle; Training; Control Station

TPOC: (407)380-4739  
2nd TPOC: (407)380-4312

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

N111-009 TITLE: Performance Assessment and Optimization of Installed Antenna and Radome

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

ACQUISITION PROGRAM: PMA-290, Maritime Patrol and Reconnaissance Aircraft

OBJECTIVE: Develop computational electromagnetics (CEM) tools to analyze and optimize on-aircraft antenna/radome performance.

DESCRIPTION: Antennas used on Navy aircraft are either commercial off the shelf (COTS) or are designed in free space, i.e., there are no objects nearby to disturb their performance. Installation of an antenna on a platform may alter its properties significantly. Develop CEM tools that will assess this change in properties and that will perturb the design of an antenna and its radome in an effort to restore the original (desirable) properties.

Aircraft radome design is a balance between electrical, aerodynamic and structural performance. Radome electrical performance is quantified in terms of transmission efficiency, antenna pattern degradation, boresight error and relative cross polarization level. While radome wall insertion loss is typically held to small values, in many instances it is the scattering loss off the internal structures that dominates the overall performance. The scattered energy spreads out into the antenna side lobes corrupting the antenna pattern. The objective of this effort is to use an exact-physics CEM code to achieve accuracy comparable to that from a high-quality antenna measurement range. Radome related parameters of interest to be computed with this code include transmission loss, beam deflection (boresight error), its rate of change with antenna scan, antenna pattern distortion, monopulse null depth degradation (as applicable) and cross polarization levels. Accuracy of +/- 0.1 dB in gain and +/- 3 degrees in phase over the peak 10 dB of element or array pattern is needed for the combined radome and antenna model. Due to the size of the problem, such a code should be able to run efficiently on central processing unit (CPU) and CPU/graphics processing unit (GPU) clusters. In case the antenna strongly interacts with a major part of the airframe, a hybrid code, comprising an exact-physics code for the antenna and its immediate surroundings and a high-frequency code for the rest of the platform, is desirable.

The second step involves the restoration of one or more of the antenna's properties. An optimization code is needed

that is well integrated with the CEM analysis code. This code should use as few computational points as possible. Multi-dimensional interpolatory methods may be used toward this end. The objective should be to satisfy certain requirements (e.g., antenna gain greater than X dB, sidelobe level below Y dB, etc.) rather than search for locally or globally optimal points. The independent variables in the optimization scheme should be the antenna and radome dimensions and material properties, as installed on the aircraft and subject to aerodynamic and structural constraints. The code should run efficiently on CPU and CPU/GPU clusters.

The result of this effort should be an antenna/radome analysis and design tool that can be used for a wide range of installed antenna problems with a high degree of confidence. A well designed graphical user interface (GUI) should guide the user through the process of engaging the code. Teaming between CEM and optimization experts is encouraged.

**PHASE I:** Demonstrate capabilities of one or more CEM and optimization codes. Choose the most promising CEM and optimization code. Perform further analysis/ computation to assess the developmental stage of the two codes. Develop a detailed outline of the requirements and plan what would be accomplished in Phase II.

**PHASE II:** Execute the requirements program developed in Phase I. Integrate CEM and optimization codes. Port codes on clusters of CPUs and CPU/GPUs. Test and demonstrate the resulting codes on cases of interest to NAVAIR. Design and develop the GUI.

**PHASE III:** Refine methodology and tool developed either alone or in partnership with another company and transition to interested platforms.

**PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:** The technology developed under this topic has direct utility in a wide variety of commercial and military applications, such as radar, communications and navigation.

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**KEYWORDS:** Computational electromagnetics; antennas; radomes; modeling and simulation; optimization; CPU/GPU clusters

TPOC: (631)673-8176  
2nd TPOC: (301)342-2637

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

N111-010

TITLE: An Innovative Integrated Chemical and Environmental Sensor for Health Monitoring of Double-Base Propellants

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Weapons

ACQUISITION PROGRAM: PMA-201 Precision Strike Weapons

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

OBJECTIVE: Develop an integrated sensor that records stabilizer depletion and environmental conditions of double-base propellants.

DESCRIPTION: Current Navy Cartridge Actuated Devices (CAD) and Propellant Actuated Devices (PAD) use double-base propellants as either a main energetic output charge or an intermediate gas generating energetic charge. It has long been known that the nitrate esters in double-base propellants decompose with age, resulting in depletion of the stabilizer. Exposure to elevated temperatures exacerbates the stabilizer depletion, producing degradation in both the service life and ballistic performance, leading to a potential cook-off safety hazard.

A need exists to monitor stabilizer depletion rates and associated environmental conditions of double-base propellants contained within PADs at operating temperatures from -65 degrees Fahrenheit to 200 degrees Fahrenheit. As double-base propellants age, the stabilizer reacts with the nitrogen oxides (NOx) released by the decomposition of the nitrate esters (nitrocellulose and nitroglycerin) present in the propellant. During exposure to elevated temperatures, this reaction increases until the stabilizer is completely depleted. Although the decrease of the primary chemical stabilizer is accompanied by the additional formation of daughter stabilizer reaction products which also possess a residual stabilization capability, the depletion of the primary chemical stabilizer can lead eventually to autocatalytic decomposition of the propellant, self-heating, and cook-off. The need exists to monitor stabilizer depletion levels so items with unsafe levels of remaining effective stabilizer can be removed from service. The most commonly used double-base stabilizers are Diphenylamine (DPA), 2-Nitrodiphenylamine (2-NDPA), and Ethyl Centralite (EC). Currently, no products exist that are capable of detecting the daughter products of these specific stabilizers. This system should be produced or packaged in a manner amenable for integration into PADs and be able to function between the temperature extremes of -65 degrees Fahrenheit and 200 degrees Fahrenheit. The data recorded by the system should be easily retrievable with minimal impact to the PAD and must be capable of being downloaded and analyzed on a computer. For integration into a common PAD, the system must be flexible and capable of sitting on a round propellant grain or a round motor tube. The system width must fall within an arc length of 1.15 inches with an arc angle of 120 degrees. The length will be less than 7 inches, and the thickness must be less than 0.08 inches.

PHASE I: Determine and prove technical feasibility of innovative and novel approaches to measuring, recording, and reporting stabilizer depletion levels of double-base propellants and the environmental conditions they are subjected to. Determine the feasibility of producing such a system within the size constraints of a common PAD.

PHASE II: Based upon Phase I results, develop one or more prototypes capable of measuring, recording, and reporting stabilizer depletion levels and environmental conditions. Demonstrate the developed technology within the temperature range. Characterize the accuracy of the stabilizer and environmental measurements.

PHASE III: Transition and integrate the developed technology into a PAD or other appropriate system.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Potential market for this technology exists in prognostics, health monitoring, and conditional maintenance of items subject to environmental exposure and degradation of volatile substances. Commercial items that may benefit from this type of health monitoring system include automotive airbag safety systems, automotive engine oil, gun ammunition, aircraft jet engines, and solid propellant gas generator systems such as airline inflatable slides and cartridge driven power tools.

REFERENCES:

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KEYWORDS: Double-base propellant; health monitoring; stabilizer depletion; diphenylamine; 2-nitrodiphenylamine; ethyl centralite

TPOC: (301)744-2359  
2nd TPOC: (301)744-2124

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

N111-011 TITLE: Improved Pilot/Maintainer Auditory Performance in Complex Air Vehicle Noise Spectra

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Human Systems

ACQUISITION PROGRAM: PMA-261, Heavy Lift Helicopter

OBJECTIVE: Develop and integrate innovative and cost-effective platform and personnel mounted technologies to improve Navy and Marine aviation hearing protection and communication.

DESCRIPTION: Working in an environment that requires wearing hearing protection diminishes the ability to communicate effectively and to detect and discriminate auditory warnings. Unfortunately, vehicle noise dampening technologies are sometimes avoided or removed to increase mission capability or to reduce weight and operational costs thus relegating solutions almost entirely to man-mounted systems.

Explore linked vehicle and personnel solutions to improve hearing quality and mission effectiveness in Navy and Marine flight operations, ideally with a reduced life cycle cost. A key objective is to analyze platform spectra and concentrate improvements on frequency ranges critical to auditory performance and hearing conservation.

While this topic focuses on improvements to any pilot/maintainer helmet, hearing, or communication system, one area of particular interest is the gap in existing hearing protection for crews of the upcoming H-53K helicopter. H-53K cabin noise predictions indicate a significant increase in sound level pressures at 500 600 Hz compared to the H-53E, which would mean the current hearing protection is deficient by about 13-14 dB (mean attenuation minus two standard deviations) in those frequencies.

This sort of spectral mismatch or inadequacy by hearing protection and communication systems to an offending noise is to be a focus of this effort. Proposals may include wireless concepts and should be supported by clear statements of the intended improvements and performance goals.

PHASE I: Determine the feasibility of innovative design solutions or new technology strategies that improve the protection, effectiveness, and system costs associated with auditory performance in Navy and Marine flight operations. Develop the initial concept design and model key elements of the impact of the innovation on at least one critical performance parameter and one life cycle cost element for the chosen improvement.

PHASE II: Develop, demonstrate and validate prototypes in laboratory and relevant environments. Initiate business case analyses (BCA) and life cycle cost estimates (LCCE).

PHASE III: Progress to production-representative prototypes, conduct necessary qualification and field testing, and transition to appropriate platforms.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: New product(s) have potential commercial applications in manufacturing environments and sports arena markets.

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6. OPNAVINST 5100.23G. Navy Safety and Occupational Health Program Manual.
7. Berger, E.G., Royster, L.H., Royster, J.D., Driscoll, D.P. & Layne, M. (2000). The Noise Manual Fifth Edition. American Industrial Hygiene Association
8. Kryter, K. (1994). The Handbook of Hearing and the Effects of Noise. Academic Press, Inc.

KEYWORDS: Helmet; Hearing; Communications; Flight Deck; Cost Reduction; Mission Effectiveness

TPOC: (301)342-9218

2nd TPOC: (301)342-8839

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

N111-012

TITLE: Non-Contact Process to Enhance the Fatigue Life of Aluminum Cold Worked Fastener Holes

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: PMA 261, Heavy Lift Helicopter

OBJECTIVE: Develop non-contact technologies and processes to enhance the residual stresses around aluminum cold worked fastener holes on wing assemblies.

DESCRIPTION: Fastener holes on aircraft wing skins can develop extensive cracking after extended periods of

service time. The cracking can initiate around the fastener holes and propagate into large cracks, resulting in catastrophic failure. Fleet crews have to inspect thousands of fastener holes and conduct repair to the cracks. Existing approaches rely on compressive residuals through a cold expansion approach, which does not completely retard the fatigue initiation/growth on the surface of the rivet holes because the residual stresses on the entry surface are lower than those of middle and hole exits.

Innovative, non-contact methods for enhancing the residual stresses on the entry surface, which will be equivalent of the cold work section, are sought. The proposed process should be cost-effective and without risk of damage to the aluminum surface and hole dimensions. The process should be able to induce deep residual stresses onto the surface around the holes with little changing of material surface roughness or dimensions of fastener holes. The process must be used on existing aircraft without any foreign object damage (FOD). Ideally, the process would be suitable for non-flat geometry, such as wing curvatures, and also suitable for an inside hole diameter as small as 0.18 inch.

PHASE I: Develop innovative concepts for imparting residual stresses in cold worked fastener holes by non-contact means. Demonstrate the feasibility of the developed approach through limited testing of flat dog bone coupons with a 0.195 inch cold worked hole.

PHASE II: Fully develop the concept conceived in Phase I into a prototype process. Provide validation and verification that the process meets the requirements.

PHASE III: Transition the developed technology to industry and aircraft maintainers.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Successful development of this technology could be transitioned to commercial airlines for the improvement of the cold worked fastener holes.

#### REFERENCES:

1. Poussard, C., Pavier, M.J. & Smith, D.J. (1995). Analytical and Finite Element Predictions of Residual Stresses in Cold Worked Fastener Holes. *Journal of Strain Analysis*, Vol. 30, No. 4, pp. 291-304.
2. Fujimoto, W.T. (2001). Analytic Testing of Joints with Cold Worked Holes. *Fatigue & Damage Advanced Structural Technology, Inc.* (203) 878-8327, pp 1-23.

KEYWORDS: Cold Work; Fastener Holes; Fatigue Life; Residual Stress; Aluminum; Low Cost Process

TPOC: (301)342-4078  
2nd TPOC: (301)342-6211

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

N111-013                      TITLE: Electromagnetic Absorbing Chaff

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Battlespace

ACQUISITION PROGRAM: PMA-272, Advanced Tactical Aircraft Protection Systems

OBJECTIVE: Develop decoy and denial electronic warfare techniques using advance materials.

DESCRIPTION: Chaff has been used for over a half a century to deny the use of propagating energy as an information source to obscure or reflect electromagnetic waveforms. Innovative changes to chaff technology, by researching and developing materials that actually absorb, and phase-shift electromagnetic propagations, effectively denying enemy use of a given frequency, are needed. Radio frequency (RF) absorbing materials, also known as metamaterials (MM), can be tailored to absorb in any frequency denying threat use. Applications of this technology include battle space control of communications, denial of global positioning systems (GPS) devices, deception of active seekers for aircraft protection, or any other frequency where the MM can be produced to absorb or phase-shift

the propagating energy.

PHASE I: Use basic modeling and simulation tools to demonstrate the feasibility of using metamaterials to achieve tactical effectiveness against a threat with expected RF absorption/phase-shifting. Use MM design models for various RF spectrums/frequencies in communication bands, radar bands, common-use bands, civilian bands, etc. to show expected performance criteria.

PHASE II: Develop a testable quantity of metamaterials in three different frequency bands, test them in a controlled environment, prove the modeling and simulation results against actual performance findings. Work produced in phase II may become classified.

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

PHASE III: Transition technology developed to appropriate platforms.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Successful outcome may have law enforcement or Department of Homeland Security application such as denial of use applications for cellular telephones, global positioning systems (GPS), or other RF bands where denial will help agents uphold peace and security.

#### REFERENCES:

1. Hu Tao et al. (2008). Highly Flexible Wide Angle of Incidence Terahertz Metamaterial Absorber. Physical Review B, Rapid Communications 78, 241103R
2. N. Papanikolaou et al. (2009). Metamaterial with Polarization and Direction Insensitive Resonant Transmission Response Mimicking Electromagnetically Induced Transparency. Applied Physics Letters, 94, 211902. DOI 10.1063/1.3138868
3. Additional information from TPOC to clarify topic requirements for N111-013 (posted in SITIS 11/16/10).

KEYWORDS: Metamaterials; Electromagnetic; Radar Absorption; Phase-Shifting; Electronic Warfare; Denial

TPOC: (301)342-0083  
2nd TPOC: (904)317-1938

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

N111-014 TITLE: Field Programmable Gate Array (FPGA) Direct Programming Tool

TECHNOLOGY AREAS: Information Systems, Sensors, Weapons

ACQUISITION PROGRAM: DASH FNC; PMA-280, Tomahawk Weapons System

OBJECTIVE: Develop a tool with a graphical user interface (GUI) that can be used to translate an algorithm designer's work directly into optimized firmware code.

DESCRIPTION: As guidance algorithms become more complex, the common view is that more general-purpose

resources (microprocessors, memory, and digital signal processors) are required to support them. This is inefficient both from a hardware and programming perspective. The intent of this topic is to circumvent the use of these general-purpose components through the direct implementation of as much of an algorithm as possible onto one or more FPGAs. The two major savings that could be gained are in development time and resources as well as resources required on the target item. Although the development resources that could be saved would primarily be software and firmware programmer time, hardware design time would also be reduced since some of the hardware would be standardized to accept the tool's output. The target item resources that would be saved are thermal load capacity, since the FPGA would put off less heat than a comparable processor/digital signal processor (DSP) chip combination, volume, since putting in one or even two FPGAs in place of a processor/DSP combination would save overall space, and power load capacity, since the FPGAs would require somewhat less power than the processor/DSP chip combination.

The software tool should enable the efficient implementation of signal processing algorithms directly onto an FPGA, allowing rapid development, testing and integration of algorithms on hardware that is identical to that which will be used in the final system. The tool design should also provide optimal processing capacity on existing and future FPGAs. The current development process requires a significant amount of sequential efforts by various technical groups to arrive at functional hardware. To shorten development time and improve performance of the resultant system, the most often used image processing functions (such as the Fast Fourier Transform (FFT) and edge detect) should be precompiled and optimized for the target platform. The software tool that is being requested is not simply a set of image processing intellectual property cores, nor is it intended to replace firmware programming altogether with a higher level language or a layout tool. The effort is intended to give software and algorithm engineers a framework that provides an efficient method to use existing algorithms and easily extend algorithms that can be used as building blocks to either augment or replace microprocessors and/or DSP chips. It is intended to help keep/simplify hardware in the loop, and as such should target several commonly used image processing functions on a given platform. The tool must be general enough to support FPGAs from common vendors (Altera and Xilinx, for example) and it should provide for adding capability (i.e., additional functions and additional platforms) as may be reasonably expected in support of future requirements. The tools must be easily used by competent professionals and provide cross-platform functionality.

The reason general-purpose processors are still used for implementing algorithms is that it allows them to be changed, even through the testing and evaluation period of the weapon's life. It is the hope that this level of flexibility is maintained while the advantages of direct firmware implementation are taken advantage of. This is non-trivial because not only are there a wide variety of algorithms, but there are also many different FPGAs, and not all are directly compatible. Making a tool like this function for many algorithms as well as making it able to program/use many FPGAs from varying companies will be a formidable challenge.

PHASE I: Determine the feasibility of the proposed programming tool by designing and demonstrating the basic functionality of a rudimentary but representative group of algorithm components that can be implemented on one FPGA platform.

PHASE II: Develop and demonstrate a prototype a tool to allow implementation of more general algorithms on multiple FPGA platforms and provide an appropriate user interface.

PHASE III: Demonstrate and transition the complex algorithm implementation and operability with multiple FPGA platforms.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The availability of this tool could prove very useful in the commercial sector as it would provide for reduced development costs, and making hardware implementations more attractive. The technology would be critical for portable or concealable electronic devices and useful in applications requiring minimizing volume, power and thermal factors.

#### REFERENCES:

1. Ye, A. & Rose, J. (2006). Measuring and utilising the correlation between signal connectivity and signal positioning for FPGAs containing multi-bit building blocks. IEE Computer & Digital Techniques Journal, Vol.153, No.3, pp.146-156



2. Kundarewichm, P. and Rose, J. (2004). Synthetic Circuit Generation Using Clustering and Iteration. IEEE Trans. on Computer-Aided Design, Vol. 23, No. 6, pp. 869-887

3. Cong, J., Fan, Y., Han, G. & Zhang, Z. (2004). Application-Specific Instruction Generation for Configurable Processor Architectures. Proceedings of the ACM International Symposium on Field-Programmable Gate Arrays

4. Advanced FPGA Design: Architecture, Implementation, and Optimization. Steve Kilts, Wiley-IEEE Press 2007

KEYWORDS: Field Programmable Gate Array (FPGA); Processing; Embedded; Algorithms; Fast Fourier Transform (FFT); Programming

TPOC: (760)939-3755

2nd TPOC: (760)939-1489

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

N111-015                      TITLE: Beam Forming/Null Steering Algorithms for Rotorcraft Mounted Global Positioning System (GPS) Anti-Jam Receivers

TECHNOLOGY AREAS: Air Platform, Information Systems, Sensors

ACQUISITION PROGRAM: PMA 299, MH-60R/S Multi-Mission Helicopter Program Office; ACAT ID

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

OBJECTIVE: Develop advanced beamforming/nulling algorithms for GPS anti-jam antenna electronics in the presence of reflections and modulation found on rotary wing aircraft.

DESCRIPTION: Current Controlled Reception Pattern Antenna (CRPA) systems are being used with GPS receivers for electronic protection in electromagnetically challenged environments. These systems are based on simple null steering that adapts antenna weights to steer nulls along the interfering signal direction with no constraint on the antenna response in the direction of a satellite signal. To improve the GPS navigational solution and satellite availability, future GPS CRPA systems will be beamforming and null steering. In these systems interfering signals are nulled while the antenna response is constrained in the direction of individual satellite directions. When these adaptive antenna weighting algorithms are used, navigational accuracy is achieved at the expense of greater complexity in the antenna electronics. These algorithms have been developed for antenna installation on fixed wing aircraft and have not been developed or studied on rotary wing aircraft. A rotary wing aircraft presents a more challenging radio frequency (RF) environment than the fixed wing aircraft where both the rotor blade modulation and reflection may affect the algorithms. The performance of these adaptive algorithms for GPS antenna systems mounted on rotary aircraft is unknown and needs to be carefully investigated. Also, rotary wing mounted CRPA antennas may be significantly smaller than those used on fixed wing platforms and should also be considered when evaluating candidate algorithms. Innovative adaptive weighting algorithms are being sought to reduce antenna induced phase biases in GPS code and carrier phase measurements in the rotary wing environment.

PHASE I: Determine the feasibility of developing advanced beamforming/null steering algorithms that maintain or improve navigation accuracy in the presence of rotor blade jammer reflection and modulation of GPS satellite signals.

PHASE II: Develop and demonstrate candidate algorithms and constraints. Demonstrate the candidate algorithms with current seven element GPS antennas and a model or a representative platform such as the Navy's H-60 aircraft. Candidate algorithms should also be demonstrated with a smaller GPS antenna with fewer than seven elements.

PHASE III: Develop the electronics for transitioning the technology to current and future rotary wing naval platforms such as the Navy's H-60 aircraft.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Technology developed under this effort will have potential applications to commercial manned and unmanned air vehicles, where varying reflections and modulation can occur.

REFERENCES:

1. McGraw, G.A., McDowell, C. & Kelly, J.M. (2006). GPS anti-jam antenna system measurement error characterization and compensation, Proceedings of ION 2006 GNSS Meeting, Fort Worth, TX
2. De Lorenzo, D. S. (2007). Navigation accuracy and interference rejection for GPS adaptive antenna arrays, Ph.D. Dissertation, Stanford University
3. O'Brien, A. & Gupta, I.J. (2008). Optimum adaptive filtering for GNSS antenna arrays. Proceedings of ION 2008 GNSS Meeting, Savannah, GA

KEYWORDS: Global Positioning System (GPS); antenna electronics; algorithms; rotor craft; anti-jam; beamforming

TPOC: (301)342-0057  
2nd TPOC: (301)342-9174

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

N111-016 TITLE: Optimizing Track-to-Track Data Fusion for Variable Cases

TECHNOLOGY AREAS: Air Platform, Information Systems

ACQUISITION PROGRAM: PMA-262, Persistent Unmanned Aircraft Systems

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

OBJECTIVE: Develop a method that will analyze different approaches of combining tracks from multiple disparate data sources and identify the approach that results in the best overall track accuracy within the processing and time constraints available.

DESCRIPTION: Autonomous air vehicles, such as Broad Area Maritime Surveillance (BAMS) or Firescout have the ability to track surface targets. They also often have multiple sensors and sources such as radar, electro-optical/infrared (EO/IR), and data streams from other sensors available to track targets. These data sources produce many tracks, sometimes numbering in the thousands, to combine. Furthermore, the various sources will differ in track count, accuracy, update rates, and uncertainty.

There are currently several algorithms for merging the tracks from these sensors/sources. However, there is no

method for determining which sets of algorithms work best together to combine the tracks or how much better the track accuracy results will be using a given method. A model-based tool is required that will be able to show how the various sources should be combined to best improve the overall accuracy within the processing and time constraints available. The model must be sufficiently robust and must be able to work with known data streams. Particular attention should be given to the primary sensors used today including radar, Automated Information Systems (AIS), and Electronic Surveillance Measures (ESM).

The state of the art is a set of various algorithms using processed sensor data with time tags, but unsatisfactory levels of accuracy and confidence. The desired outcome of this work is a tool that will use the existing algorithms, incorporate new algorithms, and combine, contrast and compare the results to produce the best possible identifications of targets at sea. The purpose of this work is to develop the methods for performing this synthesis of algorithmic output, including feed back to influence sensor processing to improve track merger success.

Various simulation tools to model the environment, targets, and sensors will be required.

The ability to filter tracks is required as well as ability to quickly create relevant scenarios and track evaluation methods. The tracking filtering tools should include Kalman filters and multi-track association algorithms. The capability of these tools as well as the visualization/analysis tools to analyze the tracking results should be discussed.

**PHASE I:** Determine the feasibility of the proposed approach by tailoring simulation for a specified problem/domain and develop a set of relevant scenarios. Provide data sets as the basis for further analysis.

**PHASE II:** Refine simulation based on government-provided information and produce refined data sets. Provide discussion and results to help validate model assumptions. Use data sets to provide comparison between the various track-to-track methodologies. Perform analysis to quantitatively show comparison tracking results. Perform initial approximation to quantify how data sources and methods relate. Demonstrate the prototype system.

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

**PHASE III:** Develop and transition the model into an analysis tool that will provide how best to combine tracks from specified sources to optimize tracker performance.

**PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:** Any commercial corporation that tracks shipments or vehicles using multiple data sources, counter-drug and counter-terrorism operations, or traffic monitoring networks could all potentially benefit from this product.

#### REFERENCES:

1. Asadi, M., Regazzoni, C.S. (2007). A Comparison of Different Approaches to Nonlinear Shift Estimation for Object Tracking. IEEE International Conference on Image Processing, Vol 3, 221-224.
2. Blanc, C., Trassoudaine, L., Gallice, J. (2005). EKF and particle filter track-to-track fusion: a quantitative comparison from radar/lidar obstacle tracks. The Eighth International Conference on Information Fusion, Vol 2, 1303-1310.
3. Blair, W.D., & Bar-Shalom, Y. Tracking maneuvering targets with multiple sensors: Does more data always mean better estimates? IEEE Transactions on Aerospace and Electronic Systems, 32(1), 450-456.

**KEYWORDS:** Data Fusion; Track-To-Track Tracking; Multi-Track Association; Modeling and Simulation; Track

Accuracy; Sensors

TPOC: (301)342-9111

2nd TPOC: (301)757-4768

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

N111-017

TITLE: Electric Field Sensor Technology

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: PMA 264, Air Antisubmarine Warfare Systems

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

**OBJECTIVE:** Develop an innovative design for compact low-noise electrodes for air-deployed electric field sensor platforms.

**DESCRIPTION:** Passive electric field sensors have the potential to provide useful information for tactical surveillance and classification of marine vessels. Exploitable electric field signatures include galvanic corrosion currents and alternating extremely low frequency electromagnetic (ELFE) signals caused by impressed current cathodic protection systems or attenuating current (AC) modulation of the electrical resistance of the shaft bearings as they rotate. Dry-storable electrode technology with a low-noise floor in both the ultra-low frequency (ULF) and ELFE bands that provides immediate signal transduction upon contact with seawater is needed for next generation electric field sensors for air-deployed sensor operation.

**PHASE I:** Provide proof of concept and innovative designs for compact low-noise electrodes that are capable of dry storage and rapid deployment with minimal thermal and salinity sensitivity.

**PHASE II:** Develop and test engineering prototypes of electrodes for electric field sensors that are compatible with A-size buoy containers and launching systems (approx. 4 7/8 in. X 36 in.). This effort will include ocean tests of prototype sensors in relevant environments to determine system effectiveness.

**PHASE III:** Develop an electrode production design for the A-size buoy for integration and transition into existing Naval sonobuoy systems.

**PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:** Technologies developed are applicable to commercial underwater vessel location and collision avoidance systems.

**REFERENCES:**

1. Pettitt, R.A.; Filloux, J.H.; & Chave, A.D. (1992). Technology For The Measurement Of Oceanic Low Frequency Electric Fields. OCEANS '92. 'Mastering the Oceans Through Technology'. Proceedings. Vol. 2, no., pp.642-647
2. Crona, L., Fristedt T., Lundberg P., & Sigraay P. (2001). Field Tests of a New Type of Graphite-Fiber Electrode for Measuring Motionally Induced Voltages. Vol 18, 92-99.
3. Applied Physics Laboratory, University of Washington. Electrode and electric field sensor evaluation. Technical Document 3124, September 2001, ADA397369.

KEYWORDS: Underwater Electric Field Sensors; Sonobuoys; Antisubmarine Warfare (ASW); Electrodes; Low Noise; Electromagnetics

TPOC: (301)342-2090

2nd TPOC: (301)342-2027

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

N111-018                      TITLE: Low Drag 2.75 Inch Rocket and Advanced Precision Kill Weapon System (APKWS) Launchers

TECHNOLOGY AREAS: Air Platform, Weapons

ACQUISITION PROGRAM: PMA 242 - Direct & Time Sensitive Strike

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

OBJECTIVE: Develop launcher concepts and prototypes for both the 2.75 inch Rocket and Advanced Precision Kill Weapon System (APKWS) weapon systems that reduce aerodynamic drag and weight, enabling integration into new and existing aircraft platforms and unmanned aircraft.

DESCRIPTION: A reduction in aerodynamic drag and weight of aircraft stores has a direct effect on the performance and flight endurance of the transporting aircraft. Many small aircraft platforms, including various unmanned aircraft systems, could potentially be configured to support the 2.75 inch Rocket and APKWS weapon systems. In these smaller aircraft platforms, the aerodynamic drag and weight of the current LAU-68 and LAU-61 launchers is high and reduces the range of the transporting aircraft. This effort calls for the development of two (2) airborne launchers of different sizes for the 2.75 inch Rocket and APKWS weapon systems. The launchers must be mechanically interoperable with the LAU-68 and LAU-61 launchers enabling integration into existing aircraft platforms. Of the two launchers, the first must be appropriately sized to have a fully loaded weight of no more than 200 pounds, enabling integration into various unmanned platforms. The second launcher should be dimensionally similar to the LAU-61 launcher enabling integration into existing fixed and rotary wing platforms. The key focus of this development effort is to explore innovative concepts that significantly reduce aerodynamic drag, over a wide operating envelope of 0 to 300 knots and 0 to 14 degrees angle-of-attack, of the launchers, both before and after firings, reduce weight, and extend service life when compared to existing LAU-68 and LAU-61 launchers. The primary structure should employ composite materials and the launch tubes should employ high-temperature composite materials to further reduce weight and increase service life. There will be significant challenges to identifying innovative materials to achieve extended service life capability and weight savings as well as the development of manufacturing technologies. Substantial effort to develop a launcher that utilizes appropriate materials and can be manufactured properly will be required.

Aspects of increasing the service life include protection from adverse environments and from overpressure from the rocket motor exhaust plume. The designs should handle heat flux, mass flow, and dynamic pressures. The rocket launchers should be able to operate in harsh environments where blowing sand, dust or water could enter the launcher tubes and cause malfunctions in the existing launchers. Systems must also provide environmental protection and protection from damage due to firing adjacent rockets.

PHASE I: Develop a proof of concept for both launcher designs to demonstrate weight reduction and

manufacturability. Provide computational data showing the reduction in aerodynamic drag.

PHASE II: Develop a prototype system for the LAU-68 launcher design for subsequent test and evaluation. Demonstrate the ability to fabricate the launcher using composite materials and the manufacturing technologies developed in Phase I. Demonstrate the reduction in aerodynamic drag of the launcher prototype through wind tunnel testing. Demonstrate the operation of the launcher prototype and the increase in service life by test firing the launcher on a test stand in an appropriate environment. 2.75 inch Rocket training rounds will be provided as government furnished equipment (GFE).

PHASE III: Develop a prototype system for the second of the two launcher designs (LAU-61) for subsequent test and evaluation. Demonstrate the reduction in aerodynamic drag of the launcher prototype through wind tunnel testing. Demonstrate the operation of the launcher prototype and the increase in service life by test firing the launcher on a test stand in an appropriate environment. 2.75 inch Rocket training rounds will be provided as GFE. Integrate onto and test both launcher prototypes on an applicable rotary wing aircraft platform, such as the H-1 Cobra. Rocket training rounds will again be provided as GFE. Transition developed technology to appropriate platforms.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: These launcher configurations could be applicable to numerous Homeland Security applications including platforms for firing marking rounds and illumination rounds from aircraft. The low drag launcher geometry could also be reconfigured to support other external commercial and Homeland Security payloads.

REFERENCES:

1. Hoerner, S.F. (1965). Fluid Dynamic Drag. Bakersfield, CA: Hoerner Fluid Dynamics
2. Office of the Secretary of Defense, "Unmanned Systems Roadmap (2009-2034)," 2nd Edition <http://www.jointrobotics.com/library02.php>

KEYWORDS: Air Launched Weapon Systems; Precision Strike Weapons; Unmanned Aircraft Systems; 2.75 inch Rocket; APKWS

TPOC: (760)939-8202  
2nd TPOC: (760)939-8201

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

N111-019 TITLE: Minimization of Chronic Back Pain in Military Pilots and Vehicle Occupants

TECHNOLOGY AREAS: Biomedical, Human Systems

ACQUISITION PROGRAM: PMA202, Aircrew Systems, Non ACAT

OBJECTIVE: Develop computational models to understand and analyze acute and chronic back pain for combat air vehicle pilots and occupants taking into consideration the interaction between seating systems and posture and the generation of spinal pain.

DESCRIPTION: Pilots and crew of combat air vehicles, including fixed-wing attack, fighter and rotary-wing aircraft, can be exposed to inertial and task position stressors that generate pain. Repeated painful exposures with or without tissue damage are precursors to pain sensitization and chronic pain. Chronic pain leads to reduced operational readiness and long term medical treatment. A means of protection is needed to minimize the development of chronic back pain while maintaining short duration, high onset acceleration protection afforded by ejection and crashworthy seating. Equally important, though less well understood, is the contribution of long duration, static/quasi-static loading to chronic pain development. Current seating systems were designed to be a 'one-size-fits-all' with minimal adjustability and were intended for short and moderate duration exposures. Aircraft

seating systems encompass a range of seat back angles from 0 degrees (vertical) to 17 degrees pitched back and seat pan angles from 0 degrees (horizontal) to 12 degrees pitched up. Seated postures vary ranging from long periods holding the same position while visually scanning the area or instruments through turning to look over their shoulders (“check six” position). All the while, they are restrained in their seats for missions as long as 12 hours and must be able to reach switches and controls overhead, behind, to the side and in front of them.

An optimal protective approach would take into account variability of operator anthropometry; the physical, inertial loading exposures of air combat vehicles; the task posture of the operator; the relevant specific low back/spinal anatomy; and the mechanisms of pain associated with back pain. There is a strong need to be able to analyze and quantify the influence of various mechanical stressors on pilot injury potential and to develop novel designs of occupant seating and restraint systems that reduce the spinal injury and chronic pain risk to all aircrew sizes during routine and catastrophic events. Computational models and parametric simulations are required to determine potential contributors to acute and chronic operator back pain and the specific pain mechanisms involved. Given the challenge of relating mechanical stresses to associated pain, a neurologist experienced working with pain patients should be included on the proposed team as a consultant. The computational models should be structured such that recommendations can be made towards improvements to seating, helmet and restraint systems, postures and operational guidelines. The models should also be able to determine the predicted design(s) efficacy.

**PHASE I:** Determine the feasibility of using human biomechanical models to expose a simulated occupant to the inertial and positional stressors, simulating the effect on the spine and onset of pain and predicting the spinal sensitization and pain time course.

**PHASE II:** Develop a human biomechanical model accounting for anthropometric variation of military population (5th to 95th percentiles), including gender related factors. This will include models of seating (geometry and cushions), restraints, cockpit geometry, and protective clothing / equipment. Validate the combined model against published data, including but not limited to the references listed below. Use the model to analyze existing operational procedures and propose improved operational guidelines.

**PHASE III:** Using guidelines developed in Phase II, develop prototype of the most promising protective concept that provide adaptive seating, comfort and adjustability for the maximum range of anthropometric sizes and conduct experimental testing and evaluation. Conduct operational unit evaluation of the prototype protective concept and implement necessary design changes. Re-evaluate the predicted performance based on implemented changes and revise protective concept based on results of evaluation until desired optimum protection is achieved.

**PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:** In addition to operators of land and sea combat vehicles, operator low back pain is a problem in the commercial transportation field. Such a protective capability would be valuable in mitigating the developing of pain and chronic back pain for operators of commercial air, land and sea vehicles.

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**KEYWORDS:** Low Back Pain; Spinal Injury; Air Combat Vehicles; Warfighter Protection; Modeling; Aircraft Seating Systems

TPOC: (301)342-8881

2nd TPOC: (301)342-8884

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

N111-020

TITLE: Detection and Tracking of Small Boats and Semi-Submersibles in the Littoral



TECHNOLOGY AREAS: Air Platform, Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: PMA-290, Maritime Patrol and Reconnaissance Aircraft

OBJECTIVE: Develop an innovative method to exploit coherent temporal processing techniques in the discrimination of small boats and semi-submersible vessels in the presence of highly variable Doppler spectra characteristics of littoral environments.

DESCRIPTION: Radar detection of small boats and semi-submersible vessels in the littoral environment can be very challenging because the radar reflectivity is masked by the much stronger reflectivity of the surrounding sea. If the Doppler spectra of the small boat's return can be adequately separated from that of the sea then improved detection performance is possible. The Doppler spectra of the littoral seas varies from being rather homogeneous to being highly inhomogeneous with large discrete Doppler packets associated with free and trapped capillaries riding on surface gravity waves and swell. Likewise the target Doppler spectra of the small boat target set of interest can be highly variable containing relatively narrow Doppler spectra from the vessel itself and a much wider response from the speed dependent boat wake and spray.

The goal of this effort is to develop robust detection, discrimination and tracking techniques for small boat and semi-submersible vessel operations in the littoral environment. In order to be effective, techniques to mitigate target obscuration due to internal clutter motion along with robust and efficient tracking techniques need to be developed. The techniques shall be developed using analytical and numerical analysis combined with strong empirical evidence obtained from representative experiments.

PHASE I: Perform a detailed analysis and modeling effort to assess the feasibility of Doppler detection, discrimination and tracking over the full range of target speeds, over multiple headings to include both cross-range movement and movement synchronous with the primary surface wave field. The analysis should consider radar waveform designs and provide expected processing gains through various coherent processing intervals over the range of target heading and maneuvers and sea returns. Complete an assessment of proposed detector performance.

PHASE II: Significantly increase the fidelity of detection, discrimination and tracking methods. Develop and demonstrate an end-to-end prototype system. Evaluate and improve the system using experimental data obtained in a real-world littoral environment.

PHASE III: Transition the developed technology to appropriate platforms and interested commercial entities.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: There is a growing need for accurate, real-time instrumentation of the sea surface for safe navigation of vessels in and around harbors and shipping lanes.

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1. Ward, K.D., Baker, C.J., & Watts, S. (1990). Maritime Surveillance Radar Part 1: Radar Scattering from the Ocean Surface. IEEE Proceedings, Pt F, Radar & Signal Processing, Vol. 137, pp. 51-62.
2. Ward, K.D., Tough, R.J.A., & Watts, S. (2006). Sea Clutter: Scattering the K-Distribution and Radar Performance. Institution for Engineering and Technology (IET), Chapters 2 and 6.

KEYWORDS: Radar Scattering; Radar Sea Clutter; Maritime Surveillance; Small Maritime Targets; Target Detection; Clutter Mitigation

TPOC: (301)342-2637

2nd TPOC: (301)342-9173

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

N111-021

TITLE: Compact High Spatial Resolution Airborne Optical System

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PMA-290, Maritime Surveillance Aircraft, ACAT I

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

OBJECTIVE: Develop a compact optical system that provides greater than diffraction-limited resolution for airborne tactical systems.

DESCRIPTION: Many airborne platforms rely on optical systems to locate and identify threats and targets. The ability to successfully carry out these missions is strongly related to the optical system's ground resolution. In traditional optical systems, ground resolution decreases linearly with stand-off distance causing operators to trade off safety and covert operation for better probability of detection, classification, and identification. For example, to get high enough resolution to detect Improvised Explosive Devices (IED), an airborne platform would likely fly low enough to risk drawing enemy ground fire.

Conventional methods to increase imagery resolution include increasing aperture size and focal lengths. These methods increase costs, add undesired weight gains, and increase wind drag to the platforms.

Innovative solutions are sought to develop an active optical system that can achieve 4X the resolution of a conventional optical system of the same aperture size. The selected approach needs to image at various distances within the systems operational range for finding targets of opportunity.

PHASE I: Determine the feasibility of developing a high resolution compact airborne optical system design. Provide analysis to show that the technique is capable of producing significantly higher resolution imagery that is at least 4X the resolution of a diffraction limited system with the same aperture with a low-cost, low-risk, and near-term design. Provide laboratory data to support theoretical analysis.

PHASE II: Design, build, and test an airborne prototype. Using actual hardware, characterize the performance of the system with respect to various lighting conditions, ranges, and other stressful conditions. Demonstrate system effectiveness during flight. The prototype demonstration shall show the effective increase in resolution using an actual 6 inch aperture system.

PHASE III: Transition and integrate on to appropriate Navy systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Successful outcome from this SBIR topic could be used in commercial still imaging systems especially from airborne platforms.

#### REFERENCES:

1. Buell, W.F., Marechal, N.J., Dickinson, R.P., Kozlowski, D., Wright, T.J., Buck, J.R. & Beck S.M., (2003). Synthetic Aperture Imaging Ladar: Lab Demo and Signal Processing. Proceedings of the 2003 Military Sensing Symposia: Active EO Systems <http://www.aero.org/publications/crosslink/summer2004/08.html>

2. Duncan, B.D., Dierking, M.P. (2008). Stripmap Holographic Aperture Ladar. IEEE Lasers and Electro-Optics Society. LEOS 2008. 21st Annual Meeting [http://ieeexplore.ieee.org/xpls/abs\\_all.jsp?arnumber=4688716](http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=4688716)

KEYWORDS: Compact; Optical; Sensor; Airborne; Imaging; Ladar

TPOC: (301)342-0100  
2nd TPOC: (301)342.9106

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

N111-022 TITLE: Intelligent Proxies for Automated Mission Planning

TECHNOLOGY AREAS: Air Platform, Information Systems, Battlespace

ACQUISITION PROGRAM: PMA-281, Strike Planning & Execution Systems

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

OBJECTIVE: Develop a software tool that acquires individual mission information for Air Tasking Orders (ATO), provides all the data necessary for each mission, establishes that all the equipment needed is available and not scheduled for a different concurrent or approximately concurrent mission and identifies an optimal flight route to the target.

DESCRIPTION: Depending on the requirements, an ATO may be enormous and highly complex. It contains everything that is scheduled in theater including helicopters and commercial flights plus all ground and airborne threats. In many cases, this would necessitate making thousands of folders in order to capture a tailored folder for each sortie. There are many processing steps involved in generating the target folder for a typical sortie. When done manually, this is time-consuming and the accuracy of the information is suspect due to direct data entry. Automation using machine-to-machine information transfer can solve both these problems. However, as success will require human-like decision making, balancing alternatives and sometimes conflicting goals, human-like reasoning and decision-making capabilities are needed, this is critical in particular during the mission execution phase.

A system is required that can perform the following reasoning and judgment in three areas:

- 1) Given a specific mission (for example, destroy a radar installation) in a specific location, choose the best combination of aircraft type, weapon type, and launch location when multiple types of each are available and launch could occur from the continental U.S, foreign bases or carrier platforms. This may require tradeoffs, such as weighing the importance of the best weapon for the task, available aircraft, and distance to target from location of aircraft. In addition during a mission execution as data changes (i.e. weather, threat information, etc.) mission planners/pilots need to be alerted to the changes, identify possible impact on current mission and compute alternative routes and/or alternative actions.
- 2) Subscribe to the required data for the mission from a variety of sources. This involves, for example, determining if the target is recognizable in imagery available and, if so, is it only recognizable from specific angles.
- 3) Plan a flight route using such factors as the likelihood of encountering threats, interfering/deconflicting with friendly operations, and geography/terrain. These three steps may be iterative.
- 4) Need to consider a virtual space around the aircraft during the mission execution so that mission planner/pilots are provided real time alert to data/information changes that may impact overall mission success that e.g. include weather, threats, change in target.

Note: The mission planning functions will be generic so that any qualified small business can submit proposals.

PHASE I: Demonstrate technical feasibility of developing a system that can emulate human-like reasoning to make best choices when choosing involves judgment and gray areas. Develop an initial concept for dealing with multiple

sources of data. Also address how to alert mission planner/pilot as data changes and define alternative course of action based on data information changes.

PHASE II: Develop a prototype that works in a modeling or model environment. The prototype must demonstrate clearly the ability to weigh conflicting choices, aid in the selection of imagery, plan routes based on that, and make the audit trail available to show how to alert mission planner and/or pilots as data and information changes during flight. Develop plans to integrate the system into the Fleet.

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

PHASE III: Integrate the software within the Joint Mission Planning System (JMPS) framework. Also, focus the development of software for additional platforms, mature the development for operational testing, and demonstrate the software as part of a Fleet exercise.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: This capability lends itself to providing situational awareness (SA) data for civil authorities during emergencies in major disaster areas such as earthquakes, hurricanes, forest fires, homeland defense emergencies and other similar types of catastrophic events.

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1. Carley, K.M. Smart Agents and Organizations of the Future. <http://oz.stern.nyu.edu/seminar/sp04/0422-3.pdf>
2. Dawidowicz E. Towards Smart Intelligent Agents in the Command and Control Environment. [http://www.dodccrp.org/events/2000\\_CCRTS/html/pdf\\_papers/Track\\_4/109.pdf](http://www.dodccrp.org/events/2000_CCRTS/html/pdf_papers/Track_4/109.pdf)
3. Sulaiman S., Shamsuddin, S.M. , Forkan F. & Abraham, A. (2009). Intelligent web proxy caching detection using Neurocomputing and particle swarm optimization. Proceedings of the 6th International Symposium on Mechatronics and its Applications (ISMA09)

KEYWORDS: Information Fusion; Decision Theory; Automation; Artificial Intelligence; Reasoning; Weapons

TPOC: (301)757-6153  
2nd TPOC: (301)757-6179

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

N111-023 TITLE: Thermal Management of Highly Integrated Radio Frequency (RF) Electronics

TECHNOLOGY AREAS: Air Platform, Sensors, Battlespace

ACQUISITION PROGRAM: PMA-234, EA-6

OBJECTIVE: Develop innovative and cost effective thermal management techniques to improve the system performance and reliability of high heat flux, air cooled, RF electronic systems operating in naval airborne operational environments.

DESCRIPTION: Modern RF electronics such as those used in airborne active electronically scanned array (AESA) based radar systems employ high power density, high temperature electronic devices requiring advanced thermal

management technology. For optimal operation these devices, in particular the transmit/receive (T/R) modules in an array need to efficiently dissipate significant quantities of heat and maintain accurate temperature control across the array. Traditional air cooling has generally been deemed to be ill suited to the high packaging density of an AESA. As a result most modern high-performance AESAs are liquid cooled. However, a liquid cooling system is not feasible for many airborne platforms. To compound this problem, the more recent utilization of wide band gap technology based on Gallium Nitride (GaN) devices can vastly increase power densities, and inevitably generate more waste heat, requiring even more advanced thermal management to fully take advantage of these devices.

Novel materials and structures are needed to improve the heat dissipation capability of air cooled AESA systems at C, X and Ku bands. Heat dissipation improvements may be achieved at the chip, module and system level. For example, performance improvements are needed in enhanced convection and fin efficiency of heat sinks, enhanced thermal interface materials between electronic devices and module cases, and less restrictive cooling channels through the array to reduce both thermal resistance and cooling fan power requirements. The total T/R module heat load for applications of interest is on the order of 3 watts per module. As this is for an airborne application total system weight is critical. Heat sink weight must be taken into consideration.

PHASE I: Identify and define approaches for high-performance thermal management techniques for air-cooled AESA radar systems. Demonstrate feasibility through numerical modeling and/or experimentation. Develop a full scale development and assessment plan on an array concept identified by the Navy.

PHASE II: Perform design optimization, fabrication process refinement, and performance enhancements for the thermal management system and demonstrate prototype for applicable candidate AESA.

PHASE III: Transition the developed technology to the appropriate platforms in the Fleet.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The technology developed under this SBIR is directly applicable to a very wide range of consumer and military electronic systems such as high density computing clusters or high power communication transmitters.

#### REFERENCES:

1. Icoz, T. & Arik, M. (2010). Light Weight High Performance Thermal Management With Advanced Heat Sinks and Extended Surfaces. Components and Packaging Technologies, IEEE Transactions on, Vol. 33, pp. 161 - 166

2. Ohadi, M. & Qi, J. (2005). Thermal Management of Harsh-Environment Electronics. In Kakaç, S. (Ed.) Microscale heat transfer: fundamentals and applications (pp. 479 – 498)  
<http://www.springerlink.com/content/mh8n16hv50424unh/fulltext.pdf>

KEYWORDS: Electronics; Thermal Management; Air-Cooled Electronics; Air-Cooled Active Electronically Scanned Array; Heat Exchanger

TPOC: (301)342-2637

2nd TPOC: (301)342-9173

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

N111-024

TITLE: Innovative Approaches for Utilizing Carbon Nanotube Technology (CNT) in Anti-Corrosion Coatings

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: PMA-265, F/A-18 / EA-18G, Hornet, Super Hornet and Growler Program

RESTRICTION ON PERFORMANCE BY FOREIGN CITIZENS (i.e., those holding non-U.S. Passports): This topic is "ITAR Restricted." The information and materials provided pursuant to or resulting from this topic are

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

**OBJECTIVE:** Develop and demonstrate a robust, durable, affordable and environmentally friendly Carbon Nanotube Technology (CNT) anti-corrosion coating that significantly reduces or eliminates critical aircraft component corrosion damage that does not require frequent periodic maintenance throughout the component service life in order to sustain effective corrosion damage protection.

**DESCRIPTION:** Navy aircraft utilize both paint and coatings on exposed structural components. An undesirable, though not totally unexpected side effect associated with the use of the paint and coatings has been the discovery of significant corrosion damage in multiple Fleet aircraft inducted for both Integrated Maintenance Concept (IMC) and Age Exploration inspections. Accordingly, platform Total Ownership Cost (TOC) is being significantly increased due to the required disposition and repair of corrosion damage in Fleet aircraft. Non-accessible forged aluminum parts are currently one of the biggest degraders from corrosion which is the primary focus substrate of this effort, but not limited to this substrate or part. Currently these parts are typically finished with a MIL-PRF-23377 high solids epoxy primer sprayed to a 0.6-0.9 dry film thickness. The coating should have corrosion performance meeting or exceeding hexavalent chromium coatings that meet MIL-PRF-23377 and compatible in electromagnetic performance with present conductive coatings. Specifically focusing on the feasibility of applying this coating to components fabricated from 7050-T74511 forged aluminum shall be assessed to the performance found in present primer specifications such as MIL-PRF-23377 and MIL-PRF-85582.

The Navy needs coatings that are capable of performing the mission in the electromagnetic spectrum but yet mitigate corrosion. Application should be by conventional spray methods both aerosol cans or pressurized pots and have the ability of being brushed on and touched up if damaged. The coatings need to be low in volatile containing compounds (VOC's) and hazardous air pollutants (HAP's). The ideal coating would have over a year shelf life for logistical reasons and be single component for ease of use in the fleet.

**PHASE I:** Develop a CNT anti-corrosion coating and demonstrate the feasibility of using it as a coating for structural aircraft components fabricated from forged aluminum alloy.

**PHASE II:** Develop, demonstrate and validate the technology developed under Phase I. Evaluate the approach through the fabrication and testing of a sufficient quantity of material property test coupons. Demonstrate this process on a representative part to show corrosion resistance.

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

**PHASE III:** Transition the CNT anti-corrosion coating technology to appropriate platforms.

**PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:** Minimizing or eliminating airframe corrosion damage in military and/or civilian aerospace applications offers the potential for substantially reducing overall Life Cycle Support (LCS) costs via reduced periodic maintenance. This technology is in demand for commercial aviation, as well as for commercial steel and aluminum structures.

**REFERENCES:**

1. MIL-PRF-23377, Epoxy Primer, High Solids

2. MIL-PRF-85582, Epoxy Primer, Waterborne

KEYWORDS: aerospace primer; carbon nanotube (CNT); Anti Corrosion Coating; CNT Coating; hexavalent coatings; forged aluminum

TPOC: (301)342-8076

2nd TPOC: (301)757-7562

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

N111-025

TITLE: Collision Avoidance Decision Making in the Face of Uncertainty

TECHNOLOGY AREAS: Air Platform, Sensors, Battlespace

ACQUISITION PROGRAM: PMA-266, Navy and Marine Corps Multi-Mission Unmanned Air Systems

OBJECTIVE: Develop optimal collision avoidance decision making processes for unmanned aircraft systems.

DESCRIPTION: Collision avoidance is a key enabler to unmanned aircraft systems (UAS) civil airspace access as well as an important capability for the integration of manned and unmanned missions in military theaters of operation. The “detect, sense, and avoid” process in collision avoidance attempts to answer three sequential questions. First, is something there? This involves searching the airspace around the aircraft and detecting, acquiring and tracking objects in the search volume. Second, is it a threat/target? This involves the sense function in evaluating the tracks, prioritizing perceived threats and deciding whether to maneuver. Third, how do we react/maneuver? This involves the avoid function in determining what action needs to be taken, commanding the action and then executing the maneuver. In the case of this SBIR topic, we are interested in optimally answering the second question in the face of uncertainty.

In addressing the sense question, measurements of a contact’s relative position information, rate of change of relative position, and/or the trajectory information for all contacts are used to decide whether a risk of collision (i.e., two aircraft are on a collision course) or a conflict (i.e., a violation of safe separation) exists and if an avoidance maneuver is required. These measurements and projections of future movements include varying degrees of uncertainty. An estimate of the uncertainty is valuable in assessing when sufficient information is available to make a maneuver decision. The decision timeline is time-constrained. Maneuver decisions must be made early enough to ensure safe separation.

Interaction with radar and airframe system manufacturers may be beneficial to successful transition of this technology.

PHASE I: Investigate optimal UAS sense decision making processes in the presence of non-cooperative aircraft. Determine the feasibility of the best process using sensor performance models and collision scenarios developed in consultation with the Navy.

PHASE II: Perform process design optimization and testing using both simulated and real sensor data. Integrate, test and demonstrate the algorithms using a candidate radar system.

PHASE III: Finalize and transition the developed technology to the Fleet.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The technology developed under this SBIR would increase safety and is directly applicable to civil manned and unmanned aviation.

REFERENCES:

1. Hottman, S.B., Hansen, K.R. & Berry, M. (2009). Literature Review on Detect, Sense, and Avoid Technology for Unmanned Aircraft Systems. <http://www.tc.faa.gov/its/worldpac/techrpt/ar0841.pdf>

2. Kochenderfer, M.J., Espindle, L.P., Edwards, M.W.M., Kuchar, J.K., & Griffith, J. D. (2009). Airspace Encounter Models for Conventional and Unconventional Aircraft: The Eighth USA/Europe Air Traffic Management Research and Development Seminar (ATM2009).  
[http://www.atmseminar.org/seminarContent/seminar8/papers/p\\_012\\_IMSA.pdf](http://www.atmseminar.org/seminarContent/seminar8/papers/p_012_IMSA.pdf)

**KEYWORDS:** Radar; Unmanned Aircraft Systems (UAS); Sense and Avoid; Due Regard; Decision Making

**TPOC:** (301)342-2637

**2nd TPOC:** (301)342-9173

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

N111-026                      **TITLE:** EOIR Multi-Sensor Fusion Tracker Algorithm

**TECHNOLOGY AREAS:** Information Systems, Sensors

**ACQUISITION PROGRAM:** PMA-290, Maritime Surveillance Aircraft

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

**OBJECTIVE:** Develop robust tracking capabilities fusing data from co-boresighted multi-sensor Electro-Optical/Infra-Red (EO/IR) turrets for near real-time surveillance and targeting.

**DESCRIPTION:** Advances in airborne EO/IR turrets provide an ever-growing array of co-boresighted video-rate sensors that cover a wide variety of wavebands and fields of view (FOV). While each additional information source nominally increases situational awareness, the operator is still limited in ability to assess the information. For real-time tactical missions where rapid response is critical, the operator must not only scan all video feeds for and hold the sensor on target, but also provide feedback to command and control and ground forces. In the case of unmanned air vehicles, this process is complicated by a limited bandwidth down link that causes compression artifacts, imagery lag, and limited access to simultaneous video feeds. To decrease operator workload and compensate for down link limitations, turrets employ on board automated tracking algorithms designed to lock on an operator-specified target and provide feedback to the turret slewing mechanism to keep the object centered in the FOV. It is critical that these algorithms be robust when the target becomes temporarily obscured and, when necessary, lose track gracefully, since loss of lock or a sudden large slew can cause a mission to be aborted.

Current tracking algorithms typically rely on linear (Kalman) algorithms. These approaches threshold input pixel regions into detections and non-detections and then perform data association. This hard-decision paradigm inherently degrades Signal-To-Noise Ratio (SNR) and loses information as it throws out regions that just nearly fail to meet the threshold, while giving regions that just barely pass the threshold full credit. As a result, in the presence of clutter, confuser vehicles frequently pass the threshold and cause the tracker to lock on to an incorrect vehicle and the desired track is lost for good. Furthermore, these algorithms mainly rely on just one of the modalities, and switch to other modalities when tracking becomes poor. This fails to exploit all of the information in the data stream at each time.

Innovative real-time data fusion and tracking algorithms capable of improving current operational implementations in EO/IR turrets on airborne platforms are sought. The algorithms should give significantly improved robustness in the presence of temporary obstructions, (e.g., when a vehicle drives under an overpass), and improved performance



in the presence of clutter. It is expected these gains will come about by exploiting non-linear (non-Kalman) tracking methods which admit both higher fidelity kinematic and sensor modeling. Enhanced kinematic modeling may exploit effects such as known go/no-go areas (e.g., roadways and water) and vehicle class-dependent preferred velocities and stopping times. Additionally, enhanced sensor statistical modeling will avoid hard-decision making (thresholding and association) of traditional methods, yielding improved information exploitation and ultimately superior performance in clutter. The algorithm must be capable of handling inputs from multiple large format (640x480) video feeds of a variety of spectral bandwidths and fields of view. The algorithm should assume co-boresighting within 10's of pixels, but must be capable of registering all feeds on the fly assuming knowledge of sensor to sensor pixel sizes and fields of view.

PHASE I: Define the architecture and concept of operation and identify the algorithm requirements to provide the capabilities described above. Through experiments, demonstrate the feasibility of the proposed approach.

PHASE II: Develop new algorithms and integrate into a hardware test bed and/or ground station. Demonstrate the new technology. For Phase II demonstration, candidate EO/IR system is the AN/AAS-52, Multi-Spectral Targeting System.

PHASE III: Transition technology to appropriate platforms and systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Successful outcome of this topic would be beneficial to security and policing actions as well as urban monitoring applications such as traffic monitoring and flow analysis, emergency response, and urban planning. In addition, wildlife management could also benefit from this application.

#### REFERENCES:

1. Bar-Shalom, Y. & Li, X. (1998). Estimation and Tracking: Principles, Techniques and Software. Artech House, Boston, MA, 1993. Reprinted by YBS Publishing.
2. Bar-Shalom, Y. & Li, X. (1995). Multitarget-Multisensor Tracking: Principles and Techniques, YBS Publishing.

KEYWORDS: Sensor; Electro-optical; Tracker; Airborne; Fusion; Multi-Band

TPOC: (301)342-0100  
2nd TPOC: (301)342.9106

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

N111-027                      TITLE: Innovative Ignition System Technologies for Advanced Tactical Solid Rocket Motors

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: PMA-259, Air-to-Air Missile Systems

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

OBJECTIVE: Develop and demonstrate a reliable low-cost ignition system for use in multi-pulse and high-volume-fraction end-burning solid rocket motors for tactical air-launched missile applications.

**DESCRIPTION:** To improve overall weapon performance, activities are ongoing to enhance the functionality of traditional volume-limited tactical solid rocket motors. These efforts have led to the evaluation of cutting-edge high-volume-fraction and multi-pulse solid rocket motors. Increasing the propellant volume loading and using multiple discrete pulses push the limit of, or even exceed the capabilities of, existing ignition systems. With higher volume fractions there is typically less propellant surface area available for ignition and significantly reduced free volume for hot ignition gases, making rapid and reliable ignition more difficult. Multiple discrete propellant grains require reliable and safe low-volume embedded igniters for each distinct pulse, all of which must work seamlessly together. The requisite level of integration and the parasitic weight penalties pose significant technical challenges. Each igniter must have a link to a remote safety-approved firing circuit that is accessed via an energy transmission line that is embedded inside and eventually transits the combustion chamber. In addition, each igniter must both rapidly ignite the discrete propellant pulse grain and fill the void volume left by burning previous pulses. Magnifying the complexity of achieving these objectives are stringent cost, space, size, and power parameters, as well as the requirements that the resultant system function reliably within the appropriate time frame and generate minimal debris. All new subsystems, both individually and in concert with the entire weapon system, must meet the performance, safety, and insensitive munitions requirements specified in MIL STD 1901A, MIL STD 2105C, and MIL STD-810F.

Realizing the ultimate goal for such a revolutionary ignition system entails developing advanced technologies for a multi-pulse initiation system, a pulse 1 igniter (main grain ignition), and a pulse 2 igniter (discrete grain ignition). Consideration will be given to innovative approaches that achieve one or more of these technologies. The ultimate objective is for all individual solutions to work flawlessly together. Finding the means to satisfy each of these disparate needs will be exceptionally difficult and will require unique and groundbreaking approaches. Even more challenging may be finding a way to integrate the resultant technologies so that they all work in concert. Extraordinary innovation and creativity, as well as the ability to push the state of the art, are required. The resultant system must function within the appropriate time frame and generate minimal debris.

**PHASE I:** Develop an innovative concept for an advanced ignition system for use in state-of-the-art end-burning solid rocket motors for tactical air-launched missiles. Demonstrate the feasibility of the technology and generate a plan to demonstrate functionality.

**PHASE II:** Devise and build a prototype ignition system for testing in a representative environment and determine the efforts required to bring the technology to the engineering and manufacturing development phase.

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

**PHASE III:** Integrate the ignition system into a full-scale analog rocket motor to be tested in firings at a designated site.

**PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:** The commercial Space sector has a need for modernized standard initiators and ignition systems for use in the next generation of launch vehicle boosters. The technologies demonstrated in this SBIR would have application to these commercial propulsion systems.

**REFERENCES:**

1. MIL-STD-1901A, Munition Rocket and Missile Motor Ignition System Design, Safety Criteria for, dated 6 June 2002
2. MIL-STD-2105C, Hazard Assessment Tests for Non-Nuclear Munitions, dated 14 July 2003

3. MIL-STD-810F, Environmental Engineering Considerations and Environmental Tests, dated 1 January 2000

**KEYWORDS:** Solid Propulsion Rocket Motors; Multi-Pulse Solid Rocket Motors; Air-Launched Rocket Motors, Ignition Systems; Multi-Pulse Ignition Systems; Ignition Safety Devices

**TPOC:** (760)939-7305

**2nd TPOC:** (760)939-7837

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

N111-028

**TITLE:** Wavefront Sensing for Tactical Systems

**TECHNOLOGY AREAS:** Sensors

**ACQUISITION PROGRAM:** PMA-290 Maritime Surveillance Aircraft

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

**OBJECTIVE:** Design and build a wavefront sensing system that can measure large amplitude wavefront errors on extended scenes in a tactical environment.

**DESCRIPTION:** Extended-scene wavefront sensing (WFS) techniques like correlations Shack-Hartmann and Phase-Diversity can be effective for measuring low to moderate atmospheric turbulence levels and optical alignment errors where the wavefront root mean square error (RMSE) is on the order of a wavelength. Astronomical systems and some defense applications fall in this turbulence and optical alignment error regime. However, important and significant applications require WFS techniques capable of measuring optical errors with wavefront RMSE larger than this regime. For example, tactical airborne systems image over paths where turbulence effects can easily defeat conventional WFS technologies. The challenging tactical operational environment, which includes platform vibration and altitude and airflow-induced temperature gradients, also produces large time-varying optical alignment errors. Furthermore, tactical system manufacturing is subject to high-tempo production schedules and cost constraints which do not allow the use of exotic materials or lengthy alignment procedures. These effects result in imagery with a significant reduction in information content compared to a diffraction-limited system with the same size aperture. As a consequence, cost-effective, near-term, innovative methods to perform near real-time measurement of large-amplitude wavefront errors on extended-scenes with the intent to use the technology as input into future tactical adaptive optics systems is sought. These WFS must be capable of measuring optical disturbances covertly (no active beacon) on extended scene imagery. The WFS will have a goal of robustly measuring optical disturbances an order of magnitude greater than those encountered in solar adaptive optics (e.g. for a 1m diameter telescope and an r0 of 10cm a RMSE is calculated of approximately 1wave tip/tilt removed). Its mechanical footprint should not require significant modification or growth in envelope of current tactical system design and aim to fit within a box 10 x 10 x 10 inches. The initial system may not draw more than 1kW of power with a goal of 100W. A design which is scalable to a variety of optical wavebands is preferable. In addition, this system needs to work in a very target rich environment. Modeling of wavefront disturbances caused by atmospheric turbulence and mechanical errors associated with optical reconnaissance and surveillance systems being used at long stand-off and medium altitude should be included.

**PHASE I:** Develop and prove feasibility of a passive, extended scene wavefront-sensing device. A performance analysis based on optical simulation should be performed.

PHASE II: Build, test and demonstrate a laboratory extended scene large amplitude wavefront sensing prototype with both hardware and software. Perform tower testing under various lighting and atmospheric conditions. Investigate ruggedizing the design and developing a real-time operational implementation of the code.

PHASE III: Integrate into a new system design with a deformable mirror. Integrate the wave front sensors to systems as upgrades as well as new builds.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Broad commercial uses such as ground imaging systems and commercial laser communications would benefit from successful development of this technology.

#### REFERENCES:

1. Rimmele, Thomas R., (2004). Recent Advances in Solar Adaptive Optics, Proc. SPIE, Vol. 5490 (34) doi: 10.1117/12.551764
2. Rimmele, Thomas R. & Radick, Richard R., (1998). Solar adaptive optics at the National Solar Observatory, Proc. SPIE, Vol. 3353 (72) doi: 10.1117/12.321734
3. Fried, David L., (1998). Branch Point Problem in Adaptive Optics. Journal of the Optical Society of America (JOSA) A, 15 (10), pp. 2759-2768. doi:10.1364/JOSAA.15.002759
4. Barchers, Jeffrey D. (2002). Closed-loop Stable Control of Two Deformable Mirrors for Compensation of Amplitude and Phase Fluctuations. Journal of the Optical Society of America (JOSA) A, 19 (5), pp. 926-945. doi:10.1364/JOSAA.19.000926
5. Tyler, G.A. (2006). Adaptive Optics Compensation for Propagation through Deep Turbulence: Initial Investigation of Gradient Descent Tomography. JOSA A, 23 pp. 1914-1923. doi:10.1364/JOSAA.23.001914
6. Roggemann, Michael C. & Lee, David J. (1998). Two-Deformable-Mirror Concept for Correcting Scintillation Effects in Laser Beam Projection through the Turbulent Atmosphere. Applied Optics, 37, pp. 4577-4585. DOI: 10.1364/AO.37.004577

KEYWORDS: Sensing; Wavefront; Imaging; Adaptive; Optics; Modulation Transfer Function

TPOC: (301)342-0100

2nd TPOC: (301)342-9106

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

N111-029

TITLE: Miniature Ultraviolet (UV) Laser Source below 280 nanometers (nm)

TECHNOLOGY AREAS: Air Platform, Sensors, Battlespace

ACQUISITION PROGRAM: PMA-272, Advanced Tactical Aircraft Protection Systems

OBJECTIVE: Design, develop and validate critical hardware for a miniature UV laser source at wavelengths below 280 nm.

DESCRIPTION: A UV laser source would target several important DoD applications to counter hostile fire identification (HFI) and degraded visual environments (DVE) by providing superior Light Detection and Ranging (LIDAR) and three-dimensional (3D) imaging through smoke, dust and smog while also supporting helicopter survivability during brownout conditions.

This topic addresses the development of the UV sources at wavelengths below 280 nm, which should be operated in continuous wave (CW) and pulsed mode with duration of 2-5 nanoseconds (ns). A number of approaches to the development of a miniature UV laser source have already been suggested but they all have limitations. UV laser source development utilizing semiconductors such as gallium nitride (GaN) is a possibility but the technology is not mature enough. Another conventional approach is to shift the wavelength towards shorter wavelengths. However, increasing the aluminum (Al) composition, in AlGaIn, makes the laser source unrealizable. UV sources at less than 280 nm of wavelength can be developed through frequency doubling or quadrupling of lasers at longer wavelengths. Semiconductor or solid-state laser sources can be used for frequency doubling or quadrupling. Hardware packaging should not exceed 1 cubic inch. The laser source should deliver energies in the range of 0.04 millijoule (mJ) to 0.2 mJ at a pulse repetition rate 1-10 kHz with an approximate average power greater than 1 watt.

PHASE I: Determine the feasibility of developing a miniaturized UV light source with the performance parameters listed above. Use modeling and simulation to demonstrate the results.

PHASE II: Based on the results of Phase I, build, test and validate a prototype of the miniaturized UV light source and test in a laboratory environment.

PHASE III: Manufacture three units of UV source lasers for a relevant environment. This iteration will be beyond bread board. Perform qualification tests in a relevant environment. Transition to appropriate platforms.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: UV light generation in laser form can illuminate fluorescence in paint markings, making them highly visible. This can be used in automobile headlights and aircraft landing lights to increase driver/pilot visibility. UV light can be bounced off atmospheric particles creating a non-line of sight communications path since light in the UV <280 nm scatters rather than being absorbed. Thus, increasing UV light intensities under this SBIR, creates an open market potential for the commercial and DoD developer.

#### REFERENCES:

1. Hamilton, C.E., Doughty, C.B., Roper, P.M., Mead, R.D. & Tidwell, S.C. (1998). All solid-state, single-frequency 193-nm laser system for deep-UV metrology. Lasers and Electro-Optics Society Annual Meeting LEOS IEEE
2. Shu-Di Pan, Ke-Zhen Han, Xiu-Wei Fan, Jie Liu & Jing-Liang He (2007). Efficient fourth harmonic UV generation of passively Q-switched Nd:GdVO<sub>4</sub>/Cr<sup>4+</sup>:YAG lasers. Optics & Laser Technology, Vol 39, Issue 5, 1030-1032
3. Shverdin, M.Y., Anderson, S.G., Betts, S.M., Gibson, D.J., Hartemann, F.V., Hernandez, J.E., Johnson, M., Jovanovic, I., McNabb, D.P., Messerly, M., Pruet, J., Tremaine, A.M., Siders, C. W., & Barty, C.P.J. (2007). Fiber-Based, Spatially and Temporally Shaped Picosecond UV Laser for Advanced RF Gun Applications. Proceedings of Particle Accelerator Conference, Albuquerque, New Mexico
4. Kojima, T., Konno, S., Fujikawa, S., Yasui, K., Yoshizawa, K., Mori, Y., Sasaki, T., Tanaka, M. & Okada, Y. (2000). 20-W ultraviolet-beam generation by fourth-harmonic generation of an all-solid-state laser. Optics Letters, Vol. 25, Issue 1, pp. 58-60

KEYWORDS: UV Laser Source; Degraded Visual Environment; Light Detection and Ranging (LIDAR); Frequency Doubled Laser; Frequency Quadrupled Laser; Solar Blind Laser

TPOC: (401)837-6887  
2nd TPOC: (301)342-0060

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

N111-030

TITLE: Optimally Integrate Automated Ship and Small Craft Classification Functions

with the Maritime Tactical Picture Tools

TECHNOLOGY AREAS: Air Platform, Electronics, Battlespace

ACQUISITION PROGRAM: PMA-290, Maritime Surveillance Aircraft Program Office

OBJECTIVE: Develop innovative techniques to intelligently allocate sensor resources in order to maximize the utility of current radar maritime target classification tools with associated common maritime tactical picture processing tools.

DESCRIPTION: The current state of the art in employing assisted target recognition for radar systems is to extract the maximum amount of target classification information using lower dwell-time radar modes prior to resorting to progressively more time consuming modes. For example, some target features may be discerned from a relatively low resolution search waveform, additional features may be identified from high range resolution (HRR) waveforms or from multiple HRR returns generated from different directions. If information from these returns does not identify sufficient features to confidently classify the target, more time consuming Inverse Synthetic-Aperture Radar (ISAR) imaging may be utilized. In certain instances ISAR and Electro Optical/Infrared (EO/IR) imaging may be done simultaneously to refine tracking of individual radar scatters on the target to support further refinement of the ISAR motion model to produce improved target dimension estimation and visual representation.

In a separate effort to create a coherent and consistent surface track picture, NAVSEA has been developing a powerful toolset as part of the Ocean Surveillance Initiative (OSI). OSI provides precision geodetic alignment and registration of tracks along with Automatic Identification System (AIS)-to-radar track auto correlation as well as correlation with digital nautical chart information, the ability to associate EO/IR and ISAR Imagery automatically with radar tracks, a set of rudimentary ISAR classification tools, and automatic track generation. OSI is also able to adaptively configure the display to suit user needs using selectable filters, zoom in/out capability and ability to select and display imagery associated with a particular track of interest.

The goal here is to optimally integrate OSI, or a comparable system, with automated radar based ship and small craft classification tools. This should be accomplished by intelligently resourcing the radar system to efficiently process targets in the radar field of view, perform real-time planning of flight tracks to optimally position the aircraft relative to targets, decide which modes are needed at what time to both maintain an up to date operational picture and classify targets, determine when sufficient feature extraction has occurred to perform classification, fuse feature data from multiple sources and times, and incorporate operator re-tasking.

PHASE I: Perform a detailed analysis and determine the feasibility of the innovative technique to merge the automated ship and small craft classification functions with the maritime tactical picture tools. Develop an RDT&E plan addressing performance metrics, integration tasks and human-system interface.

PHASE II: Design and demonstrate a prototype system in an operationally representative environment.

PHASE III: Transition the developed technology to appropriate platforms and the fleet.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The general methods developed could be applicable to a wide range of functions ranging from behavioral analysis to multiple sensor fusion and homeland security to the DoD.

REFERENCES:

1. Kawakami, K., Tanaka, H. & Yamamoto, K. (2004). 3D Object Recognition using ISAR Image: SICE Annual Conference in Sapporo, Japan. <http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=01491396>
2. Borden, B. & Cheney, M. (2002). Microlocal ISAR for Low Signal-to-Noise Environments <http://www.rpi.edu/~cheney/papers/isarieee.pdf>

KEYWORDS: Inverse Synthetic Aperture Radar; Automatic Target Recognition; Ship and Small Craft Classification; Electro-Optic Sensor; Multi-Sensor; Common Maritime Operational Picture

TPOC: (301)342-2637  
2nd TPOC: (301)342-9173

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

N111-031 TITLE: New technologies for underwater structural hull inspection

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: To implement New Underwater Hull Structural Inspections to support an Extended Drydocking Interval and apply technology to reduce the costs associated with maintenance and inspection of the underwater hull substrate material.

DESCRIPTION: Characterization of the condition of the hull plate and structure of an Aircraft Carrier is an enormous undertaking that is crucial to the life-cycle management of the ship. NSTM Chapter 100 contains new requirements regarding underwater hull inspection involving ultrasonic testing (UT) performed by diver or a portable underwater robotic hull scanner that executes a comprehensive hull material condition survey using sensors for ultrasonic testing, dry film thickness, and cathodic potential.

Conventional UT is a method of determining substrate thickness at highly localized points utilizing short ultrasonic pulse-waves. It is an effective and accurate method to determine material thickness assuming a generally uniform corrosion,. However, most marine corrosion of coated surfaces is galvanic and localized causing pitting. UT has limited effectiveness in the detection of discrete pits as commonly found in the marine environment.

The currently configured discrete point UT collection system in use for Aircraft Carrier hulls is limited in effectiveness. A recent review has shown that data collected through current methods would only identify 3% of structural pitting therefore likely missing potentially serious pitting corrosion.

Development of a method to obtain a wide band substrate condition results or otherwise detect nearly all pitting could extend the service life of hull plating and reduce costs and schedule of ship maintenance. A means to detect pitting in the shell plating will prove greatly beneficial to the Aircraft Carrier Fleet, the entire Navy, and possibly commercial shipbuilding as well.

PHASE I: Develop a concept proposal for a scanning method to be utilized on Aircraft Carriers. The ability to obtain, collect and analyze thickness data will be critical to a proposal's success.

PHASE II: Generate a full-scale working demonstration model of the wide band scanning inspection method and associated equipment. Once success is attained in the land-based environment, demonstrate operability onboard an Aircraft Carrier. Correct any shortcomings noted in the shipboard demonstration. Develop the capacity for full-scale manufacturing, including special tools. Develop the capacity for logistics support including provisioning, technical documentation, drawings, operating instructions, and training.

PHASE III: Preparation and readiness for full-scale manufacturing, Fleet introduction and fielding, training as necessary. Resolve any issues arising for development to production.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Commercial ship inspections, industrial equipment inspection.

REFERENCES:

- 1) NSTM Ch. 100
- 2) CCIMS Manual

KEYWORDS: Autonomous, inspection, ultrasonic, structural, UT, preservation

TPOC: Andrew Van Scyoc  
Phone: (202)781-2032  
Fax:  
Email: andrew.vanscyoc@navy.mil  
2nd TPOC: Joel Korzun  
Phone: (757)967-2582  
Fax:  
Email: joel.korzun@navy.mil

N111-032

TITLE: Low Light, Short Wave Infrared, Solid State Photodetector

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: Sea Shield, Surface Electronic Warfare Improvement Program (SEWIP), ACAT II

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

OBJECTIVE: To develop a low light capable solid state photodetector with low excess noise, very high gain, and a large dynamic range (single to multi-photon) up to a cut-off wavelength of 2.2 microns.

DESCRIPTION: Conventional short wave infrared (SWIR) solid state detectors are incapable of low light level performance because they have little to no gain, high dark currents, and noise limitations. Existing SWIR photocathode tubes can detect low light levels, but are bulky in size and weight, expensive, require very high operating voltages, and are difficult to implement in multi-element array formats. Recent developments in solid state photodetectors, such as discrete amplification and negative feedback avalanche processes, demonstrate low light level detection of visible, near infrared, and SWIR wavelengths at or near room temperature. These devices are compact, energy efficient, and are amenable to low cost wafer manufacturing and processing. However, these solid state photodetectors do not permit low light level detection of wavelengths exceeding 1.7 microns. This topic seeks to develop a low cost, low operating voltage (<70 V), uncooled or minimally cooled, solid state photodetector operating with low excess noise (<1.1), low dark current, very high gain (>1E5), high detection efficiency, and up to a cutoff wavelength of 2.2 microns. The technology should show a clear path to a compact, low voltage, solid state detector which can be integrated into a multi-element array format.

PHASE I: Demonstrate the technical feasibility of the proposed approach through design, simulation, and analysis. The proposed design shall be optimized for a cutoff wavelength of 2.2 microns, high gain, low noise, low light level detection (single to multi-photon detection capability), low operating voltage, and high detection efficiency. Test samples or experimental runs which demonstrate these requirements are highly desirable in the Phase I effort.

PHASE II: Using the results of the Phase I effort, design, develop, demonstrate and deliver a solid state detector which meets the aforementioned requirements. Demonstrate a clear path to develop an integrated multi-element array using these detectors.

PHASE III: Enable mass production so that unit cost is reduced. Design, development, and delivery of a multi-element linear or two dimensional array is encouraged.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The commercialization of this technology is expected to provide low cost, high performance, low light level, SWIR detectors in: Florescence



detection, spectroscopy, medical imaging, laser detection and ranging, homeland security, and free-space optical communication.

REFERENCES:

- (1) Krishna Linga, Yuriy Yevtukhov, and Bing Liang, "Near infrared single photon avalanche detector with negative feedback and self quenching," SPIE Proceedings Vol. 7419, Infrared Systems and Photoelectronic Technology IV, Eustace L. Dereniak, John P. Hartke, Paul D. LeVan, Randolph E. Longshore, and Ashok K. Sood, eds., 27 August 2009
- (2) J. Christopher Dries, Milind R. Gokhale, and Stephen R. Forrest, "A 2.0 micron cutoff wavelength separate absorption, charge, and multiplication layer avalanche photodiode using strain-compensated InGaAs quantum wells," Applied Physics Letters, Vol. 74, No. 18, pp. 2581-2583, 3 May 1999
- (3) Michael MacDougal, Jonathan Geske, and John E. Bowers, "InGaAsSbN photodiode arrays," U.S. Patent Application No. 12/254,634, Publication No. 20100096665A1, 22 April 2010

KEYWORDS: solid state; detector; extended wavelength; SWIR; low light; low noise

TPOC: Christopher Dunay  
Phone: (202)404-7647  
Fax: (202)767-1494  
Email: christopher.dunay@nrl.navy.mil  
2nd TPOC: Paul Mak  
Phone: (202)767-0088  
Fax: (202)767-1494  
Email: paul.mak@nrl.navy.mil

N111-033 TITLE: Supersonic Cold Spray Repair System

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PMS 392 In-Service Strategic and Attack Submarines; SEA-07L Sub Logistics

OBJECTIVE: Develop fixed and portable supersonic cold spray repair system that can be employed within NUWC Keyport (fixed unit) and Fleet Maintenance Activities (portable units) to salvage and restore expensive and hard-to-get consumable ship subsystem components. Examples include seawater pump components, air compressor components, and motor casings.

DESCRIPTION: Experience has shown that availability of castings and casting vendors is severely limited and at many times, the sole source for provision of these important components. An example is the Trident Trim Pump Priming Pump Vacuum Lobe, Cone, and Rotor assembly (NSN 4310-01-119-5384, 4310-01-119-5383, and 4320-01-064-7591 respectively). These units are expensive, and history has demonstrated the parts cannot be repaired using conventional means. Unit costs are \$85K per set with a 24 - 48 week lead time. There are 17 sets of "F" condition assets shelved at IMF Bangor equating to \$1.4M in unusable, consumable hardware. NUWC Keyport has investigated other repair techniques for these parts, but has not found a suitable method to date other the proposed cold spray application. Past demonstration of Supersonic Cold Spray Repair Systems on aluminum hardware in other DoD applications appears to be successful (Ref 1.) The prospects of developing systems to successfully repair materials of greater density (e.g. red brass and bronze materials used in the manufacture of these components) are highly probable. This project would complement NUWC Keyport's existing ONR-ARL/Penn State University Metal Deposition Projects, and align perfectly with Keyport's Technology Insertion Partnership with Puget Sound Naval Shipyard & IMF. For more information on Cold Spray Technology, see reference two.

PHASE I: Develop a conceptual design of multi-use Supersonic Cold Spray Repair tools (fixed and portable) that can be employed to salvage and restore consumable submarine and surface ship components such as pump lobes, impellers, cones, and motor casings.

PHASE II: Conduct beta supersonic cold spray repair applications of various metals, analyze beta samples for proper adhesion and strength properties; apply conventional engineering/manufacturing processes to ensure conformance. Conduct operational tests of repaired components using local test stands (when necessary) at Public Shipyards and Intermediate Maintenance Facilities.

PHASE III: Deploy supersonic cold spray repair systems to several Navy Repair Depots, install beta repaired parts on active U.S. Navy submarines and ships with NAVSEA and Type Commander authorization, conduct at-sea evaluation for 50 – 100 days, remove and inspect beta repaired parts to confirm process and validate system development.

NUWC Keyport personnel will work closely with the successful solicitor to assist in development of Cold Spray Repair Systems and processes; will provide adequate sample components with which to develop, test, and evaluate the repair systems, and ensure that test stands and other Government Furnished Equipment (GFE), where applicable, will be made readily available to help ensure success of this repair research project.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: This technology has great promise in refurbishing high dollar, complex, long lead time parts by restoring worn or damaged surfaces. This technology would have applications in the Commercial Ship Repair, Automotive, Petroleum, Natural Gas, and Electric Power Generation industries to repair turbines, wind power generating equipment, pumps & other mechanical components.

#### REFERENCES:

1. "Cold Spray Process Development for the Reclamation of the Apache Helicopter Mast Support," August 2009, P.F. Leyman and V.K. Champagne, U.S. Army Research Laboratory, Aberdeen Proving Ground, MD, Test Document ARL-TR-4922, <http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA505530&Location=U2&doc=GetTRDoc.pdf>
2. Centerline Supersonic Spray Technologies web site. [www.supersonicspray.com](http://www.supersonicspray.com)
3. Agile Manufacturing Center for Casting Technologies (AMCAST); Dr. Kershed Cooper
4. SSN 688 Los Angeles Class Vertical Launch System Missile Tube Robotic Laser Cladding Repair System; Dr. Kershed Cooper.
5. Repair, Refurbishment, Restoration, and Reclamation (R-4) Project; Dr. Kershed Cooper.
6. Electron Beam Free Form Fabrication, "E-Beam" Project; Mr. John Carney.

KEYWORDS: Fixed; Portable; Supersonic; Cold Spray; Metal; Reclamation; Repair; Restoration; work closely with solicitor; ensure the ready availability of test stands and GFE; help ensure success.

TPOC: Brian Mahoney  
Phone: (360)315-7879  
Fax:  
Email: [brian.t.mahoney@navy.mil](mailto:brian.t.mahoney@navy.mil)  
2nd TPOC: Kyle Morris  
Phone: (360)396-1939  
Fax:  
Email: [kyle.morris@navy.mil](mailto:kyle.morris@navy.mil)

N111-034

TITLE: High Thermal Performance Gallium Nitride Power Amplifier and Transmit/Receive Module Packaging

TECHNOLOGY AREAS: Sensors

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

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OBJECTIVE: Demonstrate innovative cost effective packaging for high power Gallium Nitride(GaN) Power Amplifiers (PAs.) for Navy Shipboard Radars and Electronic Warfare (EW) Systems.

DESCRIPTION: Gallium nitride power amplifiers have demonstrated state-of-the-art performance levels with respect to devices currently used in most Department of Defense (DoD) systems.<sup>1</sup> In particular, the relatively higher power and efficiency levels achieved with GaN PAs can be used to enable significant improvements in radar system range, weight, cooling, and cost. The reliability of GaN devices has also been established through the Defense Advanced Research Project Agency (DARPA) Wide Bandgap Semiconductor (WBGs) program.<sup>2</sup>

System insertion of GaN PAs still faces challenges related to affordable high performance packaging of GaN PAs. In particular cost effective thermal management is a key challenge for GaN PAs due to their relatively high RF power density and its corresponding high power dissipation density. To this end, solutions are sought with respect to the cost effective packaging of GaN PAs. Examples of representative solutions include (1) the development of high thermal conductivity PA heat spreaders and package base materials that address issues of mechanical damage and piezoelectric effects associated with coefficient of thermal expansion match differences between spreaders and GaN devices, plating compatibility with production eutectic solder process, and cost effectiveness. Heat spreaders should have a thermal conductivity greater than 250 W/mK that are compatible with AuSn or similar eutectic solder processes and that possess a coefficient of thermal expansion that matches silicon carbide. (2) The development of relatively high thermal conductivity solders and epoxies appropriate for attachment of GaN PAs to thermal spreaders or for attachment of transmit/receive modules to phased array cold plates. These thermally conductive interface materials shall have a thermal conductivity in excess of 25 W/mK, they shall be reworkable and suitable for low cost manufacturing processes and they shall also be able to satisfy the power dissipation levels anticipated during GaN PA operation without degradation. Finally, (3) development of affordable Transmit/Receive (T/R) module packaging technologies that provide a relative cost reduction are also sought. The technologies developed shall provide reliable life cycle operation of GaN T/R modules and reduce cost by 50%.

PHASE I: Demonstrate feasibility of proposed packaging and/or thermal management technology through modeling and empirical evaluations. Technical feasibility shall be demonstrated by meeting the stated performance objectives and demonstrating transition potential.

PHASE II: Develop and demonstrate a solid-state prototype PA module that 1) addresses the electrical, mechanical and thermal objectives of the topic, 2) that is compatible with high power operational shipboard solid state radars, and 3) will satisfy reliable long-term operation within an operational shipboard solid state radar.

PHASE III: Refine the phase II design as necessary and incorporate into a solid-state high-power amplifier module design intended for integration and demonstration in an operating IWS 2.0 radar system.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The developed high power PA modules will have technological applicability for all commercial and military avionics radars, all commercial radar applications, and all marine radar applications.

REFERENCES:

1. [www.cree.com/products/wireless\\_gan\\_hemt4.asp](http://www.cree.com/products/wireless_gan_hemt4.asp)
2. <http://www.darpa.mil/mto/programs/wbgsrf/index.html>
3. Progress in GaN Performances and Reliability Saunier, P.; Lee, C.; Balistreri, A.; Dumka, D.; Jimenez, J.; Tserng, H. Q.; Kao, M.Y.; Chao, P.C.; Chu, K.; Souzis, A.; Eliashevich, I.; Guo, S.; del Alamo, J.; Joh, J.; Shur, M.; Device Research Conference, 2007 65th Annual, 18-20 June 2007, Page(s):35 - 36.
4. [http://www.cree.com/products/wireless\\_gan\\_hemt3.asp](http://www.cree.com/products/wireless_gan_hemt3.asp)

KEYWORDS: Power Amplifier, Transmit/ Receive, GaN, Thermal Management, Radar, EW

TPOC: Charles Pagel  
Phone: (812)854-2382  
Fax:  
Email: chuck.pagel@navy.mil  
2nd TPOC: Gene Kremer  
Phone: (812)854-6433  
Fax:  
Email: eugene.kremer@navy.mil

N111-035 TITLE: High Performance Cost Effective Circulators/Isolators

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: NA, IWS 2.0 will transition into developing electronic warfare systems.

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OBJECTIVE: Demonstrate innovative cost effective high performance circulators/isolators applicable to Navy S-Band through X-Band shipboard radars and wide bandwidth electronic warfare (EW) systems.

DESCRIPTION: Circulators/Isolators are used in phased array antennas in part to isolate the power amplifier from load impedance variations created during electronic scanning. The development of circulators/isolators is particularly challenging to realize over relatively wide bandwidth (> 3:1) with relatively low insertion loss (< 1 dB), and high power capability (> 30 Watts at S-band, >10 Watts at X-band). In addition, the cost of the circulator/isolator is an important issue. Innovative and affordable circulator/isolator technologies are specifically sought that can satisfy the operational conditions required by developing Navy high power S-X Band radars and electronic warfare systems.

PHASE I: Demonstrate feasibility of proposed circulator/isolator technologies through modeling and empirical evaluation. Technical feasibility shall be demonstrated by meeting the stated performance objectives and transition potential.

PHASE II: Develop and demonstrate a circulator/isolator technology that 1) addresses the electrical objectives of the topic, 2) that is compatible with a high power operational shipboard solid state radar or wide bandwidth electronic warfare applications, and 3) that also will satisfy reliable long-term shipboard operation.

PHASE III: Refine the Phase II design as necessary and incorporate into a solid-state high-power amplifier module design intended for integration and demonstration in an operating NAVSEA IWS 2.0 radar or electronic warfare system.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The developed high performance, cost-effective circulators/isolators will have technological applicability for all commercial and military avionics radars and military electronic warfare systems, all commercial radar applications, and all marine radar applications.

REFERENCES:

1. Shur, M.S., "GaN-Based Electronic Devices", International Technology Research Institute, TTEC Report August 2000
- 2 Passive RF and Microwave Integrated Circuits ,Leo G. Maloratsky, Newnes, ISBN: 0-7506-7699-X
3. P. Schuh, "Using GaN technology in military systems," International Microwave Symposium, June 7-12, 2009, Boston, MA
4. R. Jones and B. Kopp, "Duplexer considerations for X-band T/R modules," Microwave Journal, pp. 348–352, May 2000

KEYWORDS: not changed

TPOC: Charles Pagel  
Phone: (812)854-2382  
Fax:  
Email: chuck.pagel@navy.mil  
2nd TPOC: Ceber Simpson  
Phone: (812)854-5470  
Fax: (812)854-6601  
Email: ceber.simpson@navy.mil

N111-036

TITLE: Advanced Anodes for Corrosion Control Systems for Complex Geometries

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PMS 397: Ohio Replacement Program ACAT1

OBJECTIVE: Develop and demonstrate capabilities of robust new anodes for use in corrosion control and sensing applications for naval platforms including submerged platforms.

DESCRIPTION: The objectives of this SBIR are to investigate new ICCP anode materials/concepts and develop new enhanced durability ICCP components with advanced capabilities. Advances in multifunctional materials and materials by design has created the ability to customize materials for specific purposes. Technologies of interest for the development of new anode materials include, but are not limited to conductive polymers and non-traditional high surface area electrode configurations for catalytic surfaces and electrochemical current delivery. New anodes are not limited to novel materials but also novel designs using new or traditional materials. New anodes should also have significant mechanical durability. Mechanical ruggedness is defined as the ability to withstand unplanned, but reasonable impact loads such as hammer drops and non-traditional and unexpected usages such as a step or hand-hold. Basic anode material current supply capability should be a minimum to supply 25 Amps with a system power supply driving voltage of nominally 15 Vdc. Voltage drop along the length of the anode shall be minimized. Life and reliability requirements are targeted at greater than existing technologies (30 years for anodes). Anodes developed must operate in a seawater environment of variable salinity and temperature and be compatible with ship

systems in general. Anode holders and casing materials shall be resistant to hypochlorous acid and hypochlorite generated on the anode surface during operation. Anodes electrical connections to power supply cables must be at significant hydrostatic pressures. In addition, there is a desire for anodes to allow for change out underwater, without drydocking.

PHASE I: Investigate metallic/non-metallic materials having properties to enhance ICCP anode and mechanical holder performance:

- 1) characterize proposed anode materials electronic properties and capabilities,
- 2) identify viable concepts for hull mounting/underwater replacement and evaluate improved mechanical mounting and hull replacement materials for long-term seawater performance.

Metrics for success will include the identification of appropriate materials and identify and validate proof of concept of novel anode materials and mounting configurations; including evaluation of current capacity, breakdown voltages, and anode efficiency.

PHASE II: Develop and demonstrate prototype anode performance for long term evaluation in a laboratory environment at high current densities and high driving voltages simulating Navy operational needs. Demonstrate the ability to manufacture anodes which can be installed in various configurations and sizes while still maintaining consistent performance. Demonstrate the efficacy of anode connections and proof of technology.

PHASE III: Develop of prototype suitable for installation aboard operational US Navy vessels. Develop materials, drawing packages, and manuals documentation to aid shipbuilder in installation and testing of anodes shipboard during extended operational periods. Conduct all required conformance testing.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: New anode materials could be applied to a broad range of military and civilian maritime and infrastructure applications where ICCP systems are relied upon for corrosion protection – for example, commercial shipping and interstate highway bridge maintenance.

#### REFERENCES:

1. K. E. Lucas, E. D. Thomas, K. I. Kaznoff and E. Hogan, "Design of Impressed Current Cathodic Protection Systems for US Navy Hulls," Designing Cathodic Protection Systems for Marine Structures and Vehicles, ASTM, STP 1370, pp. 17-38, 1999.
2. Underwater Ship Husbandry Manuals, Chapter 19, Cathodic Protection Systems, S0600-AA-PRO-190, NAVSEA 00C5 (Distribution A).
3. R. A. Adey (ed), Modeling of Cathodic Protection Systems, Chapter 2, Shipboard Impressed Current Cathodic Protection System Analysis, WIT Press, 2005.

KEYWORDS: Corrosion, anodes, conformal materials, ICCP, composite materials, multifunctional materials, conducting polymers, smart materials

TPOC: Diane Lysogorski  
Phone: (305) 293-4214  
Fax:  
Email: [diane.lysogorski@nrl.navy.mil](mailto:diane.lysogorski@nrl.navy.mil)  
2nd TPOC: Matthew Krupa  
Phone: (305) 293-4215  
Fax:  
Email: [krupa@nrl.navy.mil](mailto:krupa@nrl.navy.mil)

N111-037

TITLE: Modeling and Simulation Technologies Development for Combat System Integration and Certification

TECHNOLOGY AREAS: Information Systems

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**OBJECTIVE:** Develop innovative technologies for modeling and simulation of interface transactions among naval platform combat system elements.

**DESCRIPTION:** Combat systems are made up of a diverse mix of sensors, weapons, control systems, and display subsystems operating in a federated fashion. These federated subsystems may not be time-synchronized in adoption of new computing environments, improved war-fighting capabilities, data communications models, and software architectures at varying advanced capability build and capability insertion schedules. This creates a dynamic and challenging testing and integration environment for each constituent subsystem by having to adopt multiple versions of specific interfaces in order to verify the required interoperability. Typically, subsystems maintain high fidelity synthetic simulations for their sensor level interfaces; however, simulations of control system and weapon system interfaces for test, certification and training are of limited fidelity, allowing for syntax and semantic mismatches.

Innovative technologies are required to ensure interface simulations are sufficient to test both the syntax as well as semantics of a given interface in order to minimize costly and time-consuming issues during formal combat system integration and certification. Promising approaches may include parallel and distributed simulation techniques that enable data synchronization, and provide automated event schedule management and randomized controls. Innovative designs should be flexible to minimize the impact of interface changes and additions to the overall fidelity of the simulation capability. The desired simulation capability will support event modeling based upon user-defined reactive/adaptive algorithms and support synchronization with other higher level simulations.

**PHASE I:** Identify and define timing relationships and data models to be addressed in combat system interface simulators. Establish a model which enables automated interface message sequencing, and provides latency control. Provide an assessment of how the recommended simulation approach model will accurately model the syntax and semantics of combat system interfaces.

**PHASE II:** Develop a prototype combat system simulator that exploits reactive/adaptive interface techniques. The prototype should model timing relationships defined in Phase I, and provide innovative time saving automation methods that control interface testing. Perform appropriate limited-scale experiments to demonstrate product feasibility.

**PHASE III:** Develop a production simulation capability of federated peer combat subsystems for the AN/SQQ-89. Deploy the simulation system to support AN/SQQ-89 development, testing and certification. Design and develop interfaces with existing AN/SQQ89 training systems, and integrate as part of AN/SQQ-89 shipboard systems to support embedded shipboard training

**PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:** Modeling and simulation of systems with non-deterministic timing characteristics can be applied to web service interfaces used in many commercial transactions, such as banking.

**REFERENCES:**

1. ACM Transactions on Modeling and Computer Simulation (TOMACS), George F. Riley et al
2. Using Ontologies to Support Interoperability in Federated Simulation, Tarun Rathnam
3. Changing Focus on Interoperability in Information Systems: From System, Syntax, Structure to Semantics, Amit P. Sheth

KEYWORDS: Modeling; Simulation; Training; Testing; Software Architecture; Transactions; Interfaces

TPOC: Meg Stout  
Phone: (202)781-4233  
Fax:  
Email: Meg.Stout@navy.mil  
2nd TPOC: Richard Guthrie  
Phone: (202)781-4378  
Fax:  
Email: richard.guthrie@navy.mil

N111-038 TITLE: Low Cost, High Reliability Proximity Switches

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: PMS 312 fleet maintenance program

OBJECTIVE: To develop a family of proximity switches that opens or closes an electrical circuit when a target comes within a specified distance of the switch for use on numerous types of equipment including elevators, hatches, and doors on various classes of Navy ships. Increased service life, reliability, and durability along with reduced required maintenance of these switches will greatly reduce costs.

DESCRIPTION: All classes of Navy ships include various traveling equipment such as weapons elevators, aircraft elevators, hangar bay door systems, crane systems and deck edge doors. Until recently these systems used mechanical limit switches to detect when the device reached intermediate or end-of-travel positions. More recently non-contact proximity switches have been used to replace the high-maintenance and costly mechanical limit switches. Thousands of proximity switches operate and are required aboard various ships of virtually all ship classes.

Both mechanical limit switches and the proximity switches now in use are unsupported and obsolete. New technologies are needed with greater reliability and durability for the maritime environment.

Many of these switches are located in elevator trunks, catwalks and in high overhead locations which makes replacing and maintaining them very difficult, hazardous and time consuming. Most will be installed in above deck locations which makes EMI susceptibility qualification in accordance with MIL-STD-461 a critical requirement. The switches are required to maintain a consistent actuation curve for a temperature range of -20 to +70 degrees Celsius, a relative humidity range of 0-100 percent and in the presence of rain accumulation of up to four inches per hour. A newly designed military qualified proximity switch is required to maintain current ship systems as well as to allow for the replacement of limit switches in certain applications. These proximity switches would reduce cost of replacement parts, reduce associated man-hours and increase readiness of mission critical systems.

A wide variety of configurations and sizes would be required therefore a successful prototype will be versatile and have utility for the numerous applications and range of environmental requirements.

PHASE I: Develop a concept proposal for a low cost proximity switch which will meet the performance specifications detailed in Reference (1). Determine feasible packaging options to protect internal electronics of EMI susceptibility and outside environmental factors that will insure the proximity switch will operate as specified. Report on all findings, making recommendations as to the most promising and feasible technical approaches for further development.

PHASE II: Develop a new proximity switch which incorporates advanced technology and will change state when flagged at the specified distance. The switch should not allow sensing distance to decrease overtime. Also, should incorporate all temperature, humidity, shock, vibration, EMI and electrical tests detailed in Reference (1).



Build a prototype and Demonstrate that the prototype switch changes state when flagged at the specified distance. Time limitations may not allow actual lifecycle testing but a simulated test should be conducted to estimate the life expectancy of the proximity switches. Verify that sensing distance does not decrease over time. Also, perform all temperature, humidity, shock, vibration, EMI and electrical tests detailed in Reference (1). After the test period, the proximity switches will be disassembled and inspected for any damage or nonconformance of the performance specification.

During a Phase II option period, demonstrate operability onboard an Aircraft Carrier as a Test and Evaluation (T & E) during one 6-month deployment with multiple subject matter experts to verify readiness. Correct any shortcomings noted in Shipboard T & E.

PHASE III: Develop the capacity for full-scale manufacturing, including special tools. Develop the logistics support package including provisioning technical documentation, drawings, operating instructions, installation, training and maintenance procedures as necessary. Develop the capacity for logistic, communications, HW/SW, and training support, as well as provisioning technical documentation and operating instructions. Generate full-scale manufacturing, Fleet introduction and Fielding, and training as necessary.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: elevators, crane systems, industrial traveling equipment, conveyors, commercial ships

REFERENCES:

(1) MIL-PRF-24711B – Performance Specification, Proximity Switch, Solid State

(2) MIL-S-901D - MILITARY SPECIFICATION: SHOCK TESTS. H.I. (HIGH-IMPACT) SHIPBOARD MACHINERY, EQUIPMENT, AND SYSTEMS, REQUIREMENTS FOR (17 MAR 1989)

KEYWORDS: Enclosure, Proximity, Switch, Elevators, Cranes, Doors

TPOC: Andrew Stankovich  
Phone: (215)897-7305  
Fax: (215)897-1094  
Email: Andrew.Stankovich@navy.mil  
2nd TPOC: Kenneth Poole  
Phone: (215)897-7984  
Fax: (215)897-8167  
Email: kenneth.j.Poole@navy.mil

N111-039 TITLE: High Throughput, Waveguide Based, Non-Mechanical Laser Beam Steering

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: Sea Shield, Surface Electronic Warfare Improvement Program (SEWIP), ACAT II

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OBJECTIVE: Develop novel, ultra-low size, weight, and power devices for electro-optic laser beam steering over a large field of regard with high optical throughput and low-unit cost.

DESCRIPTION: New innovations hold the promise of finally providing an Electro-Optic (EO) replacement for mechanical laser beam scanners. Recent advances in waveguide based EO scanners have enabled very large refractive scan angles (up to 270 degrees) with a simple, low electrode count in a low Size, Weight, and Power (SWaP) package. Being ultra-low in power consumption, this device meets stringent energy conservation requirements for many applications. Improvements in devices such as these are sought. Of particular interest are fast scanning devices (>2 kHz) with high optical throughput (>80%) for eye-safe wavelengths (1.5 – 1.8 microns) that are also amenable to larger beam sizes (>1 cm). For example, new waveguide manufacturing techniques enable larger beam diameters, higher coupling efficiencies, and potentially dynamic two dimensional EO scanning. Furthermore, to meet often demanding requirements on pointing accuracy (can be sub-microradian), analog or refractive steering approaches are particularly attractive. The goal is a simple, cost effective, low SWaP EO laser beam scanner with a large field of regard (>50 degrees), fast scan rate (>2 kHz), and high optical throughput (>80%) for eye-safe wavelengths (1.5 – 1.8 microns) and large beam diameters (>1 cm).

PHASE I: Examine a specific innovative ultra-low SWaP laser beam steering technology, develop a concept, and design to meet the field of regard, scan rate, and throughput requirements. Because of its inherent vibration immunity and low power consumption, a non-mechanical solution is required. Experimental demonstrations that verify the feasibility of the approach are encouraged. At the end of phase I the proposing company should have a verified design to meet the aforementioned requirements.

PHASE II: The results of the feasibility phase should be analyzed and optimized to create a realistic experiment that proves the viability of the selected approach. The proposed solution developed in Phase I should be fully constructed into a working prototype system. The goal is to perform a demonstration in a relevant military environment.

PHASE III: During Phase III, the system developed in Phase II will be integrated into a wider tactical environment. Depending on the outcome of the research, the operation of the non-mechanical scanner will be assessed in a relevant, complex, and stressed environment with deployment on a variety of real world platforms.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Ultra-low SWaP beam-steering technology will find utility in: laser projection systems, laser detection and ranging, heads-up displays, and free-space optical communications.

#### REFERENCES:

1. Scott R. Davis, et al, "Analog, non-mechanical beam-steerer with 80 degree field of regard", SPIE Proceedings Vol. 6971, Acquisition, Tracking, Pointing, and Laser Systems Technologies XXII, Stephen L. Chodos and William E. Thompson, eds., 24 March 2008
2. Scott R. Davis, et al, "Liquid Crystal Waveguides: New Devices Enabled by >1000 Waves of Optical Phase Control", SPIE Proceedings Vol. 7618, Emerging Liquid Crystal Technologies V, Liang-Chy Chien, ed., January 2010

KEYWORDS: beam scan; electro-optic; non-mechanical; waveguide; high throughput; low SWaP

TPOC: Jason Auxier  
Phone: (202)404-7683  
Fax: (202)767-1494  
Email: jason.auxier@nrl.navy.mil  
2nd TPOC: Paul Mak  
Phone: (202)767-0088  
Fax: (202)767-1494  
Email: paul.mak@nrl.navy.mil

N111-040

TITLE: Wide Bandwidth, High Performance Cost Effective Antenna Elements

TECHNOLOGY AREAS: Sensors

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

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OBJECTIVE: The development of cost effective, wide bandwidth linear polarized antenna elements that provide relatively low insertion loss and high gain at broadside for Navy Shipboard Radars and Electronic Warfare (EW) Systems.

DESCRIPTION: Antenna elements are a key part of any phased array antenna system. The development of cost effective, high performance antenna elements is challenging for wide bandwidth applications, in particular with respect to the impedance at relatively broad scan angles presented by an array of antenna elements. For this reason, proposals are sought for the development of cost effective, wide bandwidth linear polarized antenna elements that provide relatively low insertion loss and high gain at broadside with relatively low voltage standing wave ratio (VSWR). Wide bandwidth antenna elements should demonstrate a VSWR of <2:1 at scan angles less than or equal to 60 degrees. The proposed technology solution must demonstrate this level of performance at low acquisition cost and provide reliable operation in a Navy shipboard application for the anticipated antenna lifecycle so that total ownership cost for the antenna modules is minimized also. There is specific interest in potential technologies with applicability to S-Band through X-Band high power radar applications.

PHASE I: Demonstrate feasibility of proposed wideband antenna elements technology through modeling and empirical evaluation. Technical feasibility shall be demonstrated by meeting the stated performance objectives and transition potential.

PHASE II: Develop and demonstrate wideband antenna elements that 1) addresses the electrical, mechanical and thermal objectives of the topic, 2) that are compatible with a high power operational shipboard solid state radar, and 3) will satisfy reliable long-term operation within an operational shipboard solid state radar.

PHASE III: Refine the phase II design as necessary and incorporate the wideband antenna elements for integration and demonstration within an operating IWS 2.0 radar system.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The Antenna elements are a key part of any phased array antenna system. The development of cost effective, high performance antenna elements has applicability for all commercial and military avionics radars, all commercial radar applications, and all marine radar applications.

REFERENCES:

1. C. A. Balanis (ed.), Modern Antenna Handbook, 1st Ed., Chap. 12, W. F. Croswell, T. Durham, M. Jones, D. Schaubert, P. Friederich and J. G. Maloney, "Wideband Arrays", (John Wiley and Sons, Inc., 2008).
2. Antenna Engineering Handbook, Johnson and Jasik.
3. Phased Array Antenna Handbook, R.J. Mailloux.

KEYWORDS: Wideband, Antenna Elements, Radar, EW, Phased Array, VSWR

TPOC: Charles Pagel  
Phone: (812)854-2382  
Fax:

Email: chuck.pagel@navy.mil  
2nd TPOC: Jonathan Gregory  
Phone: (812)854-5942  
Fax:  
Email: jonathan.j.gregory@navy.mil

N111-041 TITLE: Strike Group Active Sonar Exploitation

TECHNOLOGY AREAS: Sensors, Battlespace

ACQUISITION PROGRAM: Sonar Automation

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**OBJECTIVE:** Develop and demonstrate sonar processing technology capable of exploiting noise (e.g., active transmissions) from other platforms in a Navy strike group operating area.

**DESCRIPTION:** Most traditional Anti-Submarine Warfare (ASW) active systems process data from organic sensors with full knowledge of their own transmissions. However the systems are often deployed in proximity to other active systems, as in a carrier or expeditionary strike group.

Surface combatant active processing and displays do not currently leverage echoes from off-board sources, such as other combatants in the strike group. The ability to leverage the echoes from other ship's transmissions could improve ASW performance. Alternately, ships could retain current performance while reducing the amount of acoustic energy they emit, reducing the environmental impact on marine species.

This topic seeks innovative concepts and active signal processing technologies to improve overall strike group ASW performance by using the full spectrum of energy being transmitted from other sources. Combining these additional detection opportunities with existing monostatic active systems should lead to faster time to detect, longer holding time, and improved track performance.

**PHASE I:** Develop approaches for a Navy strike group multi-source active processing concept to exploit multi-source transmissions. Demonstrate the feasibility of implementing the proposed concept with simulated or real data.

**PHASE II:** Develop, demonstrate and validate the strike group active processing in a prototype software baseline suitable for real-time operation. Conduct proof of concept with simulated and pre-recorded sea test data. Assess performance using quantitative measures of performance, and participate in a peer-review evaluation process.

**PHASE III:** Integrate and test software in a real-time environment via the Advanced Capability Build (ACB), Advanced Processor Build (APB) program, or other program specified by the US Navy.

**PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:** Active sonar systems for port security and oceanographic survey.

**REFERENCES:**

1. Urlick, R., "Principles of underwater Sound," McGraw Hill, 3rd Edition.
2. Urban, H. G., "Adaptive Methods in Underwater Acoustics," Proceedings of the NATO Advanced Study Institute

on Adaptive Methods in Underwater Acoustics, July 1984

3. Hemple, Christian, "Adaptive Track Detection for Multi-Static Active Sonar Systems."

4. John L. Spiesberger, "Geometry of locating sounds from differences in travel time: Isodiachrons", J. Acoust. Soc. Am. 116 (5), Nov 2004

KEYWORDS: Active Sonar, Signal Processing, Multi-statics, Bi-statics, Directional Noise, Multi-ship ASW Operations, Marine Species

TPOC: Meg Stout  
Phone: (202)781-4233  
Fax:  
Email: Meg.Stout@navy.mil  
2nd TPOC: Richard Guthrie  
Phone: (202)781-4378  
Fax:  
Email: richard.guthrie@navy.mil

N111-042 TITLE: Improved Accelerated Life Testing

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: Virginia Class Submarine

OBJECTIVE: To develop a more accurate testing standard for Accelerated Life Testing (ALT) of submarine components.

DESCRIPTION: Recent Navy research has indicated that the Accelerated Life Testing (ALT) protocols have in some cases overestimated accelerated aging by a factor of ten, meaning that a component may fail in two years rather than the twenty years certified.

The Navy spends approximately 25% of its annual submarine maintenance budget on corrosion control. Debonding of paints and other polymeric coatings from metal surfaces in particular can cause hardware degradation and failure in the marine environment. Such processes typically involve an electrochemical reaction between water and dissolved oxygen, generating hydroxide ions at the polymer-metal interface. Because this reaction takes place only on cathodically polarized metal surfaces, it has been given the generic name of "cathodic delamination" (CD).

CD is responsible for an estimated \$10M to \$100M per year in unanticipated hardware failures and increased maintenance costs, and evidence has been accumulating that the "standard mechanism" for CD may not be realistic for all debonding scenarios.

This topic involves an investigation of the accuracy of the accelerated life testing protocols for CD resistance utilized by the Navy acquisition community for first article testing of a wide variety of naval hardware. Since the 1980s, new ideas for CD accelerated life testing protocols and possible CD mitigation strategies and techniques have been proposed (and in some cases partially adopted by the Navy). Proposers are encouraged to reinvestigate the nature of the CD problem and determine the effectiveness of new approaches for combating CD.

PHASE I: Develop approaches for improved Accelerated Life testing of components subject to cathodic delamination through modeling and tests of seawater diffusion into paints and other polymeric coatings.

PHASE II: Test/verify approaches against Navy components of interest to generate sufficient data to support more accurate testing standards.

PHASE III: Incorporate successful results into Navy standards, e.g., the Outboard Cable Molding Manual (NAVSEA S9320-AM-PRO-020 MLDG REV 2).

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Improved Accelerated Life Testing will impact many sectors, both military and commercial.

REFERENCES:

1. Ramotowski, T., 2002, "Accelerated Life Testing of Marine Cables and Connectors: Problems, Pitfalls, and Suggestions for Improvements," Proceedings of the Oceans 2002 MTS/IEEE Conference, Biloxi, MS, October 29-31, 2002.
2. T. Ramotowski, "A New Look at an Old Scourge: Cathodic Delamination and the 21st Century Navy" (ILIR report). <https://donst.nrl.navy.mil/cgi-bin/login-form.cgi>

KEYWORDS: corrosion; Accelerated Life Testing; debonding; cathodic delamination; aging; coatings

TPOC: Thomas Ramotowski  
Phone: (401) 832-5111  
Fax: (401) 832-6401  
Email: thomas.ramoski@navy.mil

N111-043 TITLE: Development of an Advanced Severe Service Valve Actuator

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: CVN-78 (PMS 378)

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

OBJECTIVE: Develop a valve actuator that will operate under severe vibration frequencies and amplitudes.

DESCRIPTION: The Navy is working toward reducing operating cost by reducing shipboard manning levels. Remote operation of valves and remote control and monitoring of associated shipboard fluid piping systems is the Navy's means to meet that goal. To achieve remote operation and control of fluid piping systems valves must be opened and closed by remote actuators using ships power rather than human power and the actuators must respond to both local and network commands and report their status both locally and over a network. Navy Ships have been equipped with fiber optic networks which include control and monitoring stations, sensors, and input/output (I/O) connections at each actuator.

Navy ships drainage eductors used for large scale or catastrophic casualty dewatering of ships main machinery spaces are located low in the ships structure in pump rooms and power plant equipment spaces. This system is a mission critical survivability system. The valves to be opened and closed when operating an eductor are typically co-located with the eductors making it necessary for ships force to travel down 7 decks down steep vertical ladderways and trunks to reach the valves. The drainage eductors create vacuum using energy from the ships firemain to discharge water from the ships bilges overboard. The pressure drop and resultant energy expended by the CVN eductor creates a high frequency high amplitude vibratory force which is transmitted to the piping and components local to the eductor including the eductor valve actuators. Eductor valve actuators must exhibit no mechanical, electrical, electronic component damage including the input-output connectivity ensuring the valve

actuator maintains communication with the remote operating station.

As part of the newest CVN ship design the Navy changed from a robust hydraulically controlled actuator, which was able to withstand unusually high and unique vibration amplitudes, to a new more capable electronically controlled actuator. To date ship designers have not been able to develop a reliable actuator for this system.

Current actuators meeting DOD-V-24657 are tested and qualified to standard vibratory frequencies per MIL-STD-167-1 which are much lower than the frequencies measured during CVN-77 eductor operation. The high frequencies and ultra high amplitudes that, as we now know, are unique to the Navy CVN main drainage system, are causing mechanical, electrical and electronic failures of actuators as well as loss of communication between the network and the actuators. There are currently no military or commercial actuators available to the Navy that are able to withstand the high vibratory forces experienced on CVN-77 eductor systems. The actual operating environment parameters will be provided to the successful offeror.

Research should be conducted into advanced severe service technological innovations that would enable to ensure mechanical component, electronic component, and I/O survival of the proposed solution. The resultant actuator should be able to operate the referenced Navy Standard gate, globe, and butterfly valves while maintaining communications with an attached network during severe vibration. Any mechanical or passive communication bypass mounted on the valve must also maintain communications during severe vibration.

#### GUIDELINES FOR NEW TECHNOLOGY:

1. Capable of operating in a marine environment.
2. Capable of operating Navy Standard multiple turn Gate and Globe valves, and quarter turn Butterfly valves of sizes 6 inch through 10 inch.
3. Capable of utilizing ships power 440 VAC, 3 Phase for motive force, electronic control, I/O signals, and local Human Machine Interface.
4. Capable of receiving commands and reporting out both the communication and physical status of the actuator to the control and monitoring network and use standard communication protocols (such as PROFI BUS).
5. Capable of failing such that the optical loop is not disconnected, or provide a means to bypass the optical repeater in the valve actuator and must be configurable for either loop or direct communication with the network.
6. Shall incorporate a Human Machine Interface that is focused on providing ease of operation for local open/close control and troubleshooting connectivity problems.
7. Capable of full operational performance and I/O connectivity during and following vibratory testing under sinusoidal vibratory forces of translational base input at the lesser of 0.2 inches single amplitude from 4 to 53 Hz inclusive and 50G from 53Hz through 500Hz, when frequency is varied across the range by 1/10 octave steps.
8. Physical envelope of 17"x18"x22".
9. Maximum weight of 240 pounds.

PHASE I: Conduct needed R&D to define and develop a concept for an improved actuator which will improve I/O connectivity while undergoing the operational vibratory frequencies and amplitudes as specified in guidelines. Longer term and higher amplitude testing is of interest to further prove the ability of the new technology to handle longer and more severe service.

PHASE II: Complete the R&D, detailed engineering and design for the selected actuator concept. Build an actuator prototype(s) and demonstrate I/O connectivity while operating a Navy Standard valve from open to close to open through 10,000 cycles while undergoing vibratory frequencies and amplitudes as specified in guidelines.

PHASE III: Complete engineering development, testing and manufacturing needed for Navy approval. Commercialization of the actuator in combination with a Navy-relevant actuator design. Transition developed technology to interested Navy platforms (including CVN-78).

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The private sector will benefit from this technology whenever high frequency large amplitude service actuators are required, such as for process control in oil refineries, coal processing plants, air component separation, and energy drilling operations.

#### REFERENCES:

1. DOD-V-24657 Valve Actuator, Direct Coupled, Gear Driver, Electrically Powered and Auxiliary Systems
2. MIL-STD-167-1 Mechanical Vibration of Shipboard Equipment (Type I-Environmental and Type II – Internally Excited)
3. NAVSEA Standard Drawing 803 2177917K Bronze Flanged Gate 250 PSI WOG
4. NAVSEA Standard Drawing 803 1385541 (L) Bronze Flanged Inline & Angle Stop & Stopcheck, 2-1/2” – 12
5. MIL-V-24624 Valves, Butterfly, Wafer and Lug Style, Shipboard Service
6. MIL-PRF-32307 Valve, Quarter Turn, Triple Offset, Torque Seated, Shipboard Use

KEYWORDS: valve; actuator; vibratory; frequency; amplitude; vibration

TPOC: Scott Bohlander  
Phone: (215)897-8588  
Fax: (215)897-7200  
Email: scott.bohlander@navy.mil  
2nd TPOC: Greg Brown  
Phone: (202)781-3618  
Fax: (202)781-4563  
Email: gregory.m.brown@navy.mil

N111-044

TITLE: Optimized Coordinated Search

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

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

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OBJECTIVE: Investigate and develop innovative algorithms to support coordinated acoustic and non-acoustic Anti-Submarine Warfare search by multiple heterogeneous manned/unmanned systems.

DESCRIPTION: Future ASW will incorporate networks of multiple acoustic and non-acoustic sensor modules deployed on airborne, surface, and sub-surface manned platforms and unmanned vehicles (UVs) that can detect submarines and surface ships. Recent advances in mission planning have focused on platform-level capability. In an environment with multiple heterogeneous platforms, it is critical to generate coordinated mission plans in order to optimize manned platform and UV effectiveness. The aim of this project will be to evaluate candidate algorithms and data processing technologies that will generate the best possible mission plans for multiple manned platforms and UVs. This planner will receive mission tasking information for a group of airborne, surface, and sub-surface manned platforms (e.g., MH-60R, DDG-51) and UVs. From this tasking, it will generate individual mission plans designed to optimize overall ASW mission effectiveness. In addition, it will evaluate plan effectiveness in real-time, taking into account platform constraints, sensor performance and in-situ environmental data. The mission planner will also provide dynamic re-planning when necessary. Manned platform and UV system performance metrics to be improved by transitioning this optimal mission planner into the fleet will include reduced time to search an area and reduced operator workload. These improved plans will provide improved situational awareness and threat



assessment.

PHASE I: Develop and evaluate Mission Planning algorithms for heterogeneous manned platforms and UVs that utilizes best-available search optimization techniques and are suitable for transition into Navy systems such as the Undersea Warfare Decision Support System (USW-DSS). Emphasis will be placed on future military utility (i.e., producing effective and implementable search plans based on modeling constraints on ASW platforms and sensors and their actual effectiveness in search operations). Create simulated data to evaluate system performance.

PHASE II: Following the Advanced Processor Build (APB) concept, fully develop an interactive prototype of a standalone tactical decision aid to demonstrate proof of concept and demonstrate its operation and ability to effectively optimize heterogeneous acoustic and non-acoustic ASW manned and unmanned platforms using simulated and real-world data.

PHASE III: Embed and demonstrate the Phase II Mission Planner within a prototype manned platform and UV command and control system such as USW-DSS. Demonstrate and report on performance during at-sea trials.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: This technology could be applicable to a wide range of civilian applications of autonomy and automation including the use of unmanned systems for homeland defense, automation of building, facility, and port security, search and rescue, and other first responder applications. With the increased emphasis on homeland security, this has annually become a multi-billion dollar industry.

#### REFERENCES:

1. Washburn, Alan R., Search and Detection, 4th Ed., INFORMS, 2002.
2. Stone, Lawrence D., Theory of Optimal Search, 2nd edition, MAS, 2007
3. Chandler, H.A. Alphonso, K.J., GRASP: an object-oriented approach to sonar performance modeling and tactical ASW search planning, OCEANS '02 MTS/IEEE, <http://ieeexplore.ieee.org/Xplore/login.jsp?url=http%3A%2F%2Fieeexplore.ieee.org%2Fiel5%2F8479%2F26715%2F01191851.pdf%3Farnumber%3D1191851&authDecision=-203>
4. Kunigami, Masaaki, Optimizing ASW Search for HVU Protection using the FAB Algorithm <http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA328621>
5. USW-DSS Build 3 System Requirements

KEYWORDS: Anti-Submarine Warfare; mission planning; acoustic; non-acoustic; unmanned vehicles; optimization

TPOC: Kenneth Wedel  
Phone: (202)781-5233  
Fax:  
Email: kenneth.w.wedel@navy.mil  
2nd TPOC: Michael Roth  
Phone: (202)781-4938  
Fax:  
Email: michael.roth1@navy.mil

N111-045

TITLE: Visualization Framework for Navy Tactical Applications

TECHNOLOGY AREAS: Information Systems

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**OBJECTIVE:** Develop, and demonstrate an innovative visualization framework to support rapid production of highly integrated, intuitive, and unified geospatial tactical control displays comprising tactical components from multiple suppliers.

**DESCRIPTION:** Existing tactical displays attempt to achieve integration and consistency of multiple display subsystems using a static allocation of display space to individual applications (via a combination of window tiling and control of the visibility state of application windows), with each application separately developed to the same HCI/HSI standards.

This type of approach has a number of drawbacks preventing achievement of the goal of a common tactical picture: multiple similar displays showing different aspects of the common tactical picture in physically separated windows (the "too many GEOs" problem), duplication of the same functionality in multiple applications, and inability to apply a tool provided by one application to the display of another application. Additionally the Navy has a significant investment in the tactical display tools and functionality desired however they reside in applications with various architectures and deployment models. To achieve cost savings in the development of a unified tactical GEO application from disparate implementations a framework is required.

There are a number of existing toolkit technologies and initiatives (for example C/JMTK Commercial/Joint Mapping Toolkit) that provide a rich environment for display application development. However these toolkits do not address the structure of an application framework directly that is necessary for collaboratively developed tactical applications. These toolkits can provide much of the underlying technology to build an effective tactical application framework.

The proposed new approach will overcome these drawbacks by providing a display application framework supporting the addition of separately developed components, each containing the unique aspects of a former tactical application. The framework will manage coordination of common views, tools and controls within the available display space, while the components provide additional content.

The framework will provide common application and geo-spatial services, including service registration, base map visualization, raster and vector map overlays using standard geo-spatial access protocols such as WMS and WFS, custom map overlay management, tactical symbology, event distribution and record/replay support.

The target framework will enable geo-spatial displays that reduce the time for decision-makers to view and assimilate data from diverse sources and will improve the ease with which application developers can introduce new and innovative tools to enhance the operator's situation awareness. Use of a common and shared application infrastructure will reduce development time for additions to the common tactical picture.

**PHASE I:** Define an architecture for a display application framework that enables the migration of compliant software into a single geospatial picture without loss of functionality. Develop measureable metrics for usability in the areas of user effectiveness, efficiency, and satisfaction.

**PHASE II:** Develop a prototype that demonstrates the functionality of three distinct functional applications into a single geospatial framework, and evaluate the phase I metrics for both separated and integrated scenarios.

**PHASE III:** Deploy requisite collaborative source infrastructure to support integration of USW-DSS client applications into a unified common display topology.

**PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:** The framework functions in any context which requires visual graphics, non-visual analysis tools, and a spatial database. Target markets include local government, nautical applications, digital mapping.

REFERENCES:

1. Common Presentation Layer Guide (NAVSEA 03 Standard 03-01 September 2006)
2. OSGi Service Platform Core Specification (Release 4 Version 4.1 April 2007)
3. Open GeoSpatial Consortium (GIS Interoperability Standards and Specifications)

KEYWORDS: Command and Control; Displays; Software Architecture; Display Framework; Geospatial Objects

TPOC: Kenneth Wedel  
Phone: (202)781-5233  
Fax:  
Email: kenneth.w.wedel@navy.mil  
2nd TPOC: Michael Roth  
Phone: (202)781-4938  
Fax:  
Email: michael.roth1@navy.mil

N111-046 TITLE: Very High Frequency Volumetric Acoustic Array

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: PMS 397 OHIO Replacement Program, ACAT I

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OBJECTIVE: The Navy has a need for specialized acoustic sensors to provide high array gain and high resolution for source localization. An underwater volumetric array is needed to achieve high array gain (> 28 dB) in the frequency range of 10-80 kHz in order to acquire special acoustic measurements for full and model scale submarines.

DESCRIPTION: The Navy has a need for specialized acoustic sensors to provide high array gain and high resolution source localization. Current technology to support this need has numerous shortcomings in areas that effect sensitivity, directivity and noise floor. Achieving accurate measurements in the upper frequency ranges will be particularly challenging. To achieve beamformed outputs with high array gain, a large quantity of low noise sensors will be required. To achieve the high frequency performance, the individual sensors will need to be small and packed close together. Isolating these sensors from non-direct acoustic paths, structural vibrations, and electrically coupling from adjacent sensors will require innovation in design of both the sensor and mounting configuration. Key components to this research include developing a low noise, high sensitivity acoustic sensor that can be continuously deployed in the ocean for a 10-15 year operational life. The sensor and beamformed array outputs must be capable of being calibrated both electrically and acoustically to provide sound pressure levels that can be certified to a NIST reference standard. Additionally, the array shall be capable, with the aid of advanced beamforming techniques, of resolving broadband and narrowband sources with low SNR with a precision of two feet or less.

PHASE I: Develop a conceptual design for a high gain (>28db), very high frequency (10 kHz to 80 kHz) underwater acoustic volumetric array. Perform modeling and simulate candidate array designs in realistic noise fields at various

sites, sensors and depths. Develop and/or utilize innovative sensor materials that incorporate compact, low power electronics into a packaging concept that is easily deployed for a 10-15 year operational life.

PHASE II: Develop, construct, and demonstrate the operation of a prototype high frequency volumetric array through laboratory and over-the-side testing utilizing electronically generated broadband and narrowband signals. Validate that the prototype meets the design goal for array gain and source localization. Provide signal processing needed to demonstrate array performance. Complete component design, expected sensor life analysis, and a deployable packaging concept.

PHASE III: Develop a production design of the Phase II solution. Demonstrate full operational functionality in full and model scale Navy supported test scenarios. Transition the developed technology for Navy acoustic facility use and provide a detailed supportability plan.

PRIVATE SECTOR COMMERCIAL POTENTIAL: High array gain and associated beamforming technologies have potential application in the medical industry.

REFERENCES:

1. D. C. Bertilone, D. S. Killeen, and C. Bao, "Array Gain for a Cylindrical Array with Baffle Scatter Effects", J. Acoustic Soc. Am, Vol 122, Issue 5, Nov 2007, pp. 2679-2685.
2. H. L. Van Trees, "Optimum Array Processing", Part IV of Detection, Estimation and Modulation Theory, Wiley-Interscience, New York, 2002
3. E. A. Skelton and J. H. James, "Theoretical Acoustics of Underwater Structures", Imperial College Press, London, 1997.
4. J. L. Butler and A. L. Butler, " A Tri-modal Directional Transducer", J. Acoustic Soc. Am, Vol 115, Issue 2, Feb 2004, pp. 658-665.
5. C. LeBlanc, "Handbook of Hydrophone Element Design Technology", NUSC, Oct 1978, pp. 4-27.
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7. Holden, Parsons, and Wilson, "Flexural Disk Hydrophones Using Polyvinylidene Flouride (PVDF) Piezoelectric Film: Desensitization with Increasing Hydrostatic Pressure:", J. Acoustic Soc. Am., 73(5), May 1983, pp. 1852-1862.

KEYWORDS: Volumetric array; array gain; high frequency; underwater sensor; source localization;

TPOC: Henry Stottmeister  
Phone: (301)227-1562  
Fax:  
Email: henry.stottmeister@navy.mil  
2nd TPOC: Joseph Key  
Phone: (301)227-4001  
Fax: (301)227-1989  
Email: joseph.key@navy.mil  
3rd TPOC: Keith Hertel  
Phone: (208)683-2321  
Fax:  
Email: keith.hertel@navy.mil

N111-047

TITLE: Innovative Alternatives to Roller Bearing Design Solutions

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PMS 400D, Aegis New Construction Program, ACAT 1

OBJECTIVE: Explore the development of alternatives to traditional roller bearings design configurations through the application of novel concepts and advanced material solutions to allow for improved performance, minimized maintenance and reduced life-cycle costs for the DDG 51 Helicopter Hanger Door.

DESCRIPTION: Legacy roller bearings which support the opening and closing of Helicopter Hangar Doors have been failing at a much higher rate than the desired 4800 cycles. The bearings used are currently traditional, spherical roller type with a high-load, self-lubricating liner system. There are two bearings installed per door. The bearings themselves support a door which weighs approximately 10,000 lbs. Under normal operations, the expected even loading of each bearing is 5,000 lbs. However it is believed that the actual loading seen by each bearing may, at times, exceed 10,000 lbs due to door misalignment, ship flexing and the drive motor adding unknown stresses due to continued operation after door has been closed. Previous attempts at resolving this issue have involved material changes of the bearing, additional lubrication methods and different swaging methods, but the problem still remains. Failure of the roller bearings limits the operation of the doors. Past modes of failure include, but are not limited to, contamination or encrustation as a result of the direct exposure of the bearing themselves to the marine environment as well as mechanical failure due to industrial grit contamination as well as unexpected or un-even loading. The inability to either close or open the hangar doors can negatively impact flight operations as well as expose the interior of the hangar to unwanted environmental factors and potentially introduce hazardous situations.

The topic seeks non-traditional, innovative approaches to resolve a long-standing life-cycle management issue for the DDG 51 Helicopter Hanger Doors. Proposers are encouraged to explore alternative design solutions and material systems with robust mechanical properties to withstand the harsh operating environment seen by these bearings both on a daily basis and in the event of a catastrophic event. Proposed concepts will be required to meet existing Navy shock qualifications as well as other applicable naval standards and requirements (see references). Meeting these shock requirements while providing operational reliability and maintainability in a maritime environment represents the most significant challenge associated with designing a roller-bearing replacement design solution.

PHASE I: Demonstrate the feasibility of an Improved Roller Bearings for Helicopter Hangar Door (HHD) system. The proposer shall identify suitable candidate materials as well as any applicable manufacturing processes and methods of installation anticipated to enable the development and integration of the proposed system. Establish performance goals and metrics to analyze the viability of the proposed solution. Develop a test and evaluation plan to contain discrete milestones for product development to be utilized for verifying performance and suitability.

PHASE II: Develop, demonstrate and fabricate a prototype system as identified in Phase I. In a laboratory environment, demonstrate that the prototype system meets the performance goals established in Phase I. Verify and provide results for final prototype system installation methodologies in a representative laboratory environment. Develop a cost benefit analysis for Total Ownership Cost, as well as Phase III testing and validation plan.

PHASE III: Construct a full-scale prototype system based on the Phase II results for testing in a shipboard environment. Working with government and industry, install onboard a selected DDG 51 class hull and conduct extended shipboard testing.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Roller Bearings have many applications in the marine industry. Any bearing replacement solution proposed for this topic could have the potential to be sized appropriately to meet the varied needs of the commercial sector.

REFERENCES:

1. Design Data Sheet for DDG 51 Class Helicopter Hanger Doors – Available Upon Request
2. <http://www.nstcenter.com/milspecs.aspx?milspec=3135> : Deck Covering Underlay Materials
3. <http://www.nstcenter.com/milspecs.aspx?milspec=23236> : Coating Systems For Ship Structures

4. <http://www.nstcenter.com/milspecs.aspx?milspec=24441> : Paint, Epoxy-Polyamide, General Specification
5. <http://www.nstcenter.com/milspecs.aspx?milspec=24596> : Coating Compounds, Nonflaming, Fire Protective (Metric)
6. <http://www.nstcenter.com/milspecs.aspx?milspec=24613> : Deck Covering Materials, Interior, Cosmetic Polymeric
7. <http://www.nstcenter.com/milspecs.aspx?milspec=24635> : Coating Systems, Weather-Resistant, Exterior Use
8. <http://www.nstcenter.com/milspecs.aspx?milspec=24647> : Paint System, Anticorrosive And Antifouling, Ship Hull
9. <http://www.nstcenter.com/milspecs.aspx?milspec=24667> : Coating System, Non-Skid, For Roll Or Spray Application
10. <http://www.nstcenter.com/milspecs.aspx?milspec=24763> : Enamel, Emulsion Type, For Shipboard Use
11. <https://assist.daps.dla.mil/quicksearch/> MIL-SPEC-901D (NAVY): Shock Tests H.I. (High Impact) Shipboard Machinery, Equipment and Systems

KEYWORDS: roller bearing; hangar door; corrosion; uneven loading; shock

TPOC: Jordan Rongers  
 Phone: (202)781-1305  
 Fax:  
 Email: jordan.rongers@navy.mil  
 2nd TPOC: Todd Hellman  
 Phone: (202)781-4335  
 Fax:  
 Email: todd.hellman@navy.mil

N111-048 TITLE: Coating Health Sensor System and Service Life Model

TECHNOLOGY AREAS: Information Systems, Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: OHIO Replacement Program, PEO SUB, PMS397, ACAT I

OBJECTIVE: The objective is a paint coating condition or "health" monitoring system that can signal without tank entry by an inspector when a coating actually needs opening, gas-free engineering and physical entry for inspection and possible repair and can provide diagnostic assistance in assessing with a high degree of confidence whether or not a coating needs to be replaced.

DESCRIPTION: The coatings of concern act principally as corrosion barriers for steel (and other metals) in an aggressive aqueous environment such as seawater or wastewater. They act to isolate the substrate metal from the corrosive service environment. As long as it is intact and undegraded, the corrosion barrier coating prevents the electrochemical corrosion reaction to which the metal would otherwise be subject from taking place by blocking electrical charge transfer, insulating the metal surface.

The desired coating health monitoring system must meet the following installation and service requirements:

1. Coating condition sensor element for unattended containment within inaccessible, sealed, air-tight, steel tank.
2. Condition of coating inside must be indicated or sensed outside the tank.
3. Signal emissions outside the tank wall are subject to restrictive limits.

4. Sensing element must be robust enough in the service environment to function reliably for the intended life (or planned maintenance cycle) of the coating (minimum of five years in full or intermittent seawater immersion).
5. System must indicate simply and reliably that the coating condition is "good" (no need to enter and inspect the coating) or "failing" (and in need of inspection and possible repair / replacement at the earliest opportunity) and do so regardless of the state of the coating, wet or dry.
6. The system must provide more definitive information as to the extent and distribution of the coating degradation if the "failing" indication is given and the tank entered for coating inspection.

The state-of-the-art technologies available to address this need include a number of laboratory and fielded experiments and trials that apply electrochemical protocols and instrumentation for electrochemical impedance spectroscopy (EIS) and or electrochemical noise analysis (ENA) which essentially measure the electrical impedance across the coating at sensed locations. As a coating ages and degrades, its impedance may drop from Gig ohms to less than a Megohm. Coating electrical resistance-base sensor systems have seen some promising field applications where structure access was not limited and / or test time was short relative to maintenance cycle. However, they have been used mostly in laboratory coating test panel environments where detailed visual inspection criteria still dominate. The method needs further development to establish the failure state and calls for interpretation by trained technicians.

Another very promising system is the collateral use of a tank's cathodic protection (CP) system to indicate by its protective current requirement the health of the coating. But this is a global, overall coating condition indicator, it will not apply unless the CP anodes are immersed or at least correlated with the liquid level and it may not respond to even significant localized coating degradation. It may be possible to integrate EIS-type (and/or other) local sensors with CP current monitoring to attain the desired system.

There are other new technologies that might serve as a basis for a sensor. Examples could be measuring changes in some coating structural (decrease in extent of polymer cross linking or increase in porosity) or chemical aspect (that could be sensed by a fiber optic probe such as degree of hydration and/or acidity) of the coating as it ages and degrades.

PHASE I: Preliminary design of a desired coating monitoring system requires proof of sensor function on epoxy coated steel panel in natural or artificial seawater; preliminary sensor/ system definition of coating "failure"; proof in principle of integratability of number, type and distribution of sensors required for accurate reproducible indications; and demonstrate delivery of sensor signal to and interpretation by system external to sealed steel container.

PHASE II: Demonstrate sensor / system performance and robustness in service-like conditions such as sensors on a range of coated steel panel sizes and coating thickness in alternate immersion and/or salt spray cabinet testing, 1000 hours or more.

PHASE III: Shipboard tank installation demonstration experiment to show shipboard tank applicability and advantage of sensor-based tank CBM over conventional tank scheduled maintenance.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: While the submarine tank coating monitoring problem is particularly challenging, it is by no means unique and once a system is developed it could meet the maintenance planning and decision needs of a wide variety of military vessel, marine transport, port facility, industrial, and municipal tank, pipe, and other structures reliant on organic coating health for corrosion resistance.

Another key advantage of developing this coating monitoring system rests on the data it generates to assist in coating failure diagnosis which may lead to coating formulation and application improvements.

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2. John N. Murray, "Evaluation of Electrochemical Noise to Monitor Corrosion for Double Hull Applications," Technical Report, NSWCCD, CARDIVNSWC-TR-61-94/29, August 1994.

3. R.L. Ruedisueli and B.D. Layer, "Practical Application of ECN / EIS for In-Service Coatings Assessment," NACE 2002 Conference Proceedings.

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KEYWORDS: organic paint coatings; steel tanks; corrosion; electrochemistry; impedance spectroscopy; total internal reflectance spectrometry; ultra-sonic inspection;

TPOC: Robert Ruedisueli  
Phone: (301)227-5093  
Fax: (301)227-5548  
Email: robert.ruedisueli@navy.mil  
2nd TPOC: William Needham  
Phone: (301)227-5034  
Fax: (301)227-5548  
Email: william.needham@navy.mil

N111-049 TITLE: Method to Eliminate Unwanted High Frequency Signals above 2 KHz from Accelerometers.

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: PMS 397 OHIO Replacement Program, ACAT I

OBJECTIVE: Develop and validate an improved method to isolate accelerometers used for shock testing to eliminate high frequency signals above 2Khz.

DESCRIPTION: Current dynamic measurement accelerometers which measure responses up to 100,000 g's are limited in measuring the shock response in extreme high response areas due to unwanted high frequency signals being recorded in addition to the actual response of the accelerometer. These high frequency signals are caused by the shock loading ringing throughout the mounting surface of the accelerometers and creating an undesired high frequency signal in the accelerometers which distorts the desired response. In order to eliminate these high frequency signals innovative methods of mounting, isolating and installing accelerometers need to be researched and developed to improve the fidelity of accelerometer data. Proposed approaches should focus on damping out or eliminating high frequency input above 2 KHz, while preserving the response below this.

The approach shall meet the following goals:

- High Frequency Signals above 2 KHz are damped out or eliminated in all axis of motion.
- Survivable in excessive shock environments up to 100,000 g's.
- Applicable on any steel, iron, or aluminum installation.
- Capable of operating at temperatures from -50 to 130F
- Weight should be kept to a minimum.
- Should not interfere with response below 2 KHz.
- Should be easy to install.
- Design should not adversely affect post processing (integration, differentiation).

PHASE I: Produce an isolation design and provide a theoretical or analytical demonstration of the concept.

PHASE II: Develop a detailed design and working prototype. Demonstrate operation of the prototype in a test environment.

PHASE III: Finalize design and demonstrate consistent fidelity in test environment. Conduct necessary qualification



testing.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Successful development of this technology could be used to increase fidelity in all dynamic measurement accelerometers through out industry.

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1. "Guide to Mechanical Mounting of Accelerometers," Report UO64619, American National Standards, Accredited Standards Committee S2, Mechanical Shock, February 1989.
2. "A Mechanical Filter to Protect Piezoresistive Accelerometers from Fast Rise Shock Pulses." Technical Report NSWC TR 83-424, James Richmond, Naval Surface Warfare Center, October 1983.

KEYWORDS: Accelerometer; Data; Shock; Dynamic; Measurement; Signals;

TPOC: Craig Mathews  
Phone: (301)2273959  
Fax: (301)2275702  
Email: craig.mathews@navy.mil  
2nd TPOC: Laurence O'Neill  
Phone: (301)227-0579  
Fax:  
Email: laurence.oneill@navy.mil

N111-050

TITLE: A Lightweight, Flexible, Scalable Approach to Trainer Systems

TECHNOLOGY AREAS: Sensors, Human Systems

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

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OBJECTIVE: Develop an innovative approach for flexible and scalable training systems.

DESCRIPTION: The Navy helicopter sensor systems are a critical part of the remote sensor systems for the ships they support. With the introduction of the MH-60R helicopter to the Aircraft Carrier Tactical Support Center (CV-TSC), the challenge of interpreting the multiple heterogeneous sensor streams of remotely linked data is especially challenging. Training is essential to the operator's ultimate efficacy. This trainer could be applied to the helicopter interface and also to the undersea domain by integrating it with the Submarine Multi-Mission Team Trainer.

Traditional training systems suffer severe scaling limitations, as they grow to address a multiplicity of simulated targets, simulated environments and simulated sensors. Attempts to federate moderate-scale simulators to solve the scaling problem have met with limited success, despite extensive investment.

An innovative approach is needed to tackle the scaling problem, which leverages modern track management infrastructures. An approach should be developed that decouples the scenario control of simulated targets, ships and other assets from the specific sensor simulation, while maintaining coherency. The level of success in meeting this goal will be demonstrated by the ability to add an additional sensor with a minimum amount of complexity and cross-domain coupling.

PHASE I: Propose a platform-independent model (i.e. focus on content) of the data to be exchanged using modern track management services. Develop a set of realistic use cases involving multiple scenario tier elements and sensor tier elements. Develop an architecture description for the simulation system. Assess how this approach minimizes complexity and cross-domain coupling associated with updated/new sensors and sensor capabilities

PHASE II: Develop a prototype and associated prototype documentation demonstrating the architecture will support generating the required synthetic data. The prototype should use at least two scenario control elements and at least two sensor simulation elements.

PHASE III: Provide a production implementation of the scalable MH-60R trainer for the Carrier CV-TSC and associated documentation

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: This type of approach can be applied to simulations systems involving major systems with multiple sensors such as Commercial Aircraft Controller training and USCG Vessel Traffic Services training.

REFERENCES:

1. IEEE 1516 Standard for Modeling and Simulation High Level Architecture
2. STANAG 4603 Modeling and Simulation Architecture Standards for Technical Interoperability
3. Creating Computer Simulation Systems: An Introduction to the High Level Architecture, Frederick Kuhl, Richard Weatherly, Judith Dahmann

KEYWORDS: Training; Track Management; Personnel Performance

TPOC: Kenneth Wedel  
Phone: (202)781-5233  
Fax:  
Email: kenneth.w.wedel@navy.mil  
2nd TPOC: Michael Roth  
Phone: (202)781-4938  
Fax:  
Email: michael.roth1@navy.mil

N111-051 TITLE: Improved Towed Array Localization for Active Systems

TECHNOLOGY AREAS: Sensors, Battlespace

ACQUISITION PROGRAM: Sonar Automation

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OBJECTIVE: Develop innovative methods to improve localization of acoustic echoes measured with towed array sonars.

DESCRIPTION: Accurate localization of active returns sensed by towed arrays can be critical to Anti-Submarine

Warfare mission effectiveness. Many towed arrays lack the ability to discriminate between left and right. Maneuvers, sea conditions, and tow scope introduce differences between the location and heading of the towed array relative to the tow ship and active source. Current towed array location estimates are computed based on measurements of ship heading, ship speed, and array heading, but the estimates become unacceptably coarse during severe maneuvers and when array heading sensors fail. The technology developed should complement existing array shape and localization algorithms being used in the fleet today. It is anticipated that this technology will improve not only towed array localization but also multi-sensor localization accuracy, including data fusion.

PHASE I: Define and determine an innovative approach to localize towed arrays. Demonstrate candidate technology performance using simulated or real data. Demonstrate algorithm benefits for contact fusion and tracking.

PHASE II: Develop and prototype a real-time processing application for the selected technical approach for active towed array localization and integrate into a research processing architecture. Develop quantitative measures of towed array localization performance improvement relative to current techniques using at-sea data recordings. Develop an implementation approach to transition the technology to a Navy production sonar system.

PHASE III: Implement and integrate the towed array localization technology capability in an operational sonar system.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: This technology could be applied to any complex multi-channel sensor system undergoing rapid maneuvers including seismic exploration, surveillance systems, and remote geo-science sensing.

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3. <http://www.defenseindustrydaily.com/MFTA-The-US-Navys-New-Towed-Array-for-Naval-Detection-04956/>

KEYWORDS: Classification, Automation, Torpedo, Signal Processing, Active Control, Adaptive Processing

TPOC: Meg Stout  
Phone: (202)781-4233  
Fax:  
Email: Meg.Stout@navy.mil  
2nd TPOC: Richard Guthrie  
Phone: (202)781-4378  
Fax:  
Email: richard.guthrie@navy.mil

N111-052 TITLE: High Power Monolithic Microwave Limiters

TECHNOLOGY AREAS: Sensors

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

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**OBJECTIVE:** Demonstrate innovative high power Monolithic Microwave Limiters for Navy Shipboard Radars and Electronic Warfare (EW) Systems. Lower cost and improved response time are key.

**DESCRIPTION:** Limiters are used to prevent damage to components due to excessive RF input power. Silicon PIN diodes provide excellent RF performance and are utilized in many high power RF limiter applications.1 Silicon PIN diode limiters are typically realized by integrating silicon PIN diodes with an external substrate containing RF transmission lines. Such components are typically referred to as hybrid assemblies. The cost of a hybrid RF limiter is often a significant factor in the overall cost of a T/R module, however, and improvement in this area is sought.

A MMIC limiter allows a single material to be used for both diodes and RF transmission lines. A MMIC then provides a potential cost advantage over a hybrid limiter by eliminating the labor required to integrate the substrate and diodes during module assembly. Further, a MMIC limiter may offer a faster response time. To this end, solutions are sought with respect to high power RF MMIC limiters or other potential lower cost approaches. Furthermore, solutions utilizing a silicon carbide substrate are sought to address limiter thermal management challenges.

MMIC limiter technology solutions are sought that can significantly reduce T/R Module limiter related cost. The limiter power handling for wide bandwidth, 3:1 for 1-20Ghz applications, is 50W and for S-Band is 100W with sub nanosecond response times.

**PHASE I:** Demonstrate feasibility of proposed integrated limiter technology through modeling and empirical evaluation. Technical feasibility shall be demonstrated by meeting the stated performance objectives and transition potential.

**PHASE II:** Develop and demonstrate an integrated limiter technology that 1) addresses the electrical goals of this topic, 2) that is compatible with high power operational shipboard solid state array and radar, and 3) that also will satisfy reliable long-term operation within an operational shipboard solid state array and radar.

**PHASE III:** Refine the phase II design of the integrated limiter technology as necessary and incorporate it into a solid-state high-power amplifier module design intended for Integration and demonstration in an operating IWS 2.0 radar system.

**PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:** The developed Limiter technology will have technological applicability for all commercial and military avionics radars, all commercial radar applications, and all marine radar applications.

**REFERENCES:**

1. <http://www.aeroflex.com/ams/metelics/micro-metelics-prods-PIN-diodes-limiters.cfm>
2. Passive RF and Microwave Integrated Circuits ,Leo G. Maloratsky, Newnes, ISBN: 0-7506-7699-X
3. Phased Array Antenna Handbook, R.J. Mailloux.
4. [http://www.cree.com/products/wireless\\_gan\\_hemt3.asp](http://www.cree.com/products/wireless_gan_hemt3.asp)

**KEYWORDS:** Limiter, Radar, EW, MMIC, integration, T/R Module

TPOC: Charles Pagel  
Phone: (812)854-2382  
Fax:  
Email: chuck.pagel@navy.mil  
2nd TPOC: Anthony Bryan  
Phone: (812)854-2430  
Fax:  
Email: anthony.bryan@navy.mil

N111-053

TITLE: Structural Health Monitoring of Submersible Navy Composites

TECHNOLOGY AREAS: Materials/Processes, Sensors

ACQUISITION PROGRAM: PMS 397 OHIO Replacement Program, ACAT I

OBJECTIVE: The objective of this topic is to develop an innovative structural health monitoring (SHM) system capable of detecting damage in submersible non-pressure hull composite structures. Such a system must be capable of detecting damage underwater while withstanding high levels of vibration and pressure. The goal of this project is to develop a system to successfully detect and characterize damage in non-pressure hull submersible components in the challenging underwater environment. The overall performance and geometry of the base structure cannot be degraded through the use of the SHM system. Integration of sensors and electronic within the matrix of the composite can be considered as part of an overall intelligent structural design approach.

DESCRIPTION: The use of advanced composites is becoming increasingly common for submarine components. Benefits of composite structures include reducing the overall weight and total ownership cost. While the initial design and fabrication expenses of composite structures may be increased from traditional materials (steel or aluminum), the possibility for significant reductions in maintenance and fuel expenditures while increasing the time of duty will lead to an overall cost benefit. Composites also allow for increased flexibility in design, leading to more favorable material properties and thereby increasing the operational performance of a vessel. The advanced materials used are designed to withstand normal loading due to submersion and wave impact. However, even with component testing, these composite structures will never be subjected to every environmental or operational condition before use in actual service. Therefore, the ability to detect changes or damage to an in-service composite structure could significantly reduce the amount of mechanical testing required, the time to implementation, and the tendency to overdesign such components. The aim of this program is to develop a structural health monitoring system capable of detecting and characterizing (size and location) damage in submersible composite non-pressure hull components. Many SHM techniques and systems have been developed for use on a variety of structures. The goal of this program is to determine which of these techniques is suitable for submerged Navy composites. Finding small amounts of damage in a harsh environment over the life of the component, while also considering the survivability of the sensors and SHM system itself, are main developmental areas for this topic. The main sources of damage would be fatigue or direct impact, causing cracking or delamination of the composite material. Shock or even more severe sources of damage should also be considered a possibility. Even though the vessels are designed to reduce flow noise, and thereby cavitation, there might also be secondary concern for cavitation erosion in select areas. While in service, a SHM system applied to composite structures would decrease operational costs by reducing the amount of scheduled inspection and maintenance. The system's sensors must be capable of operating in extreme environments including shock, high vibration (fatigue), high pressures, and a submerged environment. The system could also be extended for use on conventional materials subjected to the same rigorous environmental conditions. Necessary sensors and actuators may be either embedded in or surface mounted on the structure, but neither may reduce the design performance. A successfully developed SHM system will be capable of detecting small amounts of damage to a composite structure in normal operational environments.

PHASE I: The contractor must develop a concept SHM system to detect damage on an underwater structure. Proof that this system is viable will be shown on a self-developed composite prototype, allowing for sensors to be embedded if so desired. The contractor will then demonstrate damage detection and characterization capability with the composite specimen placed underwater.

PHASE II: Expand upon the Phase I work to develop a representative prototype capable of deployment for damage detection on an actual submerged structure subjected to representative loading conditions. The prototype will then be demonstrated under these conditions (such as pressure or operational cyclic loading and thermal gradients).

PHASE III: Integrate developed system with end user systems and interfaces. Conduct final experimental testing on actual naval assets. Transition damage detection of structures into both damage prognosis and damage mitigation.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: A number of other applications and industries would benefit from a submersible SHM system. The system could have potential benefit to any Navy application where damage is likely in a wet, corrosive, or underwater environment. Commercial shipping and tourism could also benefit from a successfully developed SHM system.

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KEYWORDS: Structural Health Monitoring; SHM; Composites; Submersible Structures; Sensors; Damage Detection; Smart Structures

TPOC: Benjamin Grisso  
Phone: (301)227-6327  
Fax:  
Email: benjamin.grisso@navy.mil  
2nd TPOC: Liming Salvino  
Phone: (301)227-5987  
Fax: (301)227-1020  
Email: liming.salvino@navy.mil  
3rd TPOC: Thomas Brady  
Phone: (301)227-3962  
Fax:  
Email: thomas.brady@navy.mil

N111-054

TITLE: Cloud-Enabled Track Management

TECHNOLOGY AREAS: Information Systems

## ACQUISITION PROGRAM: PEO IWS5E - USW/DSS

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**OBJECTIVE:** Investigate and develop a track management architecture that utilizes innovative persistency and information retrieval mechanisms to increase stability, scalability, longevity and performance of track data.

**DESCRIPTION:** In the general sense, track management systems (TMS) receive input from sensor feeds (examples include electro-optical, radar, electronic support measures (ESMs), and sonar) and display this information to a user. User input to TMS traditionally allows for the creation of new objects, such as tracks, contacts and contact followers, based off sensor feeds. More elaborate track management systems attempt to improve the user's situational awareness and reduce the decision cycle by fusing multiple tracks into single tracks, incorporating alerting mechanisms or visualizing track data into a unified common tactical picture (CTP).

Over time, sensor data can grow rapidly and it is sometimes in the best interest of the user to keep historical data for a finite period of time. Use of relational database management systems (RDBMS) has been one of the main technologies for persisting and retrieving track data yet RDBMS come with their own well-documented shortcomings: a high level of maintenance, poor support for ad-hoc querying, rigid storage paradigms and scalability issues.

Cloud computing and other areas show promise in improving persistency methods. For example, replication of track data both intra- and inter-node could be part of the cloud, inherent to its decentralized architecture, rather than using a customized, synchronization solution that belongs to a particular component, technology or protocol. The potential for misaligned or unequal tactical pictures between assets could be decreased in this case. Given the distributed nature of cloud-based architectures, redundancy can also be leveraged, ensuring a more fault-tolerant track picture that reduces traditional weaknesses such as single points of failure. Both of these attributes are important in naval situations that involve disconnected, intermittent and/or limited (DIL) communications.

Large scale platforms are already making moves toward cloud computing technologies such as Google, Twitter and Facebook. The goal of this project will be to research, define, and implement a framework that utilizes cloud-based technologies to measure the amount and types of improvement to track management as it exists today. The Navy will provide an unclassified production track data set as government-furnished equipment (GFE).

**PHASE I:** Conduct a trade study weighing cost, benefits, and risks of various approaches to implementing a Track management system using cloud computing persistent techniques and open source products. Recommend a development approach based on these criteria. Phase I may include a small proof-of-concept to assist in the study

**PHASE II:** Develop a design based on the Phase I trade study selection and demonstrate a prototype. Produce a Software Requirements Specification and an Interface Design Document as part of the prototype. Prototype should utilize DoD production track data (subject to classification controls) to provide accurate results and allow for verification and validation (V&V).

**PHASE III:** Transition the track management system for use in a production environment. Demonstrate that the architecture can meet the needs and requirements of its users.

**PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:** A cloud-based track management system has potential for use in any government, industrial, or military application where discrete tracking and management of geo-locatable objects exist. While track management continues to be a challenging problem that could benefit from cloud computing paradigms, the use of distributed data management has far reaching potential for many systems across various fields.

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KEYWORDS: track management, track data, persistence, reliability, query, information retrieval, cloud computing, distributed data grids

TPOC: Kenneth Wedel  
Phone: (202)781-5233  
Fax:  
Email: kenneth.w.wedel@navy.mil  
2nd TPOC: Michael Roth  
Phone: (202)781-4938  
Fax:  
Email: michael.roth1@navy.mil

N111-055 TITLE: Low Cost Hydrophones for Thin Line Towed Arrays

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: Support TB-23 and the TB-29A Thin Line Towed Array systems

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OBJECTIVE: Develop a reduced cost hydrophone that meets all of the performance requirements of current thin line towed array hydrophones.

DESCRIPTION: The U.S. Navy is interested in reducing the cost of thin line towed arrays. One major towed array cost driver is the cost of the hydrophones which equates to approximately 15-20% of the total thin line towed system cost. Reduced cost hydrophones will enable the use of more hydrophone elements per group which will lead to reduced towed array self-noise via improved spatial filtering.

Currently, hydrophones suitable for use in a thin line towed array cost ~\$52/hydrophone when purchased in quantities of roughly 1,000 units. Current thin line towed arrays use approximately 5000 hydrophones in each array. In order for the Navy to transition low cost hydrophone technology to production arrays, groups of 12 hydrophone elements, when connected in a series/parallel combination of the offer's choice, must meet following characteristics: (1) sensitivity of -192 +/- 1.0 dB re 1 V/uPa, (2) sensitivity variation no greater than +/- 0.5 dB over temperature range of -2 to +50° C and pressure range of 0 to 1000 psig, (3) capacitance greater than 500 pF, (4) dissipation factor less than 0.18, (5) resonant frequency greater than 5 kHz, (6) insulation resistance greater than 1 gigaOhm, (7)



survival pressure of at least 1500 psig, (8) diameter less than 0.37 inch, and (9) rigid length less than 2 inches. Weight should be minimized within the constraint of meeting all other requirements.

The Navy seeks innovative hydrophone technologies that will provide hydrophones that meet the stated requirements for groups that contain more than 12 hydrophone elements.

PHASE I: The Phase 1 deliverable of this SBIR is a report that describes the hydrophone concept and how the concept will meet stated performance specifications and cost goal. Additionally, a simple proof of concept prototype hydrophone is highly desirable.

PHASE II: The Phase 2 deliverable of this SBIR is prototype hydrophones suitable for in-water performance evaluation.

PHASE III: The focus of the Phase 3 effort will be the transition of the prototype hydrophones to advanced development model quantities suitable for integration into group assemblies and subsequent tow testing.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: A low cost hydrophone with the performance characteristics noted in this SBIR topic would have applications in seismic streamers as well as military towed arrays for other platforms such as unmanned underwater and unmanned surface vehicles.

REFERENCES:

1. Lemon, S. G. "Towed-Array History, 1917-2003", IEEE Journal of Oceanic Engineering, Vol. 29, No. 2, April 2004
2. Leblanc, C. L. "Handbook of Hydrophone Element Design Technology" NUSC TD 5831, Oct 1978
3. Sherman, C. H. and Butler, J. L. "Transducers and Arrays for Underwater Sound", Springer, 2007

KEYWORDS: hydrophone, towed array, acoustic sensor, thin line

TPOC: Chhay Lim  
Phone: (202)781-1396  
Fax: (202)781-4703  
Email: chhay.lim@navy.mil  
2nd TPOC: John Law  
Phone: (401)832-8189  
Fax: (401)832-7478  
Email: john.law@navy.mil

N111-056 TITLE: Precision Navigation System for Near and On-Hull Positioning Underwater

TECHNOLOGY AREAS: Ground/Sea Vehicles, Electronics

ACQUISITION PROGRAM: PMS 501, LCS Program, ACAT 1

OBJECTIVE: Develop of innovative approaches to provide the capability of precision navigation of manned and unmanned below the waterline inspection systems while in-port or in shallow water environments. Proposed technologies should be of a fidelity to provide positioning or re-positioning data to within 10 cm and should enable 100% coverage of the hull.

DESCRIPTION: Underwater hull inspection systems, whether diver or unmanned vehicle based, require a precise navigation system to provide precise location information so that all hull data measurements can be properly correlated with previously collected data measurements. It is necessary to know the location of hull features such as cracks, pitting, corrosion areas, and hull damage or discontinuities. These areas will be monitored over time so

sensor measurements need to be repeatable to within 10 cm to ensure any differences in hull data observed are real. Current systems are generally developed to position an object in relatively deep water, meaning the navigation system reference net is above or below the target, and the target has line-of-sight to at least three of the reference net elements. These systems also operate better away from structures that interfere with the acoustic path of the reference net to the target. Short baseline and ultra-short baseline systems operate well when there is sufficient distance from the reference head to the target.

These technologies will not provide the fidelity of precision required for in-port or shallow water inspections. There are many factors that affect accurate positioning of an underwater sensor on a ship hull:

- The structure of the hull often prevents “line-of-sight” triangulation used by acoustic navigation systems reference nets;
- The system must operate in a marine industrial environment and be tolerant of: acoustic noise from other devices which may produce similar frequencies (sonars, outboard motors, needle guns)
- Physical limitations for attachment of navigation system fixtures to ships or piers
- Physical movement of the ship when pier-side or in open water
- Variation of the actual ship dimensions from the ship’s drawings; as well as variations within a ship class (different flights)
- Ships may be moored to a pier using floating piers, camels, or large fenders all of which may move relative to the ship while it is pier-side
- The ship and pier structure may cause acoustic reflections or multi-path of the navigation system
- Weather, sea-state, and turbid water may affect the performance of navigation systems relying on optics
- Topside ship structure and pier structures may obstruct/affect satellite/GPS signals
- Ship intakes and discharges that create flow

This topic seeks innovative and alternative approaches to the development of methodologies and any applicable advanced algorithms to enable the precision navigation of both manned and unmanned inspection systems in port and in shallow water environments to within 10 cm of position accuracy. A key challenge is going to be the ability to integrate multiple sub-systems for successful navigation on ship hulls i.e. ship hull feature recognition; inertial sensors; acoustic transceivers/transponders, or other enabling technologies. Proposed concepts need to be designed with open architecture principles in mind to allow for easy interfacing with existing and future hull inspection systems. Proposed concepts should minimize ship impact (e.g., size, weight, power, stowage, etc.) and shall minimize the operational and personnel efforts to initiate, execute, and terminate the inspection process.

**PHASE I:** Demonstrate the feasibility of the development of innovative, alternative and affordable approaches innovative approaches to provide the capability of precision navigation of manned and unmanned below the waterline inspection systems while in-port or in shallow water environments to within 10cm. Establish performance goals and provide a Phase II development approach and schedule that contains discrete milestones for product development.

**PHASE II:** Develop, demonstrate and fabricate a prototype as identified in Phase I. In a laboratory environment, demonstrate that the prototype product meets the performance goals established during Phase I. Provide a detailed plan for software and/or hardware certification, validation, and method of implementation into a future ship test and/or design environment. Prepare cost estimates, logistics data packages, and interface documents for use in both forward fit and retrofit ship programs.

**PHASE III:** Utilizing the technology developed during Phase I and II, work with Navy and industry to certify and implement for use on existing and future naval and commercial shipbuilding programs.

**PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:** An underwater vehicle precision navigation system would be applicable to many fields. Its applications could include inspections of pilings/seawalls, hull inspections on commercial ships, surveillance and reconnaissance, or other underwater inspection activities.

#### REFERENCES:

1. Kinsley, James C., Eustice, Ryan M., Whitcomb, Louis J.: “A Survey of Underwater Vehicle Navigation: Recent Advances and New Challenges” – Available Upon Request.

KEYWORDS: Hull; Inspection; Underwater; Navigation;

TPOC: Dana Lynn  
Phone: (301)227-4493  
Fax: (301)227-4814  
Email: dana.lynn@navy.mil  
2nd TPOC: Lloyd English  
Phone: (540)653-3277  
Fax:  
Email: Lloyd.English@navy.mil

N111-057 TITLE: Non-Destructive Test and Evaluation of Aluminum Hulls Below the Waterline

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PMS 501, LCS Program, ACAT 1

OBJECTIVE: Develop an innovative and affordable approach to enable non-destructive evaluation and testing below the waterline for aluminum ships to both detect cracks and measure hull thickness. Proposed systems should demonstrate the ability to enable 100% coverage of the designated hull inspection areas, retain results

DESCRIPTION: Currently available hull thickness sensors use ultrasonics and provide coverage of a single point on the hull. The sensor must then be moved over the hull while the thickness readings are monitored to detect thin areas of hull plate. As the sensor is moved from point A to point B the coverage can be described as a "line". Currently available above-water systems are better suitable to the examination of areas in larger swaths as well as having the ability to detect cracks. These systems are generally array type sensors; however, they are not suitable for underwater applications because of the electronics and the precision involved. Other underwater technology exists that can detect cracks in steel using alternating current field measurements, but this would not work with aluminum due to the lack of magnetic properties.

The topic seeks to explore the development of innovative and alternative approaches for non-destructive evaluation and testing for crack detection and hull thickness measurement below the waterline for aluminum ships. It is desired that proposed technology solutions allow for inspection of wider swaths of hull to be able to provide timely, comprehensive assessments of the condition of the hull to the operator. Proposed concepts should be a reasonable size and shape such that they could be used by a diver or attached to a remote operating vehicle. Inspection criteria for proposed technical solutions should include, but not be limited to, hull geometry, hull physical characteristics focusing on weld seams and other likely crack formation locations together with operator defined thresholds for determining differences in sensor data from a prior inspection. Challenges to this will be the ability to distinguish between weld seams, joint areas, scantlings, hull stiffeners and bulkheads which could skew results and give false readings of hull thickness. Additional challenges will be the ability to develop a watertight enclosure that doesn't impede the performance of the technical solution(s). The proposed system should retain prior inspection results and determine any changes from the prior inspections to include, but not be limited to, discontinuities in the hull (e.g., crack formation or thickness changes indicating internal corrosion), and physical differences from previous inspections. Of a particular interest is the ability of the operator mark objects/areas for future reference as well as the ability to classify the measured differences into classes of severity for future inspections and analysis including the setting of thresholds for defining a new difference. Concepts proposed should minimize ship impact (e.g., size, weight, power, stowage, etc.) and shall minimize the operational and personnel efforts to initiate, execute, and terminate the inspection process.

PHASE I: Demonstrate the feasibility of the development of innovative, alternative and affordable approaches to enable non-destructive evaluation and testing below the waterline for aluminum ships to both detect cracks and measure hull thickness. Establish performance goals and provide a Phase II development approach and schedule that contains discrete milestones for product development.

PHASE II: Develop, demonstrate and fabricate a prototype as identified in Phase I. In a laboratory environment, demonstrate that the prototype product meets the performance goals established during Phase I. Provide a detailed plan for software and/or hardware certification, validation, and method of implementation into a future ship test and/or design environment. Prepare cost estimates, logistics data packages, and interface documents for use in both forward fit and retrofit ship programs.

PHASE III: Utilizing the technology developed during Phase I and II, work with Navy and industry to certify and implement for use on existing and future naval and commercial shipbuilding programs.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Aluminum hull forms are used through the commercial maritime industry. This technology could also be used to inspect pilings/seawalls, hull inspections on commercial ships, surveillance and reconnaissance, or other underwater inspection activities.

REFERENCES:

1. <http://www.ndt.net/article/v08n09/wong/wong.htm>

KEYWORDS: Hull; Aluminum; NDE; NDT; Inspection; Underwater

TPOC: Dana Lynn  
Phone: (301)227-4493  
Fax: (301)227-4814  
Email: dana.lynn@navy.mil  
2nd TPOC: Lloyd English  
Phone: (540)653-3277  
Fax:  
Email: Lloyd.English@navy.mil

N111-058 TITLE: Autonomous Tank and Void Inspection Technique

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

ACQUISITION PROGRAM: PMS312

OBJECTIVE: To reduce the costs associated with maintenance and inspection of the preservation systems and substrate material of all varieties of tanks and voids.

DESCRIPTION: Aircraft Carriers have thousands of tanks for the storage and distribution of numerous fluids including sea-water, fresh water, JP-5, gray water, and lube oil. In addition there are hundreds of dry voids or isolated, unused spaces. Both tanks and voids present significant corrosion challenges to the Fleet and are one of Aircraft Carriers' most costly maintenance concerns.

All shipboard tanks and voids have a preservation system applied that requires periodic repair or complete replacement. While a number of tanks are re-coated on a scheduled, periodic basis the Navy has realized considerable cost savings by moving to a condition-based maintenance strategy. Therefore the preservation coating and structural condition of each and every tank on the ship must be inspected by trained personnel every few years.

Due to the design of an Aircraft Carrier, many of these tanks are small, confined spaces of irregular shapes that are a 3-dimensional maze of structural steel that may contain a hazardous fluid or toxic environment. Agile, trained inspectors are required to enter the tanks with several pieces of gear climbing through myriad manholes and narrow passageways in order to inspect and document the condition of every square-inch of surface of that tank. Additionally, requirements to gas free engineer these spaces requires additional manpower and effort, and reduces the flexibility to conduct other maintenance simultaneously.

Developing a method to autonomously inspect tanks and voids could reduce costs greatly, reduce hazards for the inspectors, and provide better consistency in assessments. A means to remotely or autonomously inspect every square-inch of these irregular spaces will prove greatly beneficial to the Aircraft Carrier Fleet, the entire Navy, and possibly commercial shipbuilding as well. Irregularly shaped tanks or voids, confined spaces, and hazardous material interaction have long prevented successful implementation of inspection in the military, sea-going arena.

All associated equipment entering a tank or void needs to be intrinsically safe, spark-proof, waterproof, and must have a method of relaying data through steel tank walls, which may be difficult to overcome in the “dead zones” aboard the ship. Equipment should also be ruggedized to ensure successful operation in a harsh marine environment, as well as physical contact with hazardous fluid (fuel, oil, etc.). Additionally, any equipment will need to be able to be placed by a single operator into the tank or void (maximum 50 pounds), through an 18-inch square access panel. Software needs to be compatible with current network infrastructure, and capable of operation by a Sailor aboard the ship.

PHASE I: Develop a concept proposal for a portable tank and void inspection method to be utilized on Aircraft Carriers. The ability to review and record the inspection results will be critical to a proposal’s success.

PHASE II: Generate a full-scale working demonstration model of the tank and void inspection method and associated equipment. Once success is attained in the land-based environment, demonstrate operability onboard an Aircraft Carrier. Correct any shortcomings noted in the shipboard demonstration. Develop the capacity for full-scale manufacturing, including special tools. Develop the capacity for logistics support including provisioning, technical documentation, drawings, operating instructions, and training.

PHASE III: Conduct full-scale manufacturing, Fleet introduction and fielding, training as necessary.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Commercial ship inspections, industrial equipment inspection.

REFERENCES:

1. CCIMS Manual
2. NSTM Chapter 631

KEYWORDS: inspection, preservation, corrosion, confined spaces, autonomous, robot

TPOC: Andrew Van Scyoc  
Phone: (202)781-2032  
Fax:  
Email: andrew.vanscyoc@navy.mil  
2nd TPOC: Ernest Chambers  
Phone: (202)781-1239  
Fax:  
Email: ernest.chambers@navy.mil

N111-059

TITLE: Robotic Eddy Current Condenser Inspection Equipment Capability

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

ACQUISITION PROGRAM: PMS312

OBJECTIVE: New technologies to provide for remote eddy current inspection of condensers is needed. The fleet does not have an ability to safely and productively inspect condensers. Development of remote control, robotic or other automated means would reduce errors, save considerable hard physical labor, reduce acquisition time for condenser inspection and most important would reduce human exposure to harmful materials, such as lead and other toxic materials.

DESCRIPTION: Eddy current inspections are required to ensure the integrity of condenser tube walls. Loss of integrity of condenser tube wall leads to chloride contamination of the steam propulsion plant resulting in shutting down propulsion and possible loss of platform availability. During each non dry-docking availability approximately 25% of the tubes are inspected and 100% of the tubes are inspected during dry-docking availabilities. Manual tube sheet indexing and probe location has historically shown an error rate up to a 3% leading to fatigue, loss of productivity, and may negatively affect work scheduling and availability completion.

The processes required to complete this testing is repetitive, time-consuming, and inefficient due to the manual labor associated with indexing. The work environment is industrial – it is cramped, dirty, and with wide temperature ranges and humidity levels.

Research is required in this area to automate this arduous and time-consuming process by eliminating or greatly reducing the amount of human interaction required to perform this task. An automated tool, capable of multi-axis functionality would decrease error, and increase the speed and quality of eddy current testing. Decreasing the time required to conduct eddy current testing of condensers may remove this testing from the maintenance critical path, thus allowing more flexibility in scheduling and possible increase in ship's operational availability.

Due to the work environment and location, there are special requirements necessary and any solution must work with existing shipboard and shipyard systems.

Any developed equipment must be transportable by a maximum two man crew; this may be accomplished in individual elements and assembled on site. Equipment shall be capable of 30 minute setup and 30 minute tear down. Equipment should require only one operator with an associated function to record results of testing automatically.

Due to the hazardous nature of the work required, safety is a high priority. All electrical and test connections shall be water tight and quick disconnect. Pinch points shall be minimized to the maximum extent possible. Multiple LED or Strobe warning lights shall be connectable to the fixture interlocks and shall operate from initial warning tone until equipment is safety locked and shut down.

Equipment shall be capable of automated probe positioning for probe insertion/retraction of 200 tubes per hour minimum, contiguous, with calibration and required scan pattern, scalable as software/hardware improvements are installed. Equipment should interface with existing software and network infrastructure, if possible. Equipment shall Log and notify acquisition operator when a tube has any blockage preventing full length of tube inspection. Equipment shall allow manual probing of tubes found to have blockage or geometry issues, while in a hold mode for manual inspection, and probe head is still connected to the fixture.

The design should consider future scalability to allow for other smaller condenser units/different tube sheet layouts to be inspected. Fixture shall be capable of attaching to the tube sheet without damaging or deforming tubes. Equipment shall have auto tracking/error correction capabilities using Independent Position Verification (IPV).

Interfacing software will be Windows XP or newer O/S compatible and shall use AutoCAD produced maps to identify tube layout, with the ability for users to integrate new maps for different type condenser units as required. Equipment must run on 110 Vac/20 amps grounded electrical power and /or 100-120 psi tool air. Equipment shall perform self check verification prior to actual ET inspection as well as electrical self diagnostics. Equipment/Fixture shall allow calibration standardization/verification external to the condenser unit within a 15 minute window from stop to restart by accessing the probe at the front of the pusher.

PHASE I: The Vendor will develop a concept for a robotic or automated multi-axis manipulator and associated data recording capability to be utilized in Naval Shipyards for eddy current testing of condensers and heat exchangers.

PHASE II: The vendor will Build and Demonstrate a full-scale working prototype of the developed technology and data recording equipment associated with logging results of testing. The Navy will provide a detailed statement of work to include clear performance requirements. The Vendor will demonstrate operation of the prototype in meeting the Navy's statement of work. Upon satisfactory demonstration at the vendor's facility; the vendor will participate with the Navy in arranging a realistic demonstration as part of a Phase II option in a naval shipyard in an appropriate

application. The vendor and Navy will correct any discovered performance shortcomings in the Phase II option. The Navy will develop a detailed plan for implementation and funding of the successful capability into Naval Shipyard operations and inventories. Full scale testing at a Naval Shipyard is unclassified work, but access requirements dictate that the work be accomplished by U.S. citizens with a minimum of a Confidential security clearance.

PHASE III: The vendor will work with the Navy to develop a shipyard-ready capability. This includes Developing the capacity for production of fieldable units, including special tools, logistics support in the form of provisioning, technical documentation, drawings, operating manuals, and training. Phase III work, while unclassified, would be considered U-NNPI or NOFORN indicating that all work must be handled and accomplished by U.S. citizens.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Ship repair, condenser, and heat exchanger inspections, tube condensers

REFERENCES:

1. NAVSEA Instruction 9254.1
2. NAVSEA T9074-AT-GIB-010/2032
3. NAVSEA Drawing 7668287
4. IP 56 Industry Standard – Waterproof specification standard
5. MIL-STD-767-2041- Manufacturing and assembling cleanliness requirements

KEYWORDS: Eddy current, robotics, manipulator, autonomous

TPOC: Dennis Yeats  
Phone: (360)476-8744  
Fax: (360)476-0874  
Email: dennis.yeats@navy.mil  
2nd TPOC: Henry Rankin  
Phone: (757)967-2575  
Fax:  
Email: lew.rankin@navy.mil

N111-060 TITLE: Thermoelectric Scalable Power Generator

TECHNOLOGY AREAS: Ground/Sea Vehicles, Electronics, Weapons

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OBJECTIVE: The objective of this work is to develop and demonstrate a standalone Thermoelectric Scalable Power Generator using Thermoelectric technology for use in military weapon systems

DESCRIPTION: A small size, light weight, scalable and portable power generator is always needed in military weapon systems. The Thermoelectric Scalable Power Generator (TSPG) is a power generator that converts heat to electrical power in such a way that it is quite different than conventional power sources such as battery or

commercially available power generators. This topic calls for an innovative way to generate power using thermoelectric technology. The TSPG is a generator that needs a heat source on one side of thermoelectric modules and a cooling system on the other side. For a standalone TSPG, logistic fuels can be burned to provide the heat to the generator and these fuels can be JP-4, JP-5, JP-7 or JP-8. These fuels provide heat to the generator through a combustion process. The cold side of thermoelectric modules can be cooled by air or liquid. The mentioned heat source will make the thermoelectric power generator become portable and can be scalable to meet the needs of warfighters at any locations on the shipboard where power is needed. However, the heat provided by these fuels is normally at high temperature close to about 1000°C and it could pose a problem for thermoelectric materials. Therefore, the thermoelectric materials need to satisfy two conditions: high temperature operation and high conversion efficiency. These two conditions translate to a high temperature thermoelectric materials and high ZT thermoelectric materials respectively. This proposal calls for a new nanostructure thermoelectric material that has a ZT higher than 1.5 and it should be able to handle a minimum of 500°C continuously. The thermoelectric power generator should be designed to generate a minimum of 300 Watts power output and should be completed with a combustion control system, cooling system with an advanced heat exchanger design and a power management system that includes a DC/DC converter to convert generated power to 12VDC and 24VDC as needed for interfacing with other devices. The generator should be designed for a total weight of less than 8 Lbs and for signatures proof of heat, noise, vibration, RF and smoke etc. The generator should also be designed such that it is rugged and can be used safely by warfighters as a scalable power source at any locations on the shipboard or on land.

In summary, the TSPG has to be designed to operate satisfactorily based on the following requirements:

- Provide a continuous voltage of 12 VDC and 24VDC as needed
- The output power is 300 Watts or higher
- The temperature on the hot side of thermoelectric module is 500°C, the cold side can be cooled by air or liquid using advanced heat exchangers.
- The total weight should be less than 8 Lbs
- The volume should not be more than 500 cubic inches.
- The TSPG has to include all necessary electronics for combustion control, power management and DC/DC converter.

The above requirements are applicable to more than one military application taking the advantage of the scalability of TSPG.

**PHASE I:** The objective of Phase I is to allow the contractor to determine technical feasibility of the work based on current thermoelectric technology, which is showing many progress in high efficient materials development. Phase I will also include development of technical approaches and design concept for solving the problem. A modeling and simulation effort might be needed in Phase I to prove the design concept. A technical report is required at the end of phase I, in which all the progress as well as difficulties in meeting the objective have to be included for GO or No Go decision.

**PHASE II:** Phase II effort should include a prototype development and performance validation.

The contractor has to be able to produce a prototype unit based on Phase I work. All the testing and validation of the prototype unit will be done in Phase II. A final report which includes all the test data as well as analysis and recommendation will be submitted to the Navy for evaluation and determination of transition phase.

**PHASE III:** The expected transition can be carried out to surface ship weapon systems as well as other systems that require continuous power with all the advantages of thermoelectric technology. The accomplishment from Phase I&II will help in determining the transition.

**PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:** Another use of the results from this effort is in waste heat recovery application for vehicles where the waste heat can be converted to electrical power by using the high temperature and high ZT thermoelectric materials to assist the internal combustion engine, thus improve the engine efficiency.

#### REFERENCES:

- 1) Fairbanks, John. 24th International Conference of Thermoelectrics, Clemson University, South Carolina, June 19-23, 2005.



2) [http://www1.eere.energy.gov/vehiclesandfuels/pdfs/thermoelectrics\\_app\\_2009/wednesday/fleurial.pdf](http://www1.eere.energy.gov/vehiclesandfuels/pdfs/thermoelectrics_app_2009/wednesday/fleurial.pdf)

3) Harman et al. J. Electron. Materials 234, L19 (2005)

4) Rowe, D.M. Thermoelectrics Handbook: Macro to Nano. Boca Raton, FL: CRC Press (2005)

**KEYWORDS:** Thermoelectric Scalable Power Generator, High ZT thermoelectric materials, Portable Power Generator, Heat Source, Advanced Heat Exchanger, Nanostructure Thermoelectric Materials.

**TPOC:** Thanh Tran  
**Phone:** (301)227-1881  
**Fax:** (301)227-5480  
**Email:** thanh.n.tran@navy.mil  
**2nd TPOC:** James Zaykoski  
**Phone:** (301)227-4500  
**Fax:**  
**Email:** james.zaykoski@navy.mil

N111-061 **TITLE:** Serious Games for Sailor Proficiency

**TECHNOLOGY AREAS:** Sensors, Human Systems

**ACQUISITION PROGRAM:** High Fidelity Active Synthetic Training (HIFAST)

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

**OBJECTIVE:** Develop innovative ways to leverage high fidelity sonar simulation to develop sailor Anti-Submarine Warfare proficiency.

**DESCRIPTION:** The Navy is developing high fidelity synthetic training environments to improve sailor proficiency. Advances in simulation could enable more effective training techniques. The field of serious games is making rapid advances in understanding the cognitive processes that enhance learning and retention.

Current training processes consist of classroom training, with instructor-led hands-on training. Future sonar training systems immerse the student in a high fidelity environment, but lack the ability to sense trainee proficiency or target scenarios to appropriately challenge individual trainees.

An individualized simulated event that is slightly challenging should produce better learning and retention than an event that is either trivially easy or overwhelmingly difficult. An automated technology to determine proficiency level and recommend a scenario that is appropriate to the student's skill level would potentially reduce barriers to practice and develop automaticity or proficiency.

Unclassified results of Naval Mine and ASW Warfare Command (NMAWC) evaluation of scenario complexity constructs, required ASW skills, and evaluation of current simulation capabilities will be provided.

**PHASE I:** Develop concepts to significantly improve proficiency of sonar operators using serious games concepts such as cognitive loading. The concept should presume the existence of high fidelity simulation and intelligent

agents. The Phase I concept should address mid-frequency active sonar employment at the unclassified level.

PHASE II: Develop a Serious ASW Game "adjunct" for use with the latest AN/SQQ-89 A(V)15 training capability to assess proficiency at recognizing active sonar returns and recommending appropriate scenarios based on the assessed proficiency. Demonstrate proficiency assessment and differential improvement to proficiency and retention when the Serious Game adjunct is used. Phase II will require access to classified information.

PHASE III: Transition the technology to the AN/SQQ-89 A(V)15.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: This technology could benefit safety-critical governmental or commercial systems that required highly perishable skills, such as land navigation or driving using night vision devices. This technology could also be used to adaptively train individuals on proper behavior in changing environments, such as proper responses for emergency management personnel or improving social proficiency in autistic individuals.

REFERENCES:

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2. Janis Cannon-Bowers and Clint Bowers (editor), Serious Game Design and Development: Technologies for Training and Learning. Published by Information Science Reference (c) 2010
3. Aldrich, Clark, The Complete Guide to Simulations and Serious Games: How the Most Valuable Content Will be Created in the Age Beyond Gutenberg to Google. Published by Pfeiffer (c) 2009

KEYWORDS: Cognitive Load, Serious Games, Training, Proficiency, High Fidelity, Synthetic Environments, Active Sonar Employment

TPOC: Meg Stout  
Phone: (202)781-4233  
Fax:  
Email: Meg.Stout@navy.mil  
2nd TPOC: Kate Christensen  
Phone: (202)781-0092  
Fax:  
Email: kate.christensen@navy.mil

N111-062 TITLE: Geographic Information System Tools for Spatio-Temporal Statistics

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: N/A

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OBJECTIVE: Develop software tools that incorporate innovative methods for analyzing spatio-temporal data. The tools should integrate seamlessly with existing geographic information system (GIS) software.

**DESCRIPTION:** In recent years, spatio-temporal statistical methods have been developed in academia and in the GIS (Geographic Information System) community. At the same time, the ability to exploit the spatial and temporal characteristics of data has become more important in DoD applications. We seek innovative theoretical and methodological approaches for analyzing spatial data that have a time component associated with them. Of particular interest are methods that work with spatio-temporal data sets that are messy and have missing data.

Most of the methods in spatio-temporal statistics have been implemented in research software environments such as R (open-source statistical computing software) and are not available in a commercial GIS package such as ArcMap. Thus, analysts must often analyze the data using many different tools (e.g., R, Excel, MATLAB) and import the results into a GIS package; this can create errors and also takes significant time and effort on the part of the analyst.

The goal of this effort is to develop and employ state-of-the-art spatio-temporal statistical methods to create an integrated software toolbox that will work with existing GIS packages. These tools must work seamlessly with the GIS software and should be implemented in Python or visual basic to allow for an efficient analytic process.

**PHASE I:** Research literature and GIS software capabilities, conduct an evaluation to determine best-of-breed spatio-temporal analysis techniques, and propose new analytic methods.

**PHASE II:** Design, develop and demonstrate prototype software to meet performance needs, such as the ability to seamlessly connect with a GIS package. This phase might also include creating and implementing new methods for analyzing spatio-temporal data sets that are messy and have missing data.

**PHASE III:** Integrate software with existing systems and demonstrate improved capability based on realistic scenarios.

**PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:** A software toolkit developed under this effort can be applied wherever geographical information systems are used. These include geographic criminology, epidemiology, city planning, environmental science, remote sensing, and more.

**REFERENCES:**

1. Applied Spatial Data Analysis with R by Bivand, Pebesma, Gomez-Rubio, 2008, Springer-Verlag
2. Statistical Methods for Spatial Data Analysis by Schabenberger and Gotway, 2005, CRC Press
3. Statistics for Spatial Data by Cressie, John Wiley & Sons, 1993
4. Interactive Spatial Data Analysis by Bailey and Gatrell, 1995, Longman Scientific & Technical
5. CRAN website for R: <http://cran.r-project.org/>
6. Analysis of Incomplete Multivariate Data by J. K. Schafer, 1997, CRC Press

**KEYWORDS:** Spatial statistics; messy and missing data; spatio-temporal; modeling and simulation; software tools; algorithms

TPOC: Wendy Martinez  
Phone: (540)653-5997  
Fax:  
Email: wmartine@jwac.mil  
2nd TPOC: Julian Ouellet  
Phone: (540)284-0985  
Fax:  
Email: jouellet@jwac.mil  
3rd TPOC: Jerome Venteicher  
Phone:  
Fax: (540)284-1101

Email: jventeic@jwac.mil

N111-063

TITLE: Multi-fovea Parallel Sensor-processor Architectures and Algorithms to Improve UAV Based Recognition, and UAV Sense and Avoid capabilities

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Develop high-resolution (~ 1MPix), high-speed (~ 1000 fps for selected image regions) multi-fovea parallel sensor-processor architectures and the associated image processing algorithms for robust, high-performance terrain analysis, object signature recognition, and Sense and Avoid (SAA) .

DESCRIPTION: There is an increasing need to perform higher levels of sensor signal processing on board UAVs to relieve the requirements for transmitting Full Motion Video (FMV) over already overloaded data links to the ground station for processing. The goal for this effort is to introduce this capability onto UAV platforms with minimal impact on SWaP (size, weight, and power), for applications like persistent surveillance, and sense and avoid. Under persistent surveillance the improved processing capability would involve techniques for locating and identifying targets of interest in complex backgrounds. The Sense and Avoid (SAA) application would require searching large areas( minimal forward hemisphere) for airborne objects using motion clues from frame subtraction. Once the airborne objects are located they must be tracked to determine collision potential and generate escape routes. Smart sensors with on-chip processing capability will be able to address this challenge if the object signatures can be detected and identified within unprecedented response time (typically below 1 msec for 1kHz imagers)). However, this specification can only be met with complex algorithms critically optimized for novel massively parallel sensor-processor architectures. Previous efforts already demonstrated that increasing the near-sensor (“focal plane”) computational capability could only be traded against sensor resolution. Thus, designing high resolution, tightly integrated sensor-processor arrays (VIS/NIR focal plane array) is still in its infancy, and will require more development to provide significant on-chip processing capability. A possible evasion is to use a combination of high resolution sensor arrays with relatively simple nearest neighbor processing incorporated in the readout integrated circuits (ROICs) combined with a subsequent chain of “fovea processors” (a multi-chip approach). These multi-fovea architectures could support complex signature analysis around selected spatial locations at high frame rates thereby significantly increasing the probability of correct target identification by utilizing the spatial resolution needed for analyzing fine details in selected foveal areas. If properly designed, multi-fovea / multi-core processors will also show an improved robustness in extreme environmental conditions (due to dynamically maskable pixel level and exchangeable foveal processing nodes). The effort should rely on state-of-the-art commercial off-the-shelf multi-fovea ROIC solutions with simple nearest neighbor processing (1/4 MPix solutions with multi-scale processing and frame differencing capability are already available today for customization) and focus on the complementary massively parallel multi-fovea processing architecture design and implementation with the associated embedded software solutions.

PHASE I: Complete a feasibility study on massively parallel, multi-fovea sensor-processor chip architectures and algorithms for high-performance terrain analysis, object signature recognition, collision guidance and avoidance. Demonstrate the feasible architectures with the associated algorithmic solutions.

PHASE II: Design, develop and fabricate a massively parallel, multi-fovea sensor-processor chip-set with the associated algorithms for high-performance terrain analysis, object signature recognition, collision guidance and avoidance. Demonstrate the functionality of the integrated multi-chip device.

PHASE III: Develop and execute a plan to manufacture the sensor-processor(s) developed in phase II, and assist the NAVY in transitioning this technology to the appropriate prime contractor(s) for the engineering integration and testing of the proposed advanced sensor-processors.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Maritime & aviation collision avoidance sensors and medical uses.

REFERENCES:

[1] A. R. Vazquez, R. D. Castro, F. J. Garrido, S. Morillas, A. Garcia, C. Utrera, M. D. Pardo, J. Listan, and R. Romay, "A C-MOS Vision System On-Chip with Multi-Core, Cellular Sensory-Processing Front-End", in Cellular Nanoscale Sensory Wave Computing (Springer, Ed. Chagaan Bataar, Wolfgang Porod and Tamas Roska), pp. 129-146, 2010.

[2] Rekeczky, C., I. Szatmari, D. Balya, G. Timar, and A. Zarandy, "Cellular multiadaptive analogic architecture: a computational framework for UAV applications", Circuits and Systems I: Regular Papers, IEEE Transactions on Circuits and Systems I: Fundamental Theory and Applications, pp. 864–884. doi:10.1109/TCSI.2004.827629, 2004.

[3] A. Richards, J. Bellingham, M. Tillerson, and J. How, "Coordination and Control of Multiple UAVs", AIAA Guidance, Navigation, and Control Conference and Exhibit, AIAA 2002-4588, Monterey, California, 2002.

KEYWORDS: Sensor-processor architecture, Near-pixel processing, IR detector, Electro-optical detector, Sense and Avoid, Terrain recognition, Object signature analysis.

TPOC: Chagaan Baatar  
Phone: (703)696-0483  
Fax:  
Email: chagaan.baatar@navy.mil

N111-064 TITLE: High Accuracy Navigation Systems for Low Power UUVs

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors

ACQUISITION PROGRAM: Unmanned Cooperative Curing and Intervention FNC

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

OBJECTIVE: Develop new technologies or manufacturing techniques to reduce the size, power, and cost of high accuracy underwater navigation system used in large unmanned vehicles, remotely operated vehicles, and submarines to enable low power UUVs and gliders to navigate in the complex littoral environment.

DESCRIPTION: Low power UUVs and gliders are becoming a workhorse platform for sensors in both the military and research community. The Navy is procuring over 150 undersea gliders for battlespace awareness with the worlds research community using a equivalent number of undersea gliders for oceanographic research. In addition, the Navy operates over 50 man portable and light weight UUVs for mine reconnaissance and bottom mapping missions for over the past five years. Due to the size of the man portable, light weight, and undersea glider UUVs, they do not have the space, power, or can afford the expense of today's state of that art undersea navigation systems. However, they could benefit greatly from the navigation accuracy offered by these system which greatly surpasses a compass heading to extend their capability to navigate in the littorals.

This topic is looking for either new manufacturing techniques to reduce the size, weight, and cost of current navigation systems or new technologies that can provide equivalent navigation performance as current systems.

Navigation parameters of the current system:

- \* position error:<10m CEP
- \* heading accuracy: .5% error in heading per hour
- \* Velocity error: .1m/s

- \* Power: 75 watts
- \* weight: 125 lbs in air
- \* volume: 247 in<sup>3</sup>

Navigation objectives of the proposed prototype:

- \* position error: <5m CEP
- \* heading accuracy: .1% error in heading per hour
- \* Velocity error: .05m/s
- \* Power: 10 watts
- \* weight: 20 lbs in air
- \* volume: 150 in<sup>3</sup>

This topic will consider approaches for the entire system or components of the system. Example cutting edge technologies include but are not limited to mems inertial navigation units, single crystal transducers, advanced navigation algorithms, multi UUV navigation techniques, etc.

PHASE I: Phase I should include the development of the concept. Detailed report with the mathematical proof of the proposed concept which may include theoretical calculations, modeling and simulation, or collected data. Reduction of key risk items and proof of concept demonstration of high risk and critical component technologies for both manufacturing or technology development proposals. Complete the preliminary design of the proposed system or component.

PHASE II: Complete the detailed design of the proposed system or component. Fabricate three prototype systems or components. Conduct testing to validate that the performance of the proposed system or component against the predicted performance in the phase I final report.

PHASE III: Integrate proposed system or component onto a small low power UUV and complete at sea testing. The Office of Naval Research will provide two low power UUV as test platforms for the Phase III testing. These UUVs will be located at SPAWAR System Center San Diego where the integration will occur. ONR will provide technical support for the UUVs for integration and test boats for the at sea tests from non SBIR funds. The contractor should develop prototypes, an installation kit that meets the government defined interfaces, support integration tests, and lead at sea testing.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: This system will increase the navigation capability of UUVs in oil and gas industry for very high accuracy tasks, recreational diving industry for increase awareness while diving, and local search and rescue units with remotely operated vehicles to increase navigational accuracy during search and rescue responses.

#### REFERENCES:

1. Navy UUV Master Plan: [www.navy.mil/navydata/technology/uuvmp.pdf](http://www.navy.mil/navydata/technology/uuvmp.pdf)
2. OSD Unmanned Systems Roadmap: <http://www.jointrobotics.com/documents/library/UMS%20Integrated%20Roadmap%202009.pdf>

KEYWORDS: UUV; Undersea; Navigation; low power; manufacturing; single crystal

TPOC: Daniel Deitz  
Phone: (703)696-0557  
Fax:  
Email: [daniel.deitz@navy.mil](mailto:daniel.deitz@navy.mil)  
2nd TPOC: Greg Neuschafer  
Phone: (703)696-5418  
Fax:  
Email: [neuschg@onr.navy.mil](mailto:neuschg@onr.navy.mil)

N111-065

TITLE: Materials Processing with FEL Injector E-Beam

TECHNOLOGY AREAS: Materials/Processes, Sensors, Weapons

ACQUISITION PROGRAM: ONR FEL Program and NAVSEA PMS 405

OBJECTIVE: The FEL generates intense photon beams by extracting kinetic energy from very well defined and energetic electron beams. The process requires the production of modest energy (<10 MeV), bright [low emittance - 10 micron] electron pulses. Unlike the entire FEL laser system, the injector and its auxiliary equipment are relatively compact and can be installed in most manufacturing facilities.

The primary objective of this solicitation is to determine if the electron beam characteristics of the FEL injector can be used to good advantage in such applications as e-beam lithography, atmospheric welding, and others. The applications sought must be compelling, have significant utility, be affordable, and provide a unique Navy and/or commercial capability.

DESCRIPTION: Many material processing applications require the controlled input of thermal energy to achieve the desired properties. While the processing of large bulk materials can be adequately achieved with thermally controlled furnaces, some products would greatly benefit by applying varying amounts of heat to local areas to produce unique spatial characteristics. The use of high energy (<10 MeV) electron beams ability to locally deliver thermal energy for material processing opens up some potentially interesting opportunities for both manufacturing military hardware and commercial products.

The interaction of electrons with most manufacturing materials is fundamentally different than that occurring with photon beams. Photon beams tend to deposit most of their energy on the front surface (only a few microns in metals and opaque solids) causing ablation even for relative low power laser beams. This limits the useful amount of energy that can be deposited into materials thus restricting the rate of heating that can be reasonably used for bulk processing. Electron beams deposit their energy in depth; for example a 10 MeV electron can penetrate about one centimeter of aluminum. Since the electrons deliver their energy in to a larger volume of material, faster processing rates can be achieved. Furthermore, the more energetic FEL injector beams do not require the work piece to be maintained in a vacuum as do conventional electron beam welders. An important feature of the FEL injector is that it is designed to produce high quality beams, which means the electrons can be focused to a relatively small spot size, thereby producing a small heat affected zone.

The FEL uses an electron gun/injector to produce megawatt-class, high-brightness beams that can span a large operational (voltage x current) parameter space. The beam energy can be set to control the electron depth of penetration while the current pulse amplitude and length control the delivered energy. At the electron energies of interest, the e-beam can propagate through controlled atmospheres. This eliminates the need for vacuum chambers used by conventional e-beam welders.

The development of non-weapon gun/injector technologies will require improving the human machine interface for operational and maintenance considerations. Improvements in this area will greatly benefit the FEL INP weapons program much as fiber laser based weapons studies have profited from the advancement of fiber welders.

The purpose of this solicitation is to identify compelling materials processing applications using the FEL INP gun/injector system. From those applications, quantify the beam requirements and describe improvements that e-beam processing provides over conventional heat treatments.

PHASE I: In Phase I, the respondent to this solicitation should identify applications of high power electron beams that will provide a unique and compelling military and/or industrial capability. For each application identified, the respondent shall quantify the required electron beam characteristics such as electron energy, beam brightness, peak power, average power, etc. In addition to the advantages of the e-beam as a quality heat source a listing of the technical challenges such as estimating the amount of ionizing radiation shielding required, a description of the methods for steering/focusing the beam, a conceptual description of the vacuum interface. In the Phase I report, the respondent should identify first generation applications that can be demonstrated with existing FEL injectors.

The study should also provide first order estimates of capital and operating costs for each application, and suggest injector design improvements for making the equipment more user friendly.

PHASE II: The respondent shall perform demonstrations, consistent with available budget to demonstrate the advantages of a high power electron beams identified in Phase I.

Phase I operating cost estimates shall be revised using results of Phase II. The Phase II study shall include a quality and quantity comparison of e-beam processed materials with those treated with current methods, and estimates of facility production rates.

PHASE III: The respondents shall survey market the e-beam system which shall concentrate on the most compelling applications for military (ship, aircraft and submarine construction; weapons development), and commercial uses. A detailed conceptual engineering facility design(s) for the most promising application(s) should be presented in Phase III report. Special emphasis shall be given to human factors engineering for operations, safety and maintenance.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Several industrial applications could benefit from a successful demonstration of the use of electron beams as a quality focused heat source. Potential examples would be near net shape lithography of large components, uniform thermal gradation of turbo-fan blades, pre-stressing of ceramic bearings, food preservation using non-radioactive sources, curing thermo-set plastics, and controlled atmospheric e-beam welding.

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3. R. B. Miller; An Introduction to the Physics of Intense Charged Particle Beams, Plenum Press, New York, 1982.
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KEYWORDS: Free Electron Laser (FEL); Injector; E-Beam; Materials Processing; Manufacturing; Intense Electron Beams (IEB)

TPOC: Sarwat Chappell  
Phone: (703)696-4224  
Fax:  
Email: sarwat.chappell@navy.mil  
2nd TPOC: Eugene Nolting  
Phone: (202)781-3175  
Fax: (202)781-4510  
Email: eugene.nolting@navy.mil

N111-066

TITLE: Low Frequency Projector for Long Range Acoustic Communications

TECHNOLOGY AREAS: Information Systems, Electronics

ACQUISITION PROGRAM: POM-13 FNC Proposal to support IWS 5A APB/PMS 401 A-RCI

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**OBJECTIVE:** Develop a coherent acoustic projector that will provide 50-75 Hz of BW on a 150 Hz carrier at a depth of 1000 m.

**DESCRIPTION:** Continuous communication is possible only when submarines deploy a receiving antenna while operating at or near the surface. This imposes a restriction upon the submarine's operating depth and its speed, as well as increasing its exposure to detection. Low Frequency Long Range Acoustic Communications has the potential to meet some of the needs in this long standing capability gap.

Research into acoustic communications over a variety of frequencies has been on-going for many years. The size and power requirements for projectors tends to scale with the wavelength, so frequencies in the 10s of kHz with cm scale wavelengths are popular with researchers, useful in controlling underwater vehicles at km ranges, and supported by relatively mature commercial technology. Operating at lower frequencies offers more range at the expense of bandwidth, and has been explored to some degree, but research in the 100 to 200 Hz range has been hampered by the lack of a suitable projector.

**PHASE I:** Identify and design a concept for a coherent acoustic projector that will provide 50-75 Hz of BW on a 150 Hz carrier at a depth of 1000 m, and estimate the cost of the continued technical development and production of the projector.

**PHASE II:** Produce prototype hardware based on the Phase I work, as guided by requirements of a Future Naval Capabilities (FNC) development program.

**PHASE III:** Three to four projectors would be required to support an FNC development program in Long Range Acoustic Communications. A transition of the FNC program to the fleet would bring additional demands.

**PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:** Studies of the ocean, including climate studies using acoustic thermometry could leverage a new source in the 100 to 200 Hz range. Acoustic thermometry data can also be used to study seasonal and interannual temperature variability associated with a variety of oceanographic phenomena, such as El Niño/La Niña. Such a source would also be used in direct studies of acoustic propagation in littoral and deep water.

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2. Morozov and Webb: A Sound Projector For Acoustic Tomography And Global Ocean Monitoring, IEEE Journal of Oceanic Engineering, Vol. 28, No. 2, April 2003
3. Kilfoyle And Baggeroer: The State Of The Art In Underwater Acoustic Telemetry; IEEE Journal Of Oceanic Engineering, Vol. 25, No. 1, January 2000
4. P. F. Worcester, R. C. Spindel, and B. W. Howe, "Reciprocal acoustic transmissions: Instrumentation for mesoscale monitoring of ocean currents," IEEE J. Oceanic Eng., vol. OE-10, pp. 123-137, Apr. 1985.

**KEYWORDS:** Acoustic; communications; projector; telemetry; transducer; modem

**TPOC:** Robert Headrick  
**Phone:** (703)696-4135  
**Fax:**  
**Email:** bob.headrick@navy.mil

2nd TPOC: Kevin Williams  
Phone: (703)696-4525  
Fax:  
Email: kevin.l.williams9@navy.mil

N111-067 TITLE: Underwater Structural Health Monitoring of Composite Navy Propellers

TECHNOLOGY AREAS: Materials/Processes, Sensors

ACQUISITION PROGRAM: 73R Adv Sub Sys Dev Prog (PE603561, Proj 2033) and ONR AMP FNC

OBJECTIVE: Develop an innovative structural health monitoring (SHM) system capable of detecting and characterizing early signs of damage to composite propellers through an in-situ network of sensors/actuators and diagnostics algorithms.

DESCRIPTION: Composite propellers are being developed by the Navy for a number of potential benefits, including reducing weight and maintenance requirements, while increasing design flexibility and performance. The lack of Navy knowledgebase on composite propellers would result in excessive design margins and extensive structural testing to mitigate the risk of failure during operation. An intelligent structural health monitoring system capable of detecting and characterizing (size, location, and nature of) damage to composite propellers will reduce design margins and the need for extensive physical testing. While in service, an SHM system applied to composite propellers would decrease operational costs by reducing the amount of scheduled inspection and maintenance.

This SBIR seeks to develop innovative approaches to sensing mechanisms, communication types (wired or wireless), and damage detection methodologies. Damage mechanisms could range from matrix cracking, delamination, and erosion, to more severe damage such as impact and shock. Sensors must withstand an extreme seawater environment including shock, repeated cyclic motion, and high pressure that are unique challenges to Naval composite propellers. Necessary sensors and actuators may be either embedded in or surface mounted on the structure, without degrading structural and hydrodynamic performance of the composite propeller. Sensors and electronics must be integrated into the overall structural design. The data acquisition and analysis system shall be serviceable from inside the vessel or located adjacent to the propeller.

PHASE I: Evaluate various approaches to sensing and analyzing structural health. Develop an SHM system concept capable of detecting damage on a notional submerged composite beam in water. Fabricate a benchtop prototype system consisting of composite beam(s), sensors, data acquisition, and processing system. Demonstrate early stage damage detection and characterization capability in water.

PHASE II: Based on the Phase I development, validate the SHM system through prototype demonstration in two stages: (1) laboratory testing of a scaled model propeller blade, and (2) in-water testing of a large-scale propeller on a Navy demonstration platform, LSV-2. If a propeller of a classified design is used for the large-scale testing on LSV-2, and the contractor does not have the appropriate clearance, the Navy program office will facilitate obtaining personnel and facility clearance for the contractor.

PHASE III: A damage prognosis capability will be developed based on the damage detection capability using the SHM system. Transition the SHM technology to NAVSEA 73R Advanced Submarine Systems Development Program for future full-scale demonstration.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The SHM technology could be integrated into any composite structures that present a significant risk of failure. Commercial shipping and tourism industries could also benefit from the SHM system.

#### REFERENCES:

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(SSN 774) Class", NSWCCD-65-TR-2008/28, February 2010

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KEYWORDS: Structural Health Monitoring; SHM; Composite Propeller; Composites; Sensors; Damage Detection

TPOC: Ki-Han Kim  
Phone: (703)696-4305  
Fax: (703)696-2558  
Email: kihan.kim@navy.mil  
2nd TPOC: Benjamin Grisso  
Phone: (301)227-6327  
Fax:  
Email: benjamin.grisso@navy.mil  
3rd TPOC: Liming Salvino  
Phone: (301)227-5987  
Fax: (301)227-1020  
Email: liming.salvino@navy.mil

N111-068

TITLE: Affordable Beam Control Technology for Compact Beam Directors

TECHNOLOGY AREAS: Sensors, Electronics, Weapons

ACQUISITION PROGRAM: PEO SUB and PEO Ships

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

**OBJECTIVE:** Develop an affordable compact beam director system for a High Energy Laser (HEL) weapon to be employed by a US Navy Submarine for precise targeting in maritime environments.

**DESCRIPTION:** Submarine HEL employment would support covert protection and early warning for a carrier battle group as well as self defense of submarine and friendly special operating forces. Previous beam directors developed for land-based or airborne use are too large for submarine use and not submersible. This topic addresses the need for compact, agile HEL weapon beam directors that greatly reduce the weight and volume of existing HEL weapon beam director systems while providing the ability to maintain extremely accurate movement of the optical elements so that the laser intensity is maintained on target. To maintain submarine force levels in the future funding environment, weapon system affordability must be addressed upfront as a major design consideration. Proposals in this area should address the following areas: (1) opto-mechanical design of the compact beam director compatible with existing/future Submarine mast configurations, (2) innovative optics and control system that either adapts to or otherwise mitigates the effects of thermal blooming and other turbulent phenomena, (3) control or removal of beam jitter caused by on-board vibrations, (4) integration with current/future mast configurations. The HEL beam director is required to have the following capabilities: (1) capability to handle 100kw average output power, (2) -30 – +80° of altitude training range, (3) 360° of azimuth training range, (4) 1 radian training accuracy relative to an inertial reference, (5) structures and components must remain operable through 20 G shock acceleration, (6) housing must withstand fluid pressure to 100 psi without leakage and must isolate the beam director optics from the maritime environment

**PHASE I:** Identify and provide concept design of critical hardware components for demonstration of the opto-mechanical, adaptive optics, and/or jitter control concept. Indicate areas where cost reductions are possible. Integration and targeting capability must be demonstrable through simulations or models.

**PHASE II:** Develop laboratory prototype hardware to demonstrate Submarine mast integration potential and HEL weapon targeting capability. Evaluate potential for integration into surface ship configurations in larger form factors and higher energy levels.

**PHASE III:** Integration into Universal Modular Mast prototypes or a prototype compact surface ship beam director. It is expected that demonstrating a laser beam director meeting the stated requirements will result in a wide range of applications.

**PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:** The commercial market includes such areas as laser communication and power beaming.

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**KEYWORDS:** Beam Director; Beam Steering; High Energy Laser; Jitter; Optics; Submarine; Vibrations

**TPOC:** Sarwat Chappell  
**Phone:** (703)696-4224  
**Fax:**  
**Email:** sarwat.chappell@navy.mil  
**2nd TPOC:** Tariq Manzur  
**Phone:** (401)837-6887  
**Fax:**  
**Email:** tariq.manzur@navy.mil  
**3rd TPOC:** Timothy Levandowski  
**Phone:** (401)832-1381  
**Fax:**

Email: LevandowskiT@Npt.NUWC.Navy.Mil

N111-069                      TITLE: Brain fitness training program to enhance cognitive function via remote ultra-mobile computing

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION PROGRAM: OPNAV N13: Selection and classification program of record. ACAT 4

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

OBJECTIVE: Design, implement, and evaluate a brain fitness training program enhances cognitive function and learning. The training program would be deployed on ultra mobile computing technology and remotely monitored. It must demonstrate substantial behavioral benefits (e.g., transfer to a broad range of cognitive tasks and substantial increases in measured fluid intelligence) and increased connectivity of grey matter). Improvements must be accomplished with modest training time and persist for extended periods of time.

DESCRIPTION: Scientific advances in cognitive training in the last five years show that high intensity cognitive training can produce dramatic gains in general cognitive capacity (increased fluid intelligence and verbal comprehension) and produce changes in brain connective tissue and neural populations of the related cortical networks. This has been demonstrated to produce substantial improvements in learning and performance through intensive, distributed, modest-duration training (e.g., 3 times per week at 30 minutes for ten weeks). Computer exercises provide a "cognitive gym" with a circuit training to grow key networks such as working memory, attention, language processing, and decision making. Modern brain measurement techniques (fMRI, anatomical connectivity mapping) can empirically quantify brain growth. The technology could be used both to improve ability (e.g., new recruits) and sustain/recover capacity (e.g., due to aging or Traumatic Brain Injury). This technology has been demonstrated in laboratory studies. To be deployable in a DOD environment it would be valuable to make the technology operate on ultramobile platforms (e.g., iPhone, PDA, netbooks) and be automatically monitored from a central site. Research must provide empirical data to optimize training effectiveness.

PHASE I: Develop the design of the tasks, test brain training program on a pilot basis. Show both far transfer on standardized behavioral test and quantify brain tissue growth. Demonstrate operation on ultra mobile computers (e.g., iPhone, Android) and semiautomatic monitoring and motivating of the learner to exert effort to intensively execute procedures to improve capacity.

PHASE II: Develop and demonstrate a prototype system in a full automated remote training. Conduct testing to prove feasibility to move mean ability one SD in working memory tasks with populations matched to military recruit base.

PHASE III: This system could be used in a broad range of military and civilian training. Civilian training would include both corporate and educational settings. Several Fortune 500 DOD corporations are following development in this technology considering commercializing the sector.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: This system could be used in a broad range of military and civilian security applications, including for jobs that impose high cognitive demand and workload.

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KEYWORDS: Brain fitness; training; ultra mobile computing; learning; decision making, working memory; fluid intelligence

TPOC: Harold Hawkins  
 Phone: (703)696-4323  
 Fax: (703)696-1212  
 Email: harold.hawkins@navy.mil  
 2nd TPOC: Ray Perez  
 Phone: (703)696-4986  
 Fax: (703)696-1212  
 Email: ray.perez@navy.mil

N111-070                      TITLE: Scalable Warfighter Interface to Support a High-level Interactions with an Autonomous Cargo and Casualty Evacuation Unmanned Air System at Remote, Unprepared Sites

TECHNOLOGY AREAS: Air Platform, Information Systems, Human Systems

ACQUISITION PROGRAM: AACUS Candidate FY12 ONR Innovative Naval Prototype

OBJECTIVE: To develop and demonstrate a scalable human interface and related automation technologies to enable a user at a remote, unprepared site to manage a highly autonomous Vertical Take-off/Landing (VTOL) cargo/casualty evacuation unmanned air system in a simple way that requires minimal dedicated time and minimal skill/training. This will include communicating important high-level directions and spatial and temporal information about the conditions and any potential hazards of the landing site, the approach path, potential threats in the area, and any tactical considerations of the unit that is being resupplied. The approach should be scalable for a wide variety of users with different skill levels and a wide range of environmental conditions in the field. Note that the focus of this topic is on the user interaction approach and related algorithms and not the development of new hardware. Existing COTS hardware should be used to the greatest extent possible.

DESCRIPTION: There is currently interest in the idea of using an Unmanned Air System (UAS) to deliver cargo to marines in the field or to provide casualty evacuation or extraction. This type of UAS might be used to support a range of users from Forward Operating Bases with some level of available resources to support UAS operations to small unit operations at a remote site with minimal manning or equipment that can be dedicated to this purpose. A goal is to be able to operate in a broad range of conditions including night / degraded visual environments, GPS-denied areas, and areas with possible threats, high winds, and complex terrain/landing conditions including landing on slopes and around man-made and natural obstacles, people, water, and soft terrain. Safety considerations will also need to be taken into account with regards to ensuring the operation of this system does not provide a threat to friendly or noncombatant humans on the ground. ONR is currently exploring the potential of developing a very

high degree of on-board autonomy that could be implemented as part of a future system. Autonomous capabilities are envisioned to include (1) Fully autonomous or human assisted approach selection and landing zone suitability assessment, (2) Launch / recovery with little or no human supervision, including by a relatively unskilled user with limited time in the field, (3) Highly automated mission planning and fully autonomous dynamic replanning when operating beyond line of sight communications, (4) Obstacle detection and avoidance, (5) Avoidance and evasion of known threats, and (6) Contingency response. However, given limitations in the current and projected state-of-the-art in autonomy, it is likely that human users would need to provide some guidance to the system beyond that required by pilots of manned aircraft performing a similar mission. In addition, human users will need to be able to interact with the system to convey their mission objectives, priorities, constraints, and knowledge of the situation at and around the landing area. There are significant challenges involved in such high-level human interaction with systems that have a substantial degree of autonomy and complexity.

This topic will develop and demonstrate a scalable user interface approach to enable a wide range of users to interact with this type of autonomous system at a high level. This will include communicating important high-level directions and spatial and temporal information about the conditions and any potential hazards of the landing site, the approach path, potential threats in the area, and any tactical considerations of the unit that is being resupplied. The approach should be suitable for a range of users with different skills and experience levels and access to hardware interfaces ranging from ruggedized laptop computers to smaller PDA-like devices. The approach should be suitable for non-dedicated users in the field that may not be able to focus all their attention on interaction with this system. Minimizing the extent to which users must be “heads down” watching computer screens is highly desirable. Interaction approaches may include multi-modal input approaches such as sketch-input and speech/natural language. Though, the focus of this effort will be on using such advanced approaches and not developing new approaches to speech recognition, sketch input, etc. Approaches should be developed to ensure adequate situation awareness by the user and ensuring that the human has a sufficiently good mental model of how the autonomy operates to be able to effectively utilize the system. In addition, operator trust will play an important role in the usefulness of these tools and that must be considered in the development of the approach.

**PHASE I:** Develop an initial version of the proposed approach for a limited set of landing site/environmental conditions with sufficient functionality to demonstrate feasibility and allow some limited evaluation by military operators and domain experts. Ideally, this could include integration with simple, limited-fidelity simulation elements to show closed-loop performance. However, the use of canned data and/or static mock-ups will also be acceptable. Develop metrics to evaluate the system in Phase II and determine how the approach could integrate with particular types of hardware components and a future Cargo Unmanned Air System. Candidate metrics might address workload, command/interaction frequency, decision accuracy, error frequency, error impact, efficiency of use, response time, situation awareness, correlation between system state and the operator’s mental model, task time, usability, training time to achieve proficiency, and trust.

**PHASE II:** Further develop the proposed approach for a broader set of environmental conditions in a more complex dynamic and unstructured environment and integrate them with a higher fidelity simulation and sufficient autonomy components to perform laboratory operator in-the-loop demonstrations and comparison with benchmarks. Experiments with live assets may be used when of value to validate simulation results, but are not required. Revise evaluation metrics and interfaces as necessary.

**PHASE III:** Integrate the software with other components in a naval control station and participate in integrated demonstrations of autonomous systems operations

**PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:** This capability could be used in a broad range of military and civilian security applications of unmanned systems and in other applications involving management of automated systems, such as industrial applications.

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KEYWORDS: cargo unmanned air system, scalable human interface, natural language, sketch

TPOC: Marc Steinberg  
Phone: (703)696-5115  
Fax: (703)696-4274  
Email: marc.steinberg@navy.mil

N111-071

TITLE: Thermal Conversion Device for Hydrothermal Vents

TECHNOLOGY AREAS: Materials/Processes, Sensors

ACQUISITION PROGRAM: NAVSEA

OBJECTIVE: Design a conceptual thermal-to-electric conversion system for either the hydrothermal vent or diffuse bed heat source. The designs should take into consideration potential biological and mineral fouling of the system, a desired system lifetime of >1 year (preferably >5 years), system voltages and amperages compatible with sensor system and/or AUV recharging, depth of the heat sources (nominally 1500m but potentially greater), and ease/practicality of system deployment. A system power of 20kW is desired. System scalability to power levels >100kW should be examined.

DESCRIPTION: Undersea thermal vents or near ocean floor geothermal activity creates an opportunity to generate significant levels of at-sea electrical power. This topic involves conceptual design of a underwater power system to convert thermal power into electrical power that could be used to power sensors, recharge AUV's, or other missions. Two broad thermal energy sources are idealized: (1) a vent chimney structure with conduit diameter of 3 inches, a fluid velocity of 0.75 m/s, and a fluid temperature of 325C, and (2) a diffuse flow region measuring greater than 5m x 5m with a fluid velocity of 0.15m/s and a fluid temperature of 25C.



PHASE I: Develop a conceptual thermal-to-electric conversion system for either the hydrothermal vent or diffuse bed heat source as described above.

PHASE II: Build brassboard prototype of phase I concept.

PHASE III: Demonstrate feasibility of phase II prototype in lab environment and at hydrothermal vent site.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Source power for underwater drilling operations. Allows continuous operation regardless of sea states and eliminates the need for a "mother ship" for ROV/UUV operations.

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KEYWORDS: Geothermal; Energy Conversion; Hydrothermal; alternative energy;

TPOC: Sharon Beermann-Curtin  
Phone: (202)631-3693  
Fax:  
Email: sharon.beermanncurtin@navy.mil  
2nd TPOC: Maria Medeiros  
Phone: (703)696-5034  
Fax:  
Email: maria.medeiros1@navy.mil

N111-072                      TITLE: Autonomously deployed energy harvesting system in coastal and riverine environment

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors, Battlespace

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

OBJECTIVE: Design and develop a self deployable, compact, energy harvesting system capable of extracting hydrodynamic flow energy from the littorals, surf zones, and rivers for unmanned system propulsion or for sensor operations. The system shall be easily integratable as a module to a number of existing underwater deployed sensors and unmanned underwater vehicles.

DESCRIPTION: Underwater sensors and autonomous systems are often significantly limited by the availability of onboard energy. The issue of energy limitation becomes more severe for autonomous systems deployed in the littorals, in surf zones, and in rivers due to the difficulties of deploying and retrieving systems in such energetic environments to replace batteries. The abundant hydrodynamic energy in such environments might, however, be extracted for use by deployed systems. Available autonomous system capabilities would be significantly enhanced by innovative approaches to self-deployment and energy extraction from the environment. In particular, system endurance, reduced cost, and potentially higher power for onboard sensor systems could be made available by in situ energy harvesting. Concepts and capabilities are solicited that would provide a system capable of self deployment and extraction of flow energy in the littorals, surf zones, and rivers with power level sufficient for reliable operations of typical sensors and systems deployed in such environments for surveillance and environmental monitoring.

PHASE I: Specific design concepts of energy extraction, self-deployment, power generation, and interface to

existing underwater systems to achieve the objective requirements should be proposed along with an integrated system design. Component level and system level modeling and analyses are to be conducted to justify the proposed design and system integration. The design analyses should focus on feasibility of any new proposed concept of component and integration for higher overall system performance particularly in various adverse environmental conditions such as storms or river flooding. Risk analysis in both component and system levels are to be conducted to identify high risk subsystems and appropriate risk mitigation strategies are to be developed for Phase II.

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

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

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Commercial production and distribution of self-deployed energy harvesting system parallels Navy interests. Primary applications in the near-term will address environmental baselining, monitoring, and change detection seasonally and in response to incremental or episodic events. Communities, ports, and resource management entities are likely the first customers, and their requirements for endurance, affordability, and maintainability will be similar to the Navy requirements.

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KEYWORDS: energy harvesting; unmanned underwater vehicle; underwater sensor; extraction; hydrodynamic energy; self-deployed

TPOC: David Han  
Phone: (703)696-4299  
Fax:  
Email: david.k.han@navy.mil  
2nd TPOC: Thomas Drake  
Phone: (703)696-1206  
Fax:  
Email: tom.drake@navy.mil  
3rd TPOC: Kevin Williams  
Phone: (703)696-4525  
Fax:  
Email: kevin.l.williams9@navy.mil

N111-073

TITLE: Advanced Instrumentation and Non-Destructive Evaluation for Composite Structures

TECHNOLOGY AREAS: Materials/Processes, Sensors, Weapons

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

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

OBJECTIVE: Develop non-destructive instrumentation for composite materials to enable structural health monitoring and advanced diagnostics.

DESCRIPTION: The US Navy is pursuing the development of an electromagnetic launcher (also known as a rail gun) 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 through the other rail. The armature is accelerated down the barrel due to the interaction between this magnetic field and current flow (Lorentz Force). An electromagnetic rail gun (EMRG) system will accelerate projectiles to hypersonic speeds, enabling ranges beyond 200 NM in less than 6 minutes of flight time while traversing the atmospheric spectrum (endo-exo-endo). The EMRG can address time-critical targets with a rate-of-fire of 6 to 10 rounds per minute while residual energy at target impact provides lethal effects.

One of the major design challenges associated with electromagnetic launchers is the need for a containment structure around the electrically conductive rails that can maintain the positioning of the launcher components even under the high electromagnetic forces and extreme tribological conditions associated with a launch event. Historically, these containment structures have been very large and heavy and have therefore posed an impediment to the operational utility of railguns. As a result, the Navy is developing new containment designs that utilize composite materials to significantly reduce the footprint of the containment while offering similar or improved performance relative to traditional designs. Composite materials, however, are not always compatible with existing diagnostic instrumentation and therefore advanced instrumentation is needed to monitor the health of these materials and to measure properties such as strain and temperature.

Although they offer superior strength relative to metals, composite materials also have the potential for sudden catastrophic failure under high loads. Composites are structurally anisotropic and also combine different materials phases, which means that detection of flaws and damage is a difficult task. Shock, impact, and repeated stresses can cause a variety of different effects including cracking, delamination of adjacent layers, and breaking of fibers, all of which can significantly reduce the strength of the material. The additional complexity of composite materials as well as the wide variety of damage mechanisms means that existing instrumentation is often inadequate to detect defects, determine the impact of identified defects on lifetime, or determine the critical size of damage. This effort will develop instrumentation that can address these issues in the composite structures used in an EMRG. There are a variety of different composite types in use or being considered for use in EMRG applications with thicknesses up to two inches, and any instrumentation must be compatible with these material types.

For railgun applications, the most critical diagnostic need for composite materials is non-destructive methods for evaluating the structural health of the containment before, during, and after a launch event. This capability must be able to detect damage or emerging defects in order to determine the safety of the containment structure on a shot to shot basis. In order to meet this requirement, the instrumentation must be able to detect all critical damage mechanisms in real-time and must be able to do so without the need to make any modification to parts of the EMRG after each shot. In addition, the structural health monitoring instrumentation must provide data required to predict the lifetime of launchers without the need to test them to failure through actual launch events. The instrumentation should provide quantitative data (location, defect size, etc) on the presence of any flaws (to include cracking, delamination, and broken fibers) in the composite structure prior to use as well as the evolution or emergence of such flaws during operation of the launcher. It is anticipated that eventually hundreds of shots will be fired using instrumented launchers to obtain the data required to predict lifespan.

In addition to structural health monitoring, there is also a need to characterize the thermal behavior of launchers that use composite containments. For EMRG applications that have higher firing rates (multiple shots per minute) there will be a large amount of thermal energy that must be dissipated from the launcher. The ability to obtain spatially-resolved temperature measurements from the rail/armature interface to the outside of the containment will provide the data required to understand these issues and evaluate potential solutions. Any temperature sensing technique must be non-intrusive and not susceptible to the high EMI conditions that occur during launcher operation. In addition, the sensors must be able to accommodate a very wide range of temperatures as the launcher may be near room temperature on its exterior and can be as high as 1200° C (or higher) at the rail/armature interface. Spatial resolution should be sufficient to provide accurate localization data for all temperature measurements and should also provide adequate sampling over the entire launcher to map the temperature profile as a function of time. Temporal response should be adequate to provide real-time temperature data during a shot and would ideally be at least 1 MHz to provide a capability to capture dynamic temperature events.

There are a number of different technologies that could potentially be used for this application, including ultrasonic inspection, eddy-current testing, acoustic emissions, laser ultrasonics, vibration analysis, and radiography. The awardee is encouraged to explore innovative technologies in these categories or others not listed in order to address one or more of the areas above. All proposed techniques must be capable of surviving the EMRG environment, which includes extreme electromagnetic fields, electrical currents, temperatures, and mechanical stresses. The approach must also be non-intrusive, not require modifications to the launcher beyond initial sensor installation, and must not involve any destructive testing. It must be noted that the 10m continuous composite overwrap structure will have two axial, large conducting metal rails internally which may enhance or prevent certain diagnostic techniques relative to signal penetration and/or interference.

**PHASE I:** Investigate sensor technologies that will provide the necessary capability to characterize the behavior of composite structures for electromagnetic launchers. Conduct bench-top tests of promising technologies to demonstrate their suitability for rail gun applications and ability to meet the requirements outlined above and identify any scaling issues that would be addressed during the transition to full scale testing. The outcome should be instrumentation that shows strong potential applicability to composite EMRG applications.

**PHASE II:** Design and fabricate prototype devices and test using a composite electromagnetic launcher or in another environment that replicates the EMRG environment. The outcome should be at least one device that has demonstrated compliance with the requirements above and that shows promise for full-scale testing in an EMRG. A design study should be performed to show the robustness of the concept in the full-scale EMRG environment that is outlined above. The results of testing may be classified.

**PHASE III:** Incorporate the instrumentation into an existing full-scale composite launcher. Perform open-range measurements using the existing launcher to demonstrate the capability developed complies with the requirements for composite diagnostics. The EM gun may be available as a government furnished test asset or through a teaming relationship with other EM gun test sites. If successful, work with Navy contractors to incorporate the instrumentation into advanced composite launcher concepts being developed by industry. If necessary, modify design to allow for use in an at-sea environment to enable transition to PEO IWS, PMS 405, ONR Program Office and integration with industry launcher manufacturers' production weapon systems that will be sent to the fleet.

**PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:** The techniques that are developed could have application for a number of different commercial technologies that utilize composite materials. Because of their performance advantages and reduced weight, composites are increasingly being used for a variety of applications, especially in the transportation sector where future aircraft and automobile designs are comprised of high percentages of composites to reduce weight. As a result, sensor technologies that provide health monitoring and diagnostic capabilities for composites may also be used in the automotive and aviation industry for safety monitoring and non-destructive evaluation as well as for any structural diagnostic requiring high frequency response. The ability to predict structural failures and monitor critical system parameters such as temperature is an equally important capability for commercial applications as it is for Navy purposes.

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KEYWORDS: Electromagnetic launcher; railgun; composites; non-destructive evaluation; temperature

TPOC: Ryan Hoffman  
Phone: 703-696-3873  
Fax:  
Email: ryan.hoffman@navy.mil  
2nd TPOC: Roger Ellis  
Phone: (703)696-9504  
Fax:  
Email: roger.ellis@navy.mil  
3rd TPOC: Edgar (Willis) Lacy  
Phone: (540)653-3140  
Fax:  
Email: willis.lacy@navy.mil  
4th TPOC: Eric Wuchina  
Phone: (301)227-3949  
Fax: (301)227-4732  
Email: eric.wuchina@navy.mil

N111-074

TITLE: Flexible Cooled Power Conductors for Electromagnetic Railguns

TECHNOLOGY AREAS: Materials/Processes, Electronics, Weapons

ACQUISITION PROGRAM: Office of Naval Research Code 352: Electromagnetic Railgun (EMRG) INP

OBJECTIVE: Develop a flexible, compact cable or conductor capable of handling the repetitive, high magnitude, high transient, pulsed loading and flexing service required by a Naval Electromagnetic Railgun (EMRG).

DESCRIPTION: The US Navy is pursuing the development of an electromagnetic railgun for long range naval surface fire support. An electromagnetic railgun consists of two parallel electrical conductors, called rails, and a moving element, called the armature. Very high current (~5-6 mega-amperes) is passed down one rail, through the armature, and back through the other rail. The armature is accelerated down the barrel due to the interaction between this magnetic field and current flow (Lorentz Force). An electromagnetic rail gun (EMRG) system will accelerate projectiles to hypersonic speeds, enabling ranges beyond 200 NM in less than 6 minutes of flight time while traversing the atmospheric spectrum (endo-exo-endo). The EMRG can address time-critical targets with a rate-of-fire of 6 to 12 rounds per minute while residual energy at target impact provides lethal effects.

A flexible power connection at the railgun breech is required to accommodate launcher recoil and train and elevate motions. This connection must deliver ~5- 6 mega-amperes (MA) for 8-10 ms to the launcher at a repetition rate of 6 to 12 pulses per minute. The cable/conductor should be compact due to the limited volume near the launcher and due the limited surface area for electrical connections at the launcher. Because a compact conductor will have less cross-sectional area, significant heating is expected and a means to reduce or mitigate this heating will be required.

The required high voltage insulation further impedes the removal of heat. The cable/conductor must also contain the magnetic fields generated within the cable/conductor and withstand the associated electro-magnetic forces between conductors.

Because high current is present throughout the EMRG pulsed power system, this conductor may have use in other parts of the system.

PHASE I: Develop a flexible power conductor design that meets the Naval EMRG requirements and substantiate the design through analysis, simulations and scaled testing as appropriate. Demonstrate how the proposed technology could scale up to current and power levels required for a full scale EMRG.

PHASE II: Fabricate representative section of full-scale design and demonstrate operation. Deliver representative conductors to the Navy for integration and testing in prototype EMRG pulsed power systems.

PHASE III: Design and deliver a complete conductor system for integration into and EMRG prototype, and ultimately, into a high repetition rate shipboard or land-based test site EMRG system.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: This type of conductor is applicable to any commercial process that requires continuous-duty high-power transfer that is coupled with mechanical movement or commercial systems that suffer from excessive conductor heating but require compact conductors.

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KEYWORDS: Electromagnetic launcher; railgun; cable; high power; flexible; conductor; pulsed power

TPOC: Ryan Hoffman  
Phone:  
Fax: (703)696-3873  
Email: ryan.hoffman@navy.mil  
2nd TPOC: Steven Swindler  
Phone: (215)897-8384  
Fax: (215)897-8380  
Email: steven.swindler1@navy.mil  
3rd TPOC: Jack Bernardes  
Phone: (540)653-8028  
Fax:  
Email: jack.bernardes@navy.mil  
4th TPOC: Roger Ellis

Phone: (703)696-9504  
Fax:  
Email: roger.ellis@navy.mil

N111-075

TITLE: Engineering Sensors for Towed Array Reliability

TECHNOLOGY AREAS: Information Systems, Sensors

ACQUISITION PROGRAM: Submarine Acoustics Program, PMS 401, PEO Subs, ACAT II

OBJECTIVE: Develop engineering sensors to be used in thin-line submarine towed arrays to provide enhanced real-time PMFL capabilities to mitigate operational circumstances that lead to failures as well as to localize and diagnose the underlying causes of failures should they occur, to monitor the performance of the towed array handling system through measurements of its interactions with the array, and to define and prioritize tradeoffs between competing cost and array and handler performance issues.

DESCRIPTION: Towed arrays, particularly submarine thin-line towed arrays, are subjected to harsh forces during both handling and tactical operations. Towed array reliability demands an objective systems engineering approach that monitors towed array health during all modes of operation, including specifically handling. The advent of modern data networks has made it possible to perform sophisticated real time performance monitoring and fault localization (PMFL) on the basis of data from specifically designed engineering sensors as well from the tactical acoustic sensors. The analysis of those data can be used to support the adaptive reconfiguration of the data network in the event of failure detection, to more narrowly localize and diagnose a failure within the array, as well as to potentially provide clear evidence of the underlying cause(s) of the failure.

This topic seeks engineering sensors for thin-line submarine towed arrays which provide objective information, ideally actionable in real-time via a complementary PMFL capability, with which to monitor the health of the towed array handling system, the health of the towed array data network during all modes of operation, to monitor dynamically the effects attributable to submarine operations on towed array parameters known to correlate with risk of towed array failure, to detect and localize array failures.

PHASE I: Determine the feasibility of one or more candidate engineering sensors for thin-line submarine towed arrays to provide objective information, ideally actionable in real-time via a complementary PMFL capability, with which to monitor the health of the towed array handling system, the health of the towed array data network during all modes of operation, to monitor dynamically the effects attributable to submarine operations on towed array parameters known to correlate with risk of towed array failure, to detect and localize array failures. Specify data and data band width requirements as well as methods by which a subsequent Phase II demonstration would validate the technical performance of the proposed engineering sensor(s).

Outline a business case analysis process for use in a Phase II justification for implementation of any proposed engineering sensor and/or PMFL capability in an instrumented towed array segment. Include an outline for a functional description of any proposed complementary PMFL routines.

PHASE II: Produce and deliver prototype engineering sensor hardware and/or PMFL analysis software based on Phase I work for subsequent integration to an instrumented thin-towed array segment. (Obviously the density of sea water defines an upper bound on the average density allowed for a submarine towed array. A specific gravity of 1.0 or less for the sensor is then desirable.)

Those sensors are expected to be compatible with the engineering sensor telemetry low level telemetry node interface specification which will be selected for use the Submarine Thin-line Vector Sensor Towed Array (VSTA) Future Naval Capability (FNC) project. (That interface description, which will subsequently be specifically defined, is expected to be representative of a modern telecom data network standard.) Develop and validate the requisite complementary PMFL capability necessary to demonstrate the utility of the engineering sensor hardware in an instrumented towed array segment.

PHASE III: The expected Phase III effort should be expected to be for delivery of engineering sensor kits based upon the Phase II product suitable to the instrumentation of a thin-line array comprised of a number of segments up the number of segments used in a TB-29(A).

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The proposed engineering sensors and methods might be applicable to real time monitoring of distributed sensor networks using physical network cables. Towed arrays used in geoaoustic applications (oil exploration for example) might benefit from such capabilities.

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KEYWORDS: reliability, maintainability, telemetry, network, towed, array

TPOC: Charles Traweek  
Phone: (703)696-4112  
Fax: (703)696-2007  
Email: mike.traweek@navy.mil  
2nd TPOC: William Bankhead  
Phone: (202)781-1514  
Fax:  
Email: William.P.Bankhead@navy.mil

N111-076 TITLE: Piezoelectric Single Crystal Property Assessment for Cost-Effective Optimized Naval SONAR Transducers

TECHNOLOGY AREAS: Materials/Processes, Sensors, Weapons

ACQUISITION PROGRAM: PMS 415 Undersea Defensive Warfare Systems: Next Generation Countermeasure

OBJECTIVE: Develop experimental methods and evaluate the linear and non-linear electromechanical properties of relaxor piezoelectric crystals under temperature-stress-field conditions relevant to naval SONAR systems. The domain of phase stability and property linearity for first generation binary, second generation ternary, and third generation doped materials should be assessed to optimize naval SONAR transducer designs.

DESCRIPTION: More than a decade ago a class of materials (relaxor piezoelectric single crystals) came to the fore whose electromechanical transduction properties greatly exceeded those of legacy materials (primarily, piezoelectric ceramics): electromechanical coupling greater than 90% (versus 70-75%) and strain levels greater than 1% (versus, less than 0.1%) [References 1 and 2]. Based on these materials acoustic transducers have been demonstrated with dramatically enhanced performance over what is achievable with the legacy technology --- for example, increased bandwidth (>x2), source level (+12 dB), sensitivity (+12 dB), compactness (>x3) and lightness (>x2) [Reference 3]. These device performance gains (totaling one to two orders of magnitude) have yielded gains, at the system level, of factors of two to six [Reference 4]. Indeed, the PiezoCrystal transducer technology makes possible some systems that simply would not be practical with the legacy technology. Navy SONAR systems have already completed the technology development and demonstration phase and are entering the system development and demonstration phase of the acquisition process. The materials technology has undergone similar evolution. The initial binary compositions (for example, Lead Magnesium Niobate - Lead Titanate) have been supplemented with ternary compositions (for example, Lead Magnesium Niobate - Lead Indium Niobate - Lead Titanate) with expanded temperature-field-stress operating domain and with doped compositions with specific properties enhanced (for example, Manganese doping yielding reduced mechanical losses under high drive). A PiezoCrystals Standards Committee is actively drafting a set of material specifications for ratification through the IEEE as international standards for composition/properties; materials with the delineated compositions/properties will ultimately dominate



the market. Work under this topic will characterize the linear and non-linear electromechanical properties of a broad range of materials compositions under a broad range of temperature-field-stress conditions to delineate the composition/properties that optimize a variety of naval SONAR transducers.

**PHASE I:** Identify a targeted naval SONAR transducer application and select one material composition for assessment. Devise an experimental procedure and evaluate that compositions' linear and non-linear electromechanical properties under a reasonable spectrum of thermal-electrical-mechanical boundary conditions. Assess the suitability of the selected composition for the targeted application. Only materials characterization is to be performed in this phase -- no transducer fabrication and testing.

**PHASE II:** Two thrusts are to be developed in parallel. In the first the Phase I activities will be expanded: additional experimental measurement techniques will be developed; additional materials compositions will be evaluated and additional SONAR applications will be targeted; the materials properties emerging from these measurements will be contributed to the PiezoCrystals Standards Committee to ensure that the materials compositions/properties delineated by those standards are serviceable for naval SONAR transducer applications. In the second thrust a linkage will be established with a single specific naval SONAR transducer development effort and materials assessments performed in support of those development efforts (a limited amount of transducer fabrication and evaluation may be performed under this topic in this phase to validate the utility of the materials characterization work).

**PHASE III:** The characterization methods developed by this research will be applied to new PiezoCrystal compositions as they emerge and applied in development and production of PiezoCrystal transducers for a broad spectrum of Navy SONAR systems: countermeasures, mine hunting, torpedoes, acoustic modems, towed arrays, moored arrays, sonobuoys, and the like.

**PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:** The technology developed for defense transducers will be immediately applicable to transducers in civilian SONAR systems. These property assessments will be readily transferred to making electromechanical sensors and actuators for a broad spectrum of civilian applications ranging from hydraulic servo valves, through vibration energy harvesters, to robotic manipulators.

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**KEYWORDS:** piezoelectric single crystals; optimized SONAR transducers; linear materials properties; non-linear materials properties; materials phase stability; temperature-field-stress dependence of materials properties

TPOC: Wallace Smith  
Phone: (703)696-0284  
Fax: (703)696-0934  
Email: wallace.smith1@navy.mil  
2nd TPOC: Ming-Jen Pan  
Phone: (703)696-7021  
Fax: (703)696-0934  
Email: panm@onr.navy.mil  
3rd TPOC: Carl Wu

Phone: (703)696-0689  
Fax: (703)696-0934  
Email: wucarlc@onr.navy.mil  
4th TPOC: Teresa McMullen  
Phone: (703)696-0789  
Fax: (703)696-4409  
Email: teresa.mcmullen@navy.mil

N111-077

TITLE: Rapid Part Qualification Methodology of Aircraft Metallic Components using Direct Digital Manufacturing Technologies

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: PMA-265

OBJECTIVE: Develop the methodology, models, and analytical tools, required to rapidly and inexpensively qualify metallic aircraft components produced using DDM. Reduce the time and cost associated with individually qualifying aircraft parts by developing a streamlined approach to the certification wide variety of metallic DDM parts.

DESCRIPTION: Direct digital manufacturing (DDM) is very attractive because it reduces part cost, reduces the energy content of parts, and increases the operational availability of navy aircraft. Part acquisition time can be reduced from 6-12 months for long-lead time items or out-of production part to less than 24 hours. Energy and machining cost are significantly reduced because no tooling is required to produce DDM parts, and part machining is virtually eliminated. Consider that the buy-to-fly ration on a conventionally produced titanium part is 10 to 20:1, whereas for DDM, the buy-to-fly ratio approaches 1:1.

However, in order to fully realize these benefits, DDM technology needs to be certified for the fabrication of a wide range of metallic parts having diverse geometries. Presently, in order to ensure air worthiness, each type of part must pass a lengthy and costly certification process [1]. This significantly impacts the Navy's ability to use DDM to produce parts-on-demand.

It is proposed that a new innovative method be developed for part certification using a heuristic and adaptive approach combined with non-destructive inspection, and limited mechanical property tests. It is envisioned that an aircraft component to be composed of several building blocks of simple 3-dimensional geometric shapes, such as cuboids, cones, spheres, prisms and so on. These representative geometric elements of a component could be fabricated using DDM, analyzed and tested for defects and mechanical properties. The statistics of test results of the building blocks could be fused in a qualification algorithm and used to establish the basis for qualifying additional parts.

PHASE I: Develop and demonstrate the feasibility of a rapid and low cost approach to metallic DDM aircraft part qualification.

PHASE II: Develop and demonstrate a prototype (the methodology, models, and qualification algorithm) required to rapidly qualify metallic DDM components of varying shape and size.

PHASE III: These tools and methods could be used to qualify a broad range of metallic DDM parts for military and civilian applications.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The qualification algorithm along with the database of test results for the building blocks of various geometric shapes and sizes will be a marketable tool. It will be tied to the particular DDM process used and can be marketed to all private and public sector industries for rapid qualification of parts.

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KEYWORDS: Direct Digital Manufacturing, Qualification, Prototype, Certification, Heuristic, Adaptive, NDI

TPOC: Malinda Pagett  
Phone: (703)588-1047  
Fax: (703)696-4274  
Email: malinda.pagett@navy.mil  
2nd TPOC: William Frazier  
Phone: (301)342-8003  
Fax:  
Email: william.frazier@navy.mil

N111-078 TITLE: Exhaust Heat Recovery Heat Exchanger

TECHNOLOGY AREAS: Ground/Sea Vehicles

ACQUISITION PROGRAM: PMS 320 Electric Ships Office

OBJECTIVE: Develop and demonstrate durable, long-life heat exchangers suitable for recovering waste heat from highly transient exhaust combustion air ranging in temperature from 500 to 1200 °F.

DESCRIPTION: Typical gas turbine engines are less than 40% efficient at full power and significantly less at part power. Diesel engine efficiency is more uniform across its operating power range but top efficiency does not typically exceed 45%. The engine exhaust stream is the primary pathway of engine waste heat. Recovering useful energy from engine exhaust waste heat will directly reduce system fuel consumption and increase overall system efficiency. Previous U.S. Navy efforts have shown promise in recovering engine exhaust waste heat in the interest of saving fuel, but reliability issues with the heat exchanger design have prevented implementation. The heat exchanger is subjected to high thermo-mechanical stresses due to highly transient engine loading profiles, which results in large temperature variations and non-uniform heat distributions within the exhaust stream. Corrosion and fouling are common issues when extracting heat from combustion air exhaust stream. If waste heat recovery systems are to be transitioned into the current or future fleet, development of durable, long-life heat exchanger is a necessary prerequisite.

Innovative research is sought to produce the next generation of exhaust to fluid heat exchangers capable of extracting at least half of the waste heat leaving the engine: The hot exhaust combustion air shall flow on the exterior of the heat exchanger and transfer heat to a non-aqueous fluid (eg. refrigerant) assumed to be entering the heat exchanger between 60 and 130 °F. Pressure drop shall be minimized on both the combustion air and fluid side of the heat exchanger. Face velocities of the combustion air stream entering the heat exchanger shall be designed for 5000 fpm. Pressure drop across the combustion air side of the heat exchanger shall be less than 4 inches of water. The heat exchanger design shall be capable of withstanding a temperature change from ambient conditions to 1200 °F within one minute. The heat exchanger design shall also be capable of withstanding a thermal shock when a non-aqueous fluid at 60 degrees Fahrenheit enters a 1200 °F heat exchanger. Weight and volume of the heat exchanger design shall be minimized.

PHASE I: Design a durable, long-life heat exchanger for recovering waste heat meeting the characteristics described above. Quantify the heat exchanger efficiency and pressure drop to transfer heat analytic modeling and component validation. The ability of the heat exchanger to withstand highly transient temperature variation, corrosion and fouling shall be addressed.

PHASE II: Develop and demonstrate a reduced scale heat exchanger prototype sized to transfer at least 250 KW of heat. The ability to withstand extreme temperature cycles shall be demonstrated. Validate analytic models

developed in Phase I and evaluate scalability of design to larger sizes.

PHASE III: Design and develop an improved heat exchanger using the knowledge gained during Phases I and II. This heat exchanger must meet military unique requirements such as shock and vibration. Develop a commercialization strategy for dual use.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The heat exchangers developed under this topic could be used to increase the efficiency of any vehicle relying on fuel combustion engines. The developed technology can be applied to many waste heat applications to improve energy efficiency.

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3. Marine Gas Oil, ASTM D-975 Grade No. 2-D.

KEYWORDS: Thermal Management; Heat Exchanger; Waste Heat Recovery; Gas Turbine

TPOC: Mark Spector  
Phone: (703)696-4449  
Fax: (703)696-0001  
Email: mark.spector@navy.mil  
2nd TPOC: Donald Hoffman  
Phone: (215)897-7304  
Fax:  
Email: donald.hoffman@navy.mil  
3rd TPOC: Carl Grala  
Phone: (215)897-8964  
Fax:  
Email: carl.grala@navy.mil

N111-079

TITLE: Flexible Assembly of Large Complex Structures via Friction-Stir Welding

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PMS 501 (LCS Program), PMS 325 (JHSV Program), PMS 377 (LHA (R))

OBJECTIVE: The objective of this project is to develop and demonstrate a robust, transportable system for the assembly and joining of large, complex structural aluminum components using friction-stir welding as the joining process. These assembly operations are situations where the use of large, stand-alone friction welding systems is physically impossible. Shipyards assemble the superstructures of lightweight ships from pre-fabricated stiffened aluminum panels. Sub-contractors construct these panels from aluminum strips, extruded profiles, et cetera, by linear friction-stir welding. Shipbuilders assemble these pre-fabricated panels using traditional arc welding techniques which leads to distortions, loss of strength in the weld-zone, and potentially introduces defects into the structure.

DESCRIPTION: The friction-stir welding process requires the application of relatively high forces to the structure. These joints are generally "out of position" in that they are not exactly vertical or horizontal along the outside of the structure. They are often in locations with limited accessibility, and since the structures require unique setups, this prohibits using large and complex fixtures to support the components during the joining process. Because of this, the joining process requires considerable adaptability and flexibility whilst maintaining carefully controlled joining conditions that remain in the acceptable processing window. This topic seeks innovative approaches to extend the applicability of friction stir welding beyond the standard linear friction stir welding capability for the pre-fabrication

of stiffened aluminum panels. The scientific and engineering solutions to enable “out-of-position” friction stir welding capability during assembly, erection, and repair of structural sub-components in shipbuilding must address the essential design elements for broad applications, adaptability to various assembly scenarios, and maximum accessibility (that is a combination of transportability and reach and access). They must address the essential control elements for set-up and manipulation, and the ability to react welding forces induced during the process. They must also address essential welding elements to produce consistently and reliably sound welds in marine structures for the materials, applications and assembly scenarios previously identified.

PHASE I: In the phase I effort, the investigators should define operating conditions required for friction-stir welding of components. These will include the orientation of the tool, the positioning of the welding head, estimation of position tolerances allowable, and the forces expected during the operation. The investigators will then design a welding system that is capable of meeting these requirements in a shipbuilding environment. Full success will be a concept of operations and preliminary drawings of the system, with specifications for many of the major components, for evaluation.

PHASE II: Develop and demonstrate a functional prototype system. Conduct testing in a shipyard environment to prove feasibility of the system for the application.

PHASE III: The immediate application of the developed system is to shipyards constructing lightweight, high-speed ships such as the LCS and the JHSV. A successful system may also be useful to shipyards constructing internal aluminum partitions of modules within combatants, such as the aluminum command-and-control spaces in the current-construction CVN. The system should also be applicable to the construction of lightweight ground vehicles.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The shipyards may apply this technology directly to commercial ship fabrication. In addition, this type of capability has significant non-shipbuilding potential. Industry could use a flexible joining capability for aluminum structures for the fabrication of trailers and rail cars. In specific, industry might use this technology for the fabrication of coal-cars and grain-cars, which carry bulk cargo. This technology is also applicable to the fabrication of bulk aluminum enclosures and storage containers. All of these are economically important industrial applications where reduced construction costs and increased durability lead to reduced life-cycle costs and improved competitiveness.

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KEYWORDS: Friction-stir welding; aluminum; shipbuilding; aluminum fabrication; robotics; automation.

TPOC: William Mullins  
Phone: (703)696-0487  
Fax:  
Email: william.m.mullins@navy.mil  
2nd TPOC: Maria Posada  
Phone: (301)227-5017  
Fax: (301)227-5576  
Email: maria.posada@navy.mil

N111-080

TITLE: Electric Field Tunable Multi-Ferroic Filters for C-band RF Applications

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

ACQUISITION PROGRAM: IMS (Integrated Warfare Systems - Radar component) TBD

OBJECTIVE: Develop and demonstrate electric field tunable multi-ferroic material based filters for C-band RF applications with state of the art tunability, loss and linearity.

DESCRIPTION: Modern RF electronics continually push the performance envelope for power, bandwidth, linearity and efficiency. With increasing bandwidth availability, signal selectivity in a sea of clutter becomes increasingly important. Tunable filters are used to increase the signal to noise ratio across a spectrum of desired frequencies. Semiconductor varactors are typically used with good results for these applications but are limited by loss and linearity above UHF. MEMS-based filters and YIG resonator filters are limited by tuning speed.

Multi-ferroic materials provide an appealing alternative tunable filter technology by combining the tunability of ferrite materials with voltage control and miniature size. Electric field tuning in devices based on multi-ferroic materials arises from the coupling of a ferroic material to a piezo-electric material. Recent demonstration of voltage tuning of a composite multi-ferroic ferrite-piezoelectric resonators is significant in this regard. When bilayers of yttrium iron garnet (YIG)-lead zirconate titanate (PZT) and YIG/lead magnesium niobate-lead titanate (PMN-PT) bilayers are subjected to an electric field, mechanical deformation in the piezoelectric produces a frequency shift in the magnetic response of the ferrite. Such electrical tuning is rapid, requires minimal power, and has the potential to be integrated in a hybrid manner with other circuits.

It can be expected that device improvements that build on existing experiments will lead to a laboratory demonstration of multi-ferroic filters exhibiting reasonable power handling and low insertion loss, in a compact, easily hybridized form. The goal of this program is to utilize multi-ferroic devices in C-Band (5-7 GHz) filter devices. Successful proposals will support a fully connectorized filter demonstration with the following characteristics: a 3rd-order Chebychev bandpass filter shape, a tuning range > 33% (5-7 GHz), a fractional 3-dB bandwidth < 10%, a passband insertion loss < 3 dB, IIP3 > 40 dBm, P1dB: > 20 dBm, and tuning speed < 10  $\mu$ s.

PHASE I: Demonstrate, using test results of the performance of suitable multi-ferroic devices, that the filter along with its required dc magnetic field bias having the specifications listed in the description above may be successfully fabricated in a multi-functional based planar technology.

PHASE II: Fabricate, test, and deliver two multi-ferroic filters in a conventional connectorized microwave fixture, with integrated planar dc magnetic bias, meeting the specifications of Phase I, along with a compatible control interface suitable for laboratory demonstration.

PHASE III: Target industrial partners for technology transition with potential integration into one or more Navy systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The proposed technology is expected to result in a high level of interest in these circuits for current and future generation electronic warfare and radar systems.

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KEYWORDS: multi-ferroic; filter; ferrite; piezoelectric; electronic warfare; tunable

TPOC: Daniel Green  
Phone: (703)696-4220  
Fax:  
Email: daniel.s.green1@navy.mil  
2nd TPOC: Andrew C. Guyette  
Phone: (202)404-4606  
Fax:  
Email: aguyette@ccs.nrl.navy.mil

N111-081

TITLE: Stealth and Real-time Program Execution Monitoring

TECHNOLOGY AREAS: Information Systems

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

OBJECTIVE: Develop a data acquisition subsystem for a stealthy, fine grained active program execution monitoring system for modern computing system, and real-time embedded systems, with minimal implementation impact in term of monitored event's latency and overall system load.

DESCRIPTION: Achieving information dominance requires The Navy to provide information assurance within its information infrastructures. COTS based hardware and software in our computing systems and the network are large, complex and hence inherently insecure. These insecure systems are vulnerable to breaches that take advantage of the architecture, protocol and implementation weaknesses and flaws. Execution monitoring system capable of observing the behavior and state of the system components and applications can be used to enhance the system's security. A stealthy and comprehensive monitoring system stands the best chance in dealing with intelligent adversarial intrusions.

Essential to this system is a data acquisition subsystem, to bring out the internal states of a process at a fine granularity, in real-time. One of the approach often used in this case is based on virtual machine technology [1][2]. However, the use of virtual machine monitoring approach is inherently not stealthy [3]. Other approach based on program instrumentation via binary re-write [4], may generate an even higher load. Techniques such as dynamic taint analysis [4], System call monitoring [2], dynamic information flow tracking [5], automaton [6], are proposed for detecting security breaches. Each of them has their own advantages, weaknesses and costs. Each of them by itself may not provide comprehensive vulnerability coverage. It is desirable to have a data acquisition subsystem which can support a set of selected intrusion detection techniques for providing comprehensive vulnerability coverage, while maintaining low additional latency and system load, and hence undetectable by the adversarial intruders. Said subsystem can be build as hardware assisted approach or software only approach. Said real time and stealthy data acquisition subsystem provides a solid foundation on which an intelligent self-aware system can be developed.

PHASE I: Develop overall system design that includes specification for the real-time data acquisition subsystem, which has coverage over the entire system (not a particular application only), with relatively modest overhead of twenty-five percent or less, targeted toward general purpose and/or embedded computing environment. Identified a set of potential intrusion detection techniques it can support for detecting a comprehensive set of cyber attack-vectors/vulnerabilities [7], such as buffer overflow, stack & heap overflows, insufficient input validation, file

descriptor attack, symbolic link, etc.

PHASE II: Develop and demonstrate a prototype system in a realistic environment. Conduct testing to prove that the subsystem can provide supports for the proposed set of detection techniques, and to prove that the system introduce low overhead, in term of latency and system load, and hence is stealthy.

PHASE III: Integrate into a broad range of information security products within the military. The technologies developed in this SBIR will especially be beneficial in a system where adversarial intrusions can be expected.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: This system could be used in a broad range of information security products within the military, as well as in civilian enterprise applications.

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KEYWORDS: Execution monitoring, active-monitoring, virtual machine, hardware assist, event detection, malware

TPOC: Sukarno Mertoguno  
Phone: (703)696-0107  
Fax:  
Email: sukarno.mertoguno@navy.mil  
2nd TPOC: Ralph Wachter  
Phone: (703)696-4304  
Fax: (703)696-2611  
Email: Ralph.Wachter@NAVY.MIL

N111-082 TITLE: Combined spectral management/ satellite receiver modem

TECHNOLOGY AREAS: Air Platform, Information Systems, Sensors, Electronics

ACQUISITION PROGRAM: PMA290

RESTRICTION ON PERFORMANCE BY FOREIGN CITIZENS (i.e., those holding non-U.S. Passports): This topic is "ITAR Restricted." The information and materials provided pursuant to or resulting from this topic are



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

**OBJECTIVE:** The objective is to construct a software defined receiver that coherently captures many simultaneous signals in 1 GHz of bandwidth around 20.7 GHz produced by as many as 8 separate but abutting transmit elements having noise floors potentially differing by >10 dB. DSP software provided must be able simultaneously to separate this IBW into software selectable depth FFT displays of the 8 transponders and into up to 100 arbitrarily centered signals having individual IBW of from 250 kHz to 500 MHz. Demodulation software for 10 commonly used waveforms should also be provided and selectable with minimum delay at the time of execution or via a canned script. In addition, the ability to record all the data in real time is desirable and to record the demodulated signal subsets is essential. All these features should be able to run in real time. The abilities to receive simultaneously other SatCom bands, e.g. 7.25-7.75GHz, and inclusion of compatible software to detect intruding users and adaptively remove interfering signals are desirable.

**DESCRIPTION:** The purpose of this topic is to construct a single software defined receiver system that can be used to monitor satellite operations and also act as a multi-band terminal and intruder detector. While the emphasis is on a versatile set of modem related software, it is essential that the entire effort also achieve functional connection between this back-end and the RF front end that can support the wideband and coherent reception requirements without disfunctional loss of SNR. Innovations that reduce system complexity are desirable. Experience with direct reception receivers and oversampled data, if any, should be mentioned.

**PHASE I:** The phase 1 proposal should clearly identify the notional system architecture to be pursued, describe the software to be provided by the end of phase 2, and provide evidence of the vendor's ability to deliver the intended functionality, including definition of the RF front end to be used. During phase 1 this architecture will be further elaborated and a demonstration performed of processing and displaying example data from an existing vendor or government defined RF front end system

**PHASE II:** During base and first option periods of the phase 2 the vendor should finalize choice of a front end, construct a unified front and backend system and demonstrate the desired range of operations to a government audience. The second option should extend the operation to more simultaneous bands, more rapid identification of and functional alteration to changing waveforms, and/or better intrusion detection/removal software. Inclusion of the last would likely cause this option to be a classified effort.

**PHASE III:** During the phase 3 the combined system would be incorporated into government network management systems, SDR based communications systems, and collection systems.

**PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:** The need by the commercial SatCom industry to detect and defeat intruders was illustrated by the blatant pirating of satellite capacity in Asia and the need to balance traffic loads among the satellite amplifiers is also not unique to military systems. The provision of multiple waveforms will allow system customization to many different satellite bands. In addition, the intruder detection software could also be used by commercial wireless telecom companies to detect signals underlying the spectrum owner's signals if they excessively raise the noise floor and in cognitive systems to detect the need to move to a different channel.

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2. <http://www.glowlink.com/technologies.html>
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4. [http://en.wikipedia.org/wiki/Satellite\\_modem](http://en.wikipedia.org/wiki/Satellite_modem)

KEYWORDS: SatCom; Software Defined Receivers; GUI; wideband RF; intruder detection; Cognitive radio

TPOC: Deborah Van Vechten  
Phone: (703)696-4219  
Fax:  
Email: vanvecd@onr.navy.mil  
2nd TPOC: Chris Lichtenberg  
Phone: (760)939-4516  
Fax: (760)939-4515  
Email: chris.lichtenberg@navy.mil

N111-083

TITLE: Network Sensor to Geolocate Cyber Attacks and Framework

TECHNOLOGY AREAS: Information Systems, Battlespace

ACQUISITION PROGRAM: JPEO JTRS ACAT ID

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

OBJECTIVE: To develop sensor-based network defense architecture for the implementation of next generation cyber security algorithms. Two concrete objectives will be pursued: (1) implementation of algorithms to detect highly distributed, stealth cyber-attacks and their geolocation on a world map and (2) provisioning of a practical and scalable framework for future implementation of state-of-the-art cyber security algorithms.

DESCRIPTION: Navy systems (sea, air, ground and space) are increasingly integrated in IP-based global networks that are under intense attack by sophisticated adversaries. In a conflict, this attack would be expected to intensify. There are numerous documented intrusions to Navy, DOD, government and private computer systems illustrating that the problem at this point is not keeping intruders and attackers out at the borders, but rather a constant and proactive defense through the entire network.

An example of a highly distributed, stealth cyber-attack is botnet attack. The technology could detect botnet attacks by gathering information that may come from distributed sensors; the technology should then be able to geolocate the worldwide source of active botnets attacking a specific US target onto a dynamic world map. The technology should also be able to detect which types of such activities are likely to be malicious and which are likely to be benevolent (e.g., flash crowds activities), while minimizing as much as possible the presence of false positives and negatives. The framework should provide for the future detection of a potentially large and evolving family of highly distributed attacks (known or unknown today) and name what such attacks could be. Investigation and development of such attacks and their detection algorithms is also part of the topic objective.

While this topic encourages novel solutions, examples of state-of-the-art algorithms can also be found in recent scientific publications. For instance, [FAN10] presents a new algorithm to detect botnets that are highly distributed and stealth; it is the objective of this topic to design and implement a framework that allows for the implementation of such type of algorithms in a convenient, robust and scalable manner.

PHASE I: Design a concept that manages large amounts of recorded information and presents the results in a real-time and concise manner. Identify (1) methods to efficiently extract key features from network traffic for the analysis of cyber security incidents, (2) methods to efficiently store large amounts of historical information obtained from the network and (3) algorithms to process such data and provide intelligence to network managers and decision

making agents.

A preference will be given to proposed technologies that build on existing frameworks. An example of a framework is provided by BRO—the powerful network analyzer developed by ICIR [VER99].

The outcome of Phase I will be architecture and a preliminary prototype demonstrating the feasibility of the design at a small scale.

**PHASE II:** Demonstrate state-of-the-art algorithms that can detect and protect against highly distributed, low frequency stealth attacks [GIR09, FAN10] using the proposed framework. Such package will be capable of geolocating the attacks and present them in a multi-resolution world map that network managers and decision making agents will be able to use. The outcome of Phase II will be a full implementation of the design and prototype delivered in Phase I, providing technology that can be tested in a real-life environment. Of special interest are technologies that can be integrated using COTS/GOTS.

**PHASE III:** Phase III will seek to receive feedback from the real-life tests of the technology, tune the technology to satisfy the potential customers, and commercialize the technology. Special interest will be put into dual-use applications, by targeting both government and industrial/consumer uses. Examples of industrial/consumer applications that should be pursued include but are not limited to for-profit organizations responsible to manage large amounts of digital information such as cloud computing and Internet service providers.

**PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:** The proposed technology will enable communities of interest to develop and understand activity and behavior on their networks by increasing the fidelity of the networks.

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**KEYWORDS:** Cyber Networks, Cyber Security, BotNets, Cyber Defense, Network Analyzer

TPOC: John Thom  
Phone: (619)553-0727  
Fax: (619)553-0727  
Email: john.thom@navy.mil  
2nd TPOC: Alan Sweeney  
Phone: (619)524-0022  
Fax:  
Email: alan.sweeney@navy.mil

N111-084

TITLE: Virtual War Games

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

ACQUISITION PROGRAM: SPAWAR 05 Assessments and Experimentation

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

OBJECTIVE: The objective of this Small Business Innovation Research (SBIR) topic is to develop a virtual war game capability to provide more practice time and greater opportunity for the war fighter to exercise capability by augmenting table top games, experiments and exercise deployments. This effort will provide a useful complement to assessments with multiple platforms and many personnel that are costly and infrequent. Furthermore, a virtual game can provide for many more excursions and conditions and can involve more participants without travel and resources utilizing existing network resources. A virtual environment can simulate the objects of an exercise with remote access to network services to provide a 3D immersive environment. This effort will demonstrate the operational utility and effectiveness of virtual games.

DESCRIPTION: This solicitation will advance the conduct of war games and implement their execution in a virtual world, thus immensely broadening the scope and effectiveness of this important enterprise-wide activity. The virtual war game will simulate combatant platforms, systems, sensors, personnel (individual and/or groups) and fusion centers, and as such will include kinetic as well as non-kinetic engagement. The virtual war game will incorporate agent-based models for decision support, thus permitting examination of red and blue decisions and augmentation of real participants. The simulation shall provide for realistic communications by allocating resources (channel and bandwidth) between elements of the war game. Communications effects shall be considered that will include, but not be limited to, propagation channel effects, interference, terrain, geometry and network topology. The virtual game shall include federated models on the network, thus leveraging the variety and depth of simulation suites available in the DoD. The virtual simulation shall reflect realistic command and control and network operations that include decision support in non-ideal circumstances (e.g. ambiguity, conflict and capacity shortages).

The fundamental supporting technology exists in the commercial space but needs to be adapted for DoD applications in a DoD environment. Virtual gaming environments indeed exist but, aside from the choice of existing technology, R&D will be manifested in the added content, extensions and augmentation of the virtual technology. Much work is underway to provide immersive training through virtual environments. However, current work is on a small scale where this topic will show the feasibility on a much larger scale. Using and adapting a virtual environment to provide a representation of the command, control, communications, computer and intelligence (C4I) problem with full spectrum, complex and concurrent information operations with necessary fidelity is an R&D challenge. Realism and relevance is essential for war fighter value. Supporting a wide range of operations and scaling with transparency for all but military essential detail will be a challenge.

The objective of phase I is to provide an interactive and immersive virtual environment to demonstrate non-kinetic warfare and defensive operations with simulated objects and agents and real participants. The representation of the problem and design shall simulate realistic communications within the virtual world to effectively represent platforms, sensors, perception, fusion cells and kinetic engagement. Existing virtual environments will allow war fighters to access a virtual battle space but realism must be provided and, in fact, may require a federation with other models. Realistic physical properties, constraints and performance of communications between actual systems and personnel on platforms (moving and fixed), and operational protocols must be reflected. A red and blue common operating picture and status must be provided that perhaps provides a dashboard with attrition statistics and intent assessments. Clearly, innovation is required to place the war fighters in a virtual world that validates operational effectiveness. Operations shall be supported at all levels of a battle group with CONUS connectivity for realism at sensor operator, reach back support provider, commander, planner and decision maker levels.

The innovation is to develop the content and extensions for this new media and augmentation (e.g. federation) that

will effectively complement exercises and experiments to assess information dominance, i.e., effectiveness and vulnerability. Currently, assessments rely on real assets with limited objectives at great expense. Virtual technology will mitigate these limitations as is done in medicine, flight training and engineering. Participation in the virtual environment must require minimal participant training to provide a focus on operations.

**PHASE I:** Phase I shall develop a concept, design and architecture to achieve stated objectives and explore an implementation and a trade space to recommend solutions. The trade space must reveal a life cycle support plan, roadmap for growth and portability. The architecture should show the provisioning of a client-server topology for a secure network (DREN, SDREN or SIPRnet) to support a demonstration of operationally meaningful activities. The architecture shall provide a means of object reuse, rapid content development and maximum leverage to support broad virtual world operations. Phase I shall show that leverage of models and simulations across the network can be applied. The architecture shall support multiple geographically distributed red/blue players and perception management with neutral observer/controllers having ground truth maintenance. Phase I shall provide cost and scalability in the trade space.

**PHASE II:** Phase II shall build a limited prototype on a selected R&D and/or operational network and comply with certification and accreditation requirements. Prospective users and transition sponsors would play simple games with assistance. War games shall be conducted with geographically distributed players for selected scenarios that realize stated objectives.

A successful and transitionable Phase II effort will yield a virtual war gaming environment that will be of interest to the Naval War College (NWC) and other war gaming activities. DoD subject matter and modeling experts will advise with recent experience and might host the capability beyond phase I. Measures of Effectiveness (MOEs) for the game will be based upon such measurable parameters as follows

- Attrition/loss
- War fighting objective impact/effect
- Perception
- Behavior

The metrics for the gaming capability developed under this SBIR are as follows.

- Number of players and objects and types of objects (combatant platforms, sensors, fusion cells, weapons) participating in the virtual war game
- Extent of simulated geography and communications channels
- Accuracy of physics (size, velocity, force, time scaling, RF propagation, network loading and latency)
- Manageable fidelity for objective focus
- Results of evaluations/surveys/assessments distributed to participants
- Automated exercise monitoring with measures of performance and effectiveness
- Adaptation to feedback during a game

Leverage of existing venues for transition should be pursued to reduce development and supportability cost. [3], [4], [5] Extensibility shall be considered.

**PHASE III:** Phase III will implement capability at a larger scale for a virtual campaign with greater participation by the operational community. High performance environments will be leveraged as necessary and lessons from phase II will be captured for institutionalized (curriculum adapted) virtual experiments.

**PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS:** Private sector application will follow to support the infrastructure and develop additional objects and models for a broad range of operations. Data capture automation and reduction will inspire further development. Other industries such as training will naturally follow.

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[3] [www.secondlife.com](http://www.secondlife.com)

[4] <http://openwonderland.org/>

[5] [http://opensimulator.org/wiki/Main\\_Page](http://opensimulator.org/wiki/Main_Page)

Additional Resources:

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[7] IEEE-std-1730 Distributed Simulation Engineering and Execution Process (DSEEP)

[8] <http://www.xmlrpc.com/>

[9] IEEE-std-1278 Recommended Practice for Distributed Interactive Simulation

[10] [http://en.wikipedia.org/wiki/Virtual\\_world](http://en.wikipedia.org/wiki/Virtual_world) Virtual world

[11] <http://www.dodgamecommunity.com/> War games

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[14] IEEE-std-1517 Reusable Software

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KEYWORDS: virtual environment, wargames, experiments, models, simulations, information technology, perception, mission effectiveness, training, assessments

TPOC: Thomas Starai  
Phone: (301)669-2133  
Fax: 301-669-2117  
Email: [thomas.starai@navy.mil](mailto:thomas.starai@navy.mil)

N111-085 TITLE: Real-Time RF Channel Impairment Emulator

TECHNOLOGY AREAS: Information Systems, Sensors

ACQUISITION PROGRAM: JPEO JTRS ACAT I Airborne, Maritime, Fixed (AMF) Program

OBJECTIVE: Research and develop a multi-channel, programmable, scalable, and extensible RF-channel emulator that will enable laboratory verification of next-generation military and commercial radio and waveform capabilities by emulating a high-fidelity operationally-representative radio frequency environment for networks of 8 to 100 radio nodes.

DESCRIPTION: The Joint Tactical Radio System Program (JTRS) produces a family of multi-functional Software Defined Radio (SDR) communications systems operating within the 2 MHz to 2 GHz that provides the next generation of voice, video and data for Joint and Coalition Warfighter. A key goal of next-generation military and commercial protocols is to provide a means for greater spectral efficiency, reduced Inter-symbol Interference (ISI), resilience against interference, Multipath, and Doppler-shift distortions. Unlike legacy waveforms, newer Internet Protocol (IP) based protocols incorporate complex link adaptation algorithms that make spectrum and modulation decisions based on continuously-sensed link conditions. In order to measure their effectiveness, a real-time channel impairment high isolation emulator with extensive capabilities is required.

Existing Hardware in the loop (HWIL) channel emulators are geared towards fixed infrastructure architectures and do not provide support for Ultrawideband or wideband frequency agile mesh radio architectures. The current state of the art wideband channel emulators support 5kHz-125 Mhz bandwidths starting at 30-225Mhz and are geared for single protocol channel emulation for half duplex point to point satellite or terrestrial line of sight communications. This poses challenges for military communication protocols which, due to their extensive use of fast and slow frequency hopping spread spectrum algorithms, can span up to 255+ Mhz. This limitation also impacts research communities that are investigating frequency agile or Ultrawideband protocols (span over 500+ Mhz).

The ability to test a frequency agile mesh network requires a combinatorial channel count which based on existing wideband channel emulation technology would require tens to hundreds of devices for small radio counts (i.e 16 radio net could require 120 radios links) and would require a complex external RF interconnect infrastructure. The drawbacks of this approach is that isolation between emulated links would be impossible.

A key difference from commercially available emulators, is that the RF Channel Impairment emulators should be able to interconnect multiple RF channels (at a minimum 8 channels) for any given permutation of configurations. It should not be designed to work with a limited number of pre-programmed waveforms within these bands, since this limitation in commercial products is one of the drivers originating this SBIR. Unlike existing channel emulators, solutions produced herein would require significant research efforts in parallel computation and effective resource partitioning to develop an architecture that can manipulate a multitude of independent channels and recombine these channels into logically distinct networks. The goal of this system is to support channel emulation for several hundred megahertz bandwidth coverage within the 2 MHz to 2 GHz spectrum using predefined characterization input (i.e delay, attenuation, doppler shift, etc.) and real-time configurable control. The system should support satellite unlink/downlink frequency range conversions and delays of up to one second. The system should facilitate the emulation of pathloss, doppler shift, a subset of statistical fading profiles and predefined user channel characterization input.

**PHASE I:** Develop an architecture and a conceptual design for a modular programmable RF channel emulator that supports the waveforms and RF channel impairments described above. Perform basic proof-of-concept testing to validate the feasibility of the design. Approach may leverage COTS hardware/hardware or utilize a custom design.

**PHASE II:** Develop detailed designs for the Phase I modular programmable RF channel emulator and fabricate an eight-channel prototype suitable for proof of concept testing in a laboratory environment. Conduct preliminary testing demonstrating eight channel communications capability for the 2 MHz to 2 GHz range with the implemented channel impairment capabilities identified in Phase 1.

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

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

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**KEYWORDS:** RF; channel; emulator; simulator; multipath; radio; JTRS

TPOC: Maulin Patel  
Phone: (619)553-8481  
Fax:  
Email: maulin.patel@navy.mil  
2nd TPOC: Ripal Shah  
Phone: (619)767-4626  
Fax:  
Email: ripal.shah@navy.mil

3rd TPOC: Alan Sweeney  
Phone: (619)524-0022  
Fax:  
Email: alan.sweeney@navy.mil

N111-086 TITLE: Innovative Lighting System for Base-Insulated Transmitting Antenna Towers

TECHNOLOGY AREAS: Materials/Processes, Electronics

ACQUISITION PROGRAM: PMW 770 Submarine Communications Program ACAT II

OBJECTIVE: The objective is to develop for a 1500 foot tower a lighting system that will replace an electrical lighting system whose components have proven troublesome and incur significant costs in replacement and in downtime of the overall system. . The new system would need to provide lighting that is functionally equivalent to that presently in use but incurs no downtime for the antenna broadcast system, safe for maintenance teams to replace and are economical in nature, and would need to be approved by aviation safety authorities. The system would need to be robust in high RF electric fields and weather, including sun, heat, cold, and lightning.

DESCRIPTION: The desired tower lighting system will provide light in accordance with standard FAA and FCC guidance. Red light systems have alternating levels of flashing and non-flashing light. Systems producing white strobe light meeting aviation safety requirements may be considered. Existing systems are based on incandescent lights or on light-emitting diodes (LED).

Towers can be classified as grounded or base insulated.

Grounded towers serve to support one or more antennas that are small compared to the tower. Lighting systems on grounded towers are wired as on any other structure exposed to the elements. Wiring consists of conduit with wire, or armored cable, with junction boxes and fixtures, all chosen for weather resistance. Problems encountered, mainly corrosion, are not unique to towers. A base insulated tower is the antenna. Wiring and lighting is now constructed the same as for grounded towers. In addition, to get power on to the tower, a special tower lighting isolation transformer is installed next to the base. This type of transformer is made by only one manufacturer. One alternative system that has been used is a motor generator set with a long insulating (fiberglass) shaft.

RF current flows along the height of a base insulated tower. The RF voltage relative to ground varies along the height of the tower. Recent measurements have confirmed that significant RF voltage exists between the conduit and the lighting system wires inside.

High RF field exists at the outer surface of the tower, particularly at the top. Electric light fixtures are installed at several levels of the tower, in accordance with FAA/FCC and international guidelines. The light fixtures have traditionally contained incandescent lights, but many recent installations use LED lights. The LED lights consume less energy than the incandescent lights, and require less maintenance, but have not been trouble-free, particularly for the Navy's very high powered transmitting stations. The radio-frequency signal from the transmitter interferes with the lights, particularly LED lights, in ways we are only beginning to understand. The service is looking for innovation in either replacing existing lights systems or in delivering lights remotely. The new processes or hardware should allow maintenance teams to operate safely around and about the large antenna systems without shutting them down.

Fiber-optic distribution is seen as one possibility.

Fiber optic distribution is used for communications. The fiber is thin glass. Fiber communications use low power, the cable is low loss, and signals can go several kilometers in "single mode" (narrow bandwidth) or shorter distances in "multi mode" (wider bandwidth) cable. Since the purpose is communications, not power transfer, losses of ten or twenty decibels (factors of 10 to 100) could be acceptable. Such losses are not acceptable when efficiency of power transfer is a consideration. Fiber optic distribution is also used in lighting. The fiber may be plastic. Distances achieved are a few meters for white (broad bandwidth) light.



Fiber optic distribution for tower lighting could be possible if fiber combining long distance (low loss) and wide bandwidth could be developed. Such fiber is not known to exist. Other approaches have been tried, and might be worth exploring. At least one tower built prior to WW2 used lights on the ground and mirror assemblies at the tower's top. Maintaining alignment of such a system is but one challenge.

Isolated lights with photovoltaic arrays and batteries could be built. Challenges include cost, complexity, battery life vs. available light, and susceptibility to environmental damage. All the critical components would be on the tower, beyond easy reach.

The challenges seen for this project are (1) high electric field, on the order of 100 kV per meter at the base insulator, (2) attenuation in the fiber optics, and (3) weather ( sunshine, heat, cold, ice, wind, rains and frequent fogs and mist, lightning, salt air, and in some locations sulfur gasses of volcanic origin).

PHASE I: Develop an innovative concept for producing light, conveying the light to the various levels of the 1500 foot towers, and permitting emitting light in a way that will meet the standard FAA requirements for tower beacons and obstruction lights. Propose specific methods for dealing with the known high electric field at the base insulator, weather and radio frequency signal disturbances to existing light fixtures. Solution ideas need not be limited to concepts described in the description above.

PHASE II: Develop and fabricate a small-scale prototype lighting system. Test the prototype in the laboratory with respect to the performance parameters identified in the Phase I study. Identify new issues with new prototype system such as material degradation, sensitivity to tower flexibility, environmental attenuation, etc. Propose specific methods for dealing with these new issues.

PHASE III: Build a full-scale prototype lighting system, install it on a Navy communications tower, and field test with respect to the performance parameters identified in the Phase I and the new issues identified in Phase II. Assess the reliability of the new prototype system. Goal is to outperform the current system by a fiscal factor of at least 10.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Commercial business for tower lighting systems is potentially large, given the large number of telecommunications towers in use worldwide, particularly those in the medium-frequency (MF) broadcasting business. Since the telecommunications industry does not have the specific problems associated with the Navy's FSBS, then this industry will only adopt this new lighting technology only if it can be broadly cost-beneficial compared with existing electrical lighting systems. The lighting propagation techniques developed here could be applicable in the much broader lighting industry.

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TPOC: Geoff Dann  
Phone: (805)982-1366  
Fax:  
Email: geoff.dann@navy.mil  
2nd TPOC: Robert Zueck  
Phone: (805)982-1210  
Fax: (805)982-3481  
Email: robert.zueck@navy.mil

