NAVY
PROPOSAL SUBMISSION

INTRODUCTION:

The responsibility for the implementation, administration and management of the Navy STTR program is with the Office of Naval Research (ONR). The Navy STTR Program Manager is Mr. John Williams, (703) 696-0342, williajr@onr.navy.mil. If you have questions of a general nature or specific to the STTR program and not the topic, contact Mr. Williams. For general inquiries or problems with the electronic submission, contact the DoD Help Desk at 1-866-724-7457 (8AM to 5PM EST). For technical questions about a topic, contact the Topic Authors listed under each topic only available on the website at **http://www.onr.navy.mil/sbir** under "Solicitation" before **01 March 2004.** Beginning 1 March, you must use the SITIS system listed in section 1.5c at the front of the solicitation or go to the DoD website at **http://www.acq.osd.mil/sadbu/sbir** for more information.

PHASE I PROPOSAL SUBMISSION:

Read the DoD front section of this solicitation for detailed instructions on proposal format and program requirements. When you prepare your proposal, keep in mind that Phase I should address the feasibility of a solution to the topic. The Navy only accepts Phase I proposals with a base effort not exceeding $70,000 and with the option not exceeding $30,000. The technical period of performance for the Phase I should be 7 months to commence on or about 01 July 2004. The Phase I option should be 3 months and address the transition into the Phase II effort. Phase I options are typically only funded after the decision to fund the Phase II has been made. Phase I proposals, including the option, have a 25-page limit (see section 3.3). The Navy will evaluate and select Phase I proposals using scientific review criteria based upon technical merit and other criteria as discussed in this solicitation document. Due to limited funding, the Navy reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded. The Navy typically provides a firm fixed price contract or awards a small purchase agreement as a Phase I award.

It is mandatory that the **entire** technical proposal, DoD Proposal Cover Sheet, Cost Proposal, and the Company Commercialization Report are submitted electronically through the DoD SBIR/STTR website at http://www.dodsbir.net/submission**.** This site will lead you through the process for submitting your technical proposal and all of the sections electronically. Each of these documents are submitted separately through the website. If you have any questions or problems with the electronic submission contact the DoD SBIR Helpdesk at 1-866-724-7457 (8AM to 5PM EST). Your proposal must be submitted via the submission site on or before the **6:00 a.m. EST, Thursday, 15 April 2004 deadline. A hardcopy will NOT be required**. A signature by hand or electronically is not required when you submit your proposal over the Internet.

Online Submission: All technical proposal files must be in Portable Document Format (PDF) for evaluation purposes. The Technical Proposal should include all graphics and attachments, but not include Cover Sheets or Cost Proposal as they are submitted separately. Technical Proposals should conform to the limitations on margins and number of pages specified in the front section of this DoD Solicitation. However, your Cost Proposal will only count as one page and your Cover Sheets will only count as two, no matter how they print out. Most proposals will be printed out on black and white printers so make sure all graphics are distinguishable in black and white. It is strongly encouraged that you perform a virus check on each submission. To verify that your technical proposal has been received, click on the "Check Upload" icon to view your uploaded technical proposal. Typically, your proposal will be uploaded within the hour. However, if your proposal does not appear after an hour, please contact the DoD Help Desk. It is recommended that you submit early, as computer traffic gets heavy nearer the solicitation closing and slows down the system.

Within one week of the Solicitation closing, an e-mail notification will be sent to the principal investigator and the corporate official listed on the proposal indicating that your proposal has been received and processed for evaluation by the Navy.

PHASE I ELECTRONIC SUMMARY REPORT:

All Phase I award winners must electronically submit a Phase I summary report through the Navy SBIR website at the end of their Phase I. The Phase I Summary Report is a non-proprietary summary of Phase I results. It should not exceed 700 words and should include potential applications and benefits. It should require minimal work from the contractor because most of this information is required in the final report. The summary of the final report will be submitted through the Navy SBIR/STTR website at: **http://www.onr.navy.mil/sbir**, click on "Submission", then click on "Submit a Phase I or II Summary Report".

ADDITIONAL NOTES:

1. The Small Business Administration (SBA) has made a determination that will permit the Naval Academy, the Navy Post Graduate School and the other military academies to participate as a Research Institution or subcontractor in the SBIR/STTR program, since they are institutions of higher learning.

2. The Navy will allow firms to include with their proposals, success stories that have been submitted through the Navy SBIR website at **http://www.onr.navy.mil/sbir**. A Navy success story is any follow-on funding that a firm has received based on technology developed from a Navy SBIR or STTR Phase II award. The success stories should be included as appendices to the proposal. These pages will not be counted towards the 25-page limit. The success story information will be used as part of the evaluation of the third criteria, Commercial Potential (listed in Section 4.2 of this solicitation) which includes the Company's Commercialization Report and the strategy described to commercialize the technology discussed in the proposal. The Navy is very interested in companies that transition SBIR/STTR efforts directly into Navy and DoD programs and/or weapon systems. If a firm has never received a Navy SBIR/STTR Phase II it will not count against them.

PHASE II PROPOSAL SUBMISSION:

Phase II is the demonstration or further development of the technology that was found feasible in Phase I. Only those Phase I awardees which achieved success in Phase I, as determined by the Navy Activity point of contact (POC) measuring the results achieved against the criteria contained in section 4.3, will be invited to submit a Phase II proposal. During or at the end of the Phase I effort awardees will be notified to participate for evaluation of their proposal for a Phase II award. The invitation will be based on the success to which the company has accomplished for the particular topic as evaluated by the monitoring activity/command. If you have been invited to submit a Phase II proposal to the Navy, obtain a copy of the Phase II instructions from the Navy SBIR website or request the instructions from the Navy STTR Program Manager.

Upon receiving an invitation, submission of a Phase II proposal should consist of three elements: 1) A base effort, which is the demonstration phase of the SBIR/STTR project; 2) A 5 page Transition/Marketing plan describing how, to whom and at what stage you will market and transition your technology to the government, government prime contractor, and/or private sector; and 3) At least one Phase II Option which would be a fully costed and well defined section describing a test and evaluation plan or further R&D. Phase II efforts are typically two (2) years and Phase II options are typically an additional six (6) to 12 months. Phase II proposals together with the Phase II Option are limited to 40 pages (unless otherwise directed by the TPOC or contract officer). All Phase II proposals must have a complete electronic submission. Complete electronic submission includes the submission of the Cover Sheets, Cost Proposal, Company Commercialization Report, the **ENTIRE** technical proposal and any appendices via the DoD Submission site. The DoD proposal submission site **http://www.dodsbir.net/submission** will lead you through the process for submitting your technical proposal and all of the sections electronically. Each of these documents are submitted separately through the website. The Navy Activity that invited your PH II may also require a hardcopy of your proposal.

All Phase II award winners must attend a one-day Transition Assistance Program (TAP) meeting typically held in the July to August time frame in the Washington D.C. area during the second year of the Phase II effort. If you receive a Phase II award, you will be contacted with more information regarding this program or you can visit **http://www.dawnbreaker.com/navytap**.

As with the Phase I award, Phase II award winners must electronically submit a Phase II summary report through the Navy SBIR website at the end of their Phase II. The Phase II Summary Report is a non-proprietary summary of Phase II results. It should not exceed 700 words and should include potential applications and benefit. It should require minimal work from the contractor because most of this information is required in the final report.

The Navy has adopted a New Phase II Enhancement Plan to encourage transition of Navy STTR funded technology to the Fleet. Since the Law (PL102-564) permits Phase III awards during Phase II work, the Navy will provide a 1 to 4 match of Phase II to Phase III funds that the company obtains from an acquisition program. Up to $250,000 in additional STTR funds for $1,000,000 match of acquisition program funding, can be provided as long as the Phase III is awarded and funded during the Phase II. If you have questions, please contact the Navy Activity POC.

PHASE I PROPOSAL SUBMISSION CHECKLIST:

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

____1. Your complete STTR PH I proposal (coversheet, technical proposal, cost proposal, and DoD Company Commercialization Report) has been submitted electronically through the DoD submission site by 6:00 a.m. EST, Thursday, 15 April 2004.

____2. The Phase I proposed cost for the base effort does not exceed $70,000. The Phase I Option proposed cost does not exceed $30,000. The costs for the base and option are clearly separate, and identified on the Proposal Cover Sheet, in the cost proposal, and in the work plan section of the proposal.

Navy 04 STTR Topic Index

Navy 04 STTR Topic Descriptions

N04-T001 TITLE: High-Temperature Coatings for Turbine Blades and Vanes

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: PEO (JSF) – Joint Strike Fighter Program Office

OBJECTIVE: Develop a high-temperature protective coating system that increases the hot-section components durability, time "on-wing," flight safety, and affordable readiness for naval gas turbine engines.

DESCRIPTION: Military and commercial gas turbine engines used for aircraft, ships, and utility power generation require more durable and more reliable hot-section components in order to achieve their "designed for" life. Less durable parts lead to increases in unscheduled (and costly) inspections, engine repairs, and major engine overhauls. For aircraft applications, this equates to less time "on-wing," a severe reduction in flight safety, and a significant reduction in operational readiness. Typical in-service Naval aircraft that are affected include the AV-8B with the F402 engine and the E-2/P-3/C-2/C-130 aircraft with T56 engines and Global Hawk Unmanned Aerial Vehicle (UAV). Advanced turbine engines currently in development, such as the F414 (F-18E/F) and the F135/F136 (Joint Strike Fighter (JSF)), require much higher levels of turbine inlet temperatures, and hence much hotter hot-section components, to achieve robust engine performance. In the case of JSF and AV-8B, short takeoff/vertical landing (STOVL) operations are even more severe and critically limit the life of high temperature turbine engine components. A high temperature protective coating on components is key to enable longer life durability on the engine during these adverse conditions. In addition, T56-derivative engines (501K) are used for power generation on many Naval ships, and are experiencing thermal corrosion issues on turbine airfoils and have similar turbine durability issues.

A 40 degree F reduction in a turbine airfoil metal temperature can result in a doubling of stress rupture life and LCF life of aircraft gas turbine engine hot section components. The proposed program will address advanced TBCs with specific thermal resistance that are up to double that of conventional EB-PVD zirconia based thermal barrier coatings (TBCs). Many of these advanced TBC coatings are not very durable and prematurely spall-off the vane and blade turbine airfoils. At least doubling the Durability that of today's baseline of platinum aluminide, zarconia electron beam-physical deposition (EB-PVD) coating systems is one of the projects goals. In addition, while the insulation qualities provided by TBCs are highly desirable, TBCs add non-load bearing weight and thickness to the rotating components. Too much coating will significantly decrease blade creep life and detrimentally impact airfoil aerodynamics and result in significant loss of turbine efficiency and operability. A very durable low thickness (below 125 mils) high-temperature protective coating system; comprised of a robust bond coat and an advanced TBCs with half the low thermal conductivity of today's platinum aluminide, zarconia EV-PVD coatings is the goal of the project.

PHASE I: Identify high temperature coating performance requirements and specifications for military gas turbine engines. Define potential application techniques and characterize the high temperature coating system's composition and assess potential coating candidates. Select one or more coatings for further development in Phase II.

PHASE II: Coat several coupons and conduct laboratory/university hot gas and cascade testing of experimental coating systems and compare the results to baseline non-coated test coupons. Based on the success of the most promising high temperature coating, coat engine hot-section hardware/components and conduct further high temperature rig testing simulating realistic gas turbine operational conditions to predict and confirm component service life improvements. Determine the return on investment of the high temperature coated parts versus non-coated parts. Finalize the coating composition and the coating process for final development in Phase III.

PHASE III: If engine assets and test situations are available (university or Navy), the university/small business will provide coated blades for insertion into a candidate engine(s) for test. To realistically determine the coating system performance and durability under realistic operational conditions and mission cycles. A possible candidate engine test may be a NAVAIR Accelerated Simulated Mission Endurance Test (ASMET) or a NAVSEA ship gas turbine engine durability test

PRIVATE SECTOR USE OF TECHNOLOGY: High temperature coatings are pervasive across all gas turbine engine applications. They can be used for a wide variety of hot section engine components in industrial gas turbine engines used for electrical power generation, and commercial airline engines, as well as applications in hybrid automotive applications and ship propulsion systems.

REFERENCES:
1. Ultra-Efficient Engine Technology Program Technical Accomplishment; Advanced Thermal Barrier Coating (TBC) Composite Selected for Increasing Temperature Capability of Turbine Airfoil System; Robert Miller; September 2000, http://www.ueet.nasa.gov/images/Milestones/4.0.pdf

2. Protective Caotings for Turbine Blades, Y. Tamarin, ASM International http://www.asminternational.org/

KEYWORDS: Gas Turbines; High-Temperature Coatings; Thermal Erosion; Coating Processes; Engine Durability; Life-Cycle Cost

N04-T002 TITLE: High Sensitivity Magnetometer for Earth Field Ranges

TECHNOLOGY AREAS: Air Platform, Sensors

ACQUISITION PROGRAM: PMA 264: Air Anti-Submarine Warfare (AASW) Systems

OBJECTIVE: Develop innovative technology to provide a magnetometer capable of measuring magnetic fields on a moving platform down to the sub-femto-Tesla level.

DESCRIPTION: While searching for targets with magnetic signatures, the Navy desires improved probability of detection and increased stand-off ranges (greater than 9000 ft). To accomplish this task, it is necessary to be able to detect magnetic anomalies at the 1 fT level in an environment where motion is the major noise source. Platform motion leads to noise at the 50 pT per meter of travel level.

PHASE I: Provide theoretical and experimental evidence to demonstrate the feasibility of the proposed technology to meet the objectives.

PHASE II: Further develop the technology culminating in a prototype demonstration. Prototype demonstration should include moving platform simulations.

PHASE III: Complete technology development and transition to fleet.

PRIVATE SECTOR USE OF TECHNOLOGY: Private sector applications are in airport security and in the medical field (MRI, NMR).

REFERENCES:
1. D. Budker, V. Yashchuk, and M. Zolotorev. “Nonlinear Magneto-Optic Effects With Ultra-Narrow Widths,” Phys. Rev. Lett., 81, 5788 (1988).
2. D. Budker, W. Gawlik, D.F. Kimball, S.M. Rochester, V.V. Yashchuk, A. Weis, Resonant nonlinear magneto-optical effects in atoms; Rev. Mod. Phys. 74, 1153 (2002),
3. J. C. Allred, R. N. Lyman, T. W. Kornack, and M. V. Romalis , “High-Sensitivity Atomic Magnetometer Unaffected by Spin-Exchange Relaxation,” Phys. Rev. Lett. 89, 130801 (2002)

KEYWORDS: Magnetometry; Anti-Submarine Warfare; Mine Detection; Magnetic Fields; Magnetic Gradients; Magnetic Sensor

N04-T003 TITLE: Automated Path and Mission Planning for Aerial Platforms under Dynamic Conditions and Constraints

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

ACQUISITION PROGRAM: PMA 281: Cruise Missile Weapons Systems

OBJECTIVE: Develop innovative algorithms and software tools to automate path planning and mission planning for unmanned platforms such as UAV's, UUV's, UGV's, and weapons. Algorithms should account for the changing battlespace conditions, multi-objective cost functions, and incorporate dynamic constraints of the platforms and constraints driven by rules of engagement.

DESCRIPTION: Current approaches for path planning often rely on Djikstra's algorithm, which often are computationally intensive and are based on fixed grid points, ignoring physical limitations of the vehicles. The Navy has an interest in developing new optimization algorithms that will allow for minimizing a given cost function in a continuous manner, and also allows for the incorporation of constraints or dynamic environments. Future host platforms for unmanned vehicles, such as the Littoral Combat Ship will require the ability to perform collaborative planning and tactical monitoring for multiple heterogeneous unmanned vehicles with reduced manning. Planning is also a critical item for future re-targetable and loitering weapons such as cruise missiles. Depending on the type of platform and mission, planning may need to take into account a wide variety of factors such as terrain, weather/ocean currents, the platform's dynamic maneuvering capabilities, multispectral signature information, threats/obstacles, communications limitations, desired risk/chance of detection, and payload capabilities. Desired optimization criteria may be complex and multi-objective and include the quality of data required for Intelligence Surveillance & Reconnaissance (ISR), the likelihood of destroying a target for a combat unmanned vehicle or weapon, the exposure of the vehicle to threats, chance of detection, risks to the host platform, time on station, deconfliction with other platforms, and "time-on-target" specifications that require a particular goal to be achieved by a particular time. The platform may also be under a wide range of constraints, such as rules of engagement or the need to remain within specific corridors.
It is expected that the algorithms initially developed be able to construct cooperative paths from point to point that jointly minimize exposure to missile threats, visibility to both Electro-Optical/Infra-Red (EO/IR) and radar sensors, while incorporating constraints that are introduced by the terrain, airframe, and the potential missions. The algorithms will need to demonstrate the ability to dynamically alter the path solution in response to a changing environment such as new threats/targets detected, changes in no-fly zones or rules of engagement, new mission tasks required, new target priorities, new prioritization between threat exposure and image quality requirements. The new algorithms should subsume Djikstra's algorithm and significantly expand upon the capabilities Ideally, these should require no more than a small number of high-level inputs from human operators and allow fully autonomous operation when required.

PHASE I: Develop initial algorithms that provide a continuous path solution (or very fine grid spacing on the order of meters) and can minimize visibility to threats and incorporate dynamic changes in the battlespace environment. Algorithms should have the potential to run in near real time.

PHASE II: Further develop initial algorithms to incorporate dynamic constraints, such as the platform dynamics (turn rate, climb rate, operational ceiling, maximum velocity etc.), minimize mission cost functionals, such as time en-route, fuel expenditure, threat exposure, proximity to friendly vehicles and constrained final approach directions. Algorithm computational performance will be expected to be near real time on commercially available PC platforms.

PHASE III: Completed algorithms will be transitioned into the Cruise Missiles Command and Control Program, or through the Time Critical Strike FNC and/or Autonomous Operations FNC. A major bottleneck in prosecuting time critical targets is the mission planning process, and by automating that procedure the strike timeline will be significantly shortened.

PRIVATE SECTOR USE OF TECHNOLOGY: Robotic exploration of remote locations would directly benefit from this research, as autonomous operations are often required for such exploration. Future smart cars could adapt this technology for driver aids or enable potential autonomous vehicles. Agricultural harvesting is another potential area that would benefit from dynamic optimization for path planning, allowing for more efficient harvesting, minimizing equipment use.

REFERENCES:

1. Ioannis K. Nikolos ; Kimon P. Valavanis ; Nikos C. Tsourveloudis ; Anargyros N. Kostaras ; "Evolutionary Algorithm Based Offline/Online Path Planner for UAV Navigation"; Transactions on Systems, Man, and Cybernetics - Part B: Cybernetics : Accepted for future publication , 2003
2. Tomono, M.; "Path planning with target finding by single camera under map uncertainty"; Computational Intelligence in Robotics and Automation, 2003. Proceedings. 2003 IEEE International Symposium on, Volume: 1, July 16 - 20, 2003; Page(s): 465 -470
3. Amnin Zhu; Yang, S.X.; "ath planning of multi-robot systems with cooperation"; Computational Intelligence in Robotics and Automation, 2003. Proceedings. 2003 IEEE International Symposium on, Volume: 2 , July 16 - 20, 2003; Page(s): 1028 -1033
4. Lambert, A.; Bouaziz, S.; Reynaud, R.; "Shortest safe path planning for vehicles"; Intelligent Vehicles Symposium, 2003. Proceedings. IEEE , June 9-11, 2003; Page(s): 282 -287
5. Lambert, A.; Gruyer, D.; Mangeas, M.; Hesdin, F.; "Safe path planning and replanning with unmapped objects detection"; Intelligent Vehicle Symposium, 2002. IEEE , Volume: 1 , 17-21 June 2002; Page(s): 166 -171 vol.1
6. Navy Unmanned Aerial Vehicles PMA-263 Homepage, http://uav.navair.navy.mil
7. Littoral Combat Ship Homepage, http://peoships.crane.navy.mil/lcs/default.htm
8. DOD UAV Roadmap, http://www.acq.osd.mil/usd/uav_roadmap.pdf, Dec. 2002.
9. The Navy Unmanned Undersea Vehicle Master Plan, http://www.auvsi.org/resources/UUVMPPubRelease.pdf, Apr. 2000.

KEYWORDS: path planning; Djikstra method; optimization; dynamic constraints; real-time planning; vehicle deconfliction

N04-T004 TITLE: Sonobuoy Tube Launched UAV

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

ACQUISITION PROGRAM: Autonomous Operations FNC

OBJECTIVE: Develop a small, expendable Unmanned Air Vehicle (UAV) launched and controlled from P-3 aircraft in direct support of their mission.

DESCRIPTION: The Navy and other government-sponsored agencies use the P-3 aircraft. Due to the diverse missions and limited number of P-3 aircraft, the most economical and expeditious way to enhance operations and assure crew safety would be to incorporate low-cost expendable tactical unmanned air vehicles (UAV's). If UAVs were incorporated into each P-3, a load-out of sonobuoy launched UAV's with interchangeable payloads (i.e., IR, TV, RF, HS, etc.) tailored to the specific mission could be locally launched, be controlled by the on-board sensor operator, and assist the platform in carrying out its mission. It would serve to enhance sensor capability and, in effect, allow the aircraft to operate in several areas at the same time due to the UAV's capability to detect/confirm contact data and relay information to the special missions crew without forcing the aircraft to leave station. The UAV would keep the crew safe because it could penetrate and operate in areas deemed hostile for manned operations.

The advantage of a universal "A" size sonobuoy (4.875" X 36.0") expendable UAV with the capability for interchangeable payloads is that the sonobuoy size "A" tubes are standardized throughout the P-3 and H-60 communities, yielding cost and time savings through consolidation of efforts and reduction of redundant technology. Each community would be able to configure aircraft based on mission requirements.

While there are currently commercially off the shelf (COTS) electro-optical (EO) equipment, cameras, receivers, and transmitters small enough to fit into the special mission application, there are no small ("A" size sonobuoy chute) UAV vehicles and associated delivery systems currently in use. Based on current studies, these vehicles would be deployed in airspeeds of 150-250 knots, have 50+ knots of speed, have a flight duration of 1½+ hours, and have a range of 50 nautical miles to meet current P-3 mission requirements. Concept UAV's can be powered or gliders, but can not carry explosive fuels. This capability is 4-5 years from introduction into operational scenarios. Several ongoing industrial programs are examining small, expendable UAVs; "Silent Eyes" is one such program. There are several programs investigating folded wing, glider, safe fuels, and electric motor technologies that could be used with sonobuoy size UAV's. These technologies could be consolidated into a usable package for P-3 and special missions applications.

PHASE I: Develop design approach and demonstrate feasibility to meet the above requirements for a sonobuoy launched UAV.

PHASE II: Develop and produce a prototype UAV capable of launch from Navy P-3 aircraft using the current sonobuoy system. This should demonstrate capability for the aircraft to safely launch the vehicle, interact with it in tactically useful behaviors, and have plug-and-play payloads (EO/IR, RF, etc.).

PHASE III: Produce qualified UAV assets for use by Navy maritime patrol aircraft.

PRIVATE SECTOR USE OF TECHNOLOGY: This technology could be used by other government sectors for homeland defense purposes. It could be used by search-and-rescue organizations to enable wider area search than can be accomplished by current airborne assets as well as by commercial fishing fleets. In addition, these could potentially be used by fire-fighting organizations to drop into large-scale fires to map the location of hot spots and the forward edge of the fire.

REFERENCES:

1. Multi-Mission Maritime Aircraft (MMA) Tactical Deployable Study dated November 2002
2. OSD Unmanned Aerial Vehicle Roadmap 2002 - 2007 dated December 2002

KEYWORDS: Unmanned Aerial Vehicles; UAV; Maritime; sonobuoy; surveillance; P-3

N04-T005 TITLE: <u>Development of a Concept for Swarmed mini-UAVs for Automatic Target Recognition</u>

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

ACQUISITION PROGRAM: Autonomous Operations FNC

OBJECTIVE: To implement and evaluate a concept using swarms of reactive agents for discovering emergent behavior of automatic target recognition.

DESCRIPTION: The use of reactive agents, without much reasoning capability or "intelligence" to accurately and effectively perform automatic target recognition. It is assumed that the reactive agent will be hosted on a small Unmanned Aerial Vehicle (UAV), types that will be bandwidth and processing power restricted. For this concept each reactive agent has a simple behavior. As the reactive agents perform the mission swarming behavior will emerge from the large-scale interaction of the agents. The theoretical challenge of the swarm concept is to discover a design method that synthesizes agent behaviors given a description of the mission. The agent behaviors must be descriptive in a way that allows external sources to correctly interpret the presence, location, and type of a target.

PHASE I: Provide an initial development effort that demonstrates scientific merit and capabilities of the proposed method of Automatic Target Recognition. The concept should be defined to the point that large-scale simulation will be possible. Tools created using genetic programming and factorial experiments should be investigated and developed.

PHASE II: Using advanced simulation techniques new (software) reactive agents will be tested as a swarm to detect, localize, and classify targets in a constructive simulation. The sensor for the agents will be defined as a low cost electro-optic camera (1 mega-pixel resolution). The communication link shall be line of sight and low bandwidth.

PHASE III: Produce software that can hosted on micro and small UAVs that performs Automatic Target Recognition under a wide variety of environmental conditions.

PRIVATE SECTOR USE OF TECHNOLOGY: The concept of low cost swarming machines is very attractive to the private sector to aid in detection and containment of intruders and spill detection. Be using swarms they can have active agents that can detect, notify, and contain hazardous items. These swarms can be on station 24/7 while still maintaining a low-cost solution.

REFERENCES:
1. Parunak, Brueckner and Odell, “Swarming coordination of multiple UAVs for collaborative sensing” AIAA Unmanned Unlimited.

2. Gaudiano, Shargel, and Bonabeau, “Control of UAV swarms: What the bugs can teach us” AIAA Unmanned Unlimited.
KEYWORDS: Sensors; Automatic Target Recognition; Time Critical Strike; Unmanned Arial Vehicle; UAV; Reactive Agents

N04-T006 TITLE: Compact conformal arrays

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

ACQUISITION PROGRAM: PMA 231: E-2/C-2 Leadership Council

OBJECTIVE: Explore and develop intelligent compact conformal arrays for high-resolution spatial enhancement of signals in a highly dynamic environment

DESCRIPTION: Future emphasis in the DoD is to build large multi-function phased antenna arrays on ground, sea, air or space based platforms that will simultaneously perform multiple functions. One major problem to be addressed in this situation is isolation between components of the arrays which perform different types of signal processing, i.e., different portions of an ar-ray need to act as a transmitter, a receiver, a communication system, an electronic jamming and counter measure system, etc. Secondly the physical size of the large array has to fit on a UAV. Hence, it may be necessary to build a compact conformal array on substrates with high electrical constants (The substrates may be dielectric, ferromagnetic or may consist of electronic band gap materials) so that the physical size can be reduced without any deterioration in the performance. In dealing with such a wide variety of applications, it is necessary to achieve appropriate antenna beam patterns and electrical isolations between different parts of the array, using as few antenna elements as possible. Moreover, since every Navy and DoD antenna system is strongly influ-enced by its surroundings, the electromagnetic (EM) effects of complex nearby structures, as well as of the propagation media between the antenna and a desired target, must be appropriately included in any data processing to obtain accurate information on targets and the environment. In addition, during operation some of the elements of the array may fail. The question then is how to reconfigure it so that its performance degrades gracefully and not be catastrophic. Currently, existing classical stochastic methods fail to extract accurate direction of arrival, amplitude, phase, polarization, and number of signals in the presence of artificial and naturally occurring in-terference, because they do not adequately account for the EM effects of the array/antenna (cou-pling, non-uniform spacing, not identical elements, near-field scatterers), highly non-stationary and transient environs, and signals more closely spaced than Rayleigh resolution.

Therefore, it is necessary to develop a dynamic evolutionary adaptive scheme to reconfigure the array when there is a partial or total failure of any of the antenna elements or the electronics as-sociated with that channel. This self adaptive procedures must take into account the electrical and electromagnetic characteristics of the sensors and their environments along with the various platform effects on which they are mounted to provide acceptable performance when the envi-ronment changes which may include failure of portion of the array.

PHASE I: Provide an initial development effort that demonstrates scientific merit and capabilities of the proposed methodologies to design compact conformal arrays that are equiva-lent in performance to very large antenna arrays and demonstrate that they can operate in real time.

PHASE II: Synthesize an array over high material constant materials that can perform wideband processing and dynamically adapt to the environment in the presence of transient inter-ferers or failure of portion of the array. The array need to be also suitable for spaceborne applica-tion and the size reduction should be an order of magnitude.

PHASE III: Develop a proptotype of such an array.

PRIVATE SECTOR USE OF TECHNOLOGY: Successful development of such intelligent compact conformal arrays can be used in all types of GPS, wireless networks for computer appli-cations and various mobile and personal communication systems.

REFERENCES:
1. T. K. Sarkar, M. C. Wicks, M. Salazar and R. Bonneau, Smart Antennas, John Wiley and Sons, New Jersey, 2003.

KEYWORDS: Adaptive arrays; conformal arrays; array size reduction; self-correcting arrays; signal processing; platform effects.

N04-T007 TITLE: Waveform Diversity for Adaptive Radar

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

ACQUISITION PROGRAM: PMA 231: E-2/C Leadership Council

OBJECTIVE: Explore and develop waveform diversity for efficient spatio-temporal focusing of the transmitted energy on a target of interest for good reception in the presence of jammer and clutter.

DESCRIPTION: In nature, diverse waveforms are transmitted by animals for specific applica-tions. For example, when a bat and a whale are in the search mode for food, they emit a different type of waveform than when they are trying to locate their prey. The Doppler-invariant wave-forms that they transmit are environment dependent. Hence, in practical applications, say in adaptive radar, it may be useful to transmit different waveshapes for different applications. For example, in a search radar the goal may be to transmit a waveform that will provide a spatio-temporal focusing of the energy on the target and deal with waveshapes which possibly decouple the range Doppler processing. Also, the sensor arrays on a UAV are physically small and so would their power handling capability. However, by using waveform diversity on transmit it may be possible to focus the energy on the target. Hence it may also be more robust to clutter and jamming. In communication, the objective may be to use a waveshape that will not only be Dop-pler-invariant but will be robust to multipaths and hard to decode in a non-cooperative environ-ment.

Therefore, the goal here will be on the design of waveforms for efficient spatial and temporal adaptivity including the focusing of the transmitted energy on the target, so that it will be possi-ble to synthesize waveforms in the space-time continuum for both monostatic and bistatic appli-cations so that they can be mission adaptive. The objective will be to develop and demonstrate spatially and temporally adaptive sensor technology for application to air, space and ground sys-tems operating in isolation or in concert with other sensor systems.

PHASE I: Provide an initial development effort that demonstrates focusing of the energy on objects as a function of time, frequency and space.

PHASE II: Synthesize an array of realistic sensors that will use the environment for both transmit and receive for spatio-temporal focusing of the energy on objects of interest.

PHASE III: Develop a prototype of such a waveform diversity system using commer-cially available products, such as an arbitrary waveform generator, linear broad band amplifiers and wideband sensors with prescribed phase responses.

PRIVATE SECTOR USE OF TECHNOLOGY: Successful development of such special pur-pose waveshapes will have tremendous applications in various GPS, wireless and computer ap-plications and various mobile and personal communication systems.

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1. R. A. Johnson and E. L. Titlebaum, ”Range Doppler Uncoupling in the Doppler Tolerant Bat Signal”, in Proc. of IEEE Ultrasonics Symposium, IEEE, New York, pp. 64-67, 1972.

2. A. Papandreou, G.F. Boudreaux-Bartels, and S.M. Kay, “Detection and estimation of general-ized chirps using time-frequency representations”, Conference Record of the Twenty-Eighth Asi-lomar Conference on Signals, Systems and Computers, Vol. 1, pp. 50 –54, 31 Oct.-2 Nov., 1994.
KEYWORDS: Waveform diversity; adaptive radar; energy focusing; adaptive sensors; signal processing; space-time waveform synthesis.

N04-T008 TITLE: Nanograin Ceramic Optical Composite Window

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop and produce optically transparent ceramic windows and domes containing two or more ceramic phases and having a strength or thermal shock resistance superior to that of sapphire. The range of infrared transparency should be at least as great as that of sapphire.

DESCRIPTION: Sapphire is the most durable, commercially available electro-optic window and dome material [1]. Future Navy weapons and aircraft require windows and domes capable of withstanding greater heating rates, greater mechanical loads, and more severe rain and particle impact environments than can be withstood by sapphire. A wide range of monolithic ceramic materials has been examined in the last 30 years, and sapphire remains the best material. A possible route to more durable materials is to create composites with mechanical properties not available in monolithic materials.

Transparent, composite ceramics have not been made yet because optical scatter arising at every grain boundary makes these materials opaque. If the composites could be made with grain sizes less than or equal to ~50 nm, then optical scatter in the 3-5 ƒÝm mid-wave infrared region could be as low as 1-2%. If the particle size is even smaller, it is possible to obtain visible transparency.

The goal of this program is to demonstrate composite ceramic materials that are transparent at least in the 3-5 ƒÝm infrared region, and preferably in the near infrared and visible region, as well. The new materials would probably only be useful if they are superior to sapphire in one or more respects. The new material should be stronger, or more resistant to thermal shock, or more resistant to impact damage than is sapphire.

In formulating such materials, the best properties will be obtained by matching the thermal expansion of the ceramic phases, minimizing the thermal expansion of the phases, maximizing the thermal conductivity of the phases, maximizing the long wavelength infrared transmission of the phases, and minimizing the difference in refractive index of the phases. Oxides, nitrides, and fluorides offer the most promising possibilities.

PHASE I: Demonstrate a process for making a fully dense, nanograin ceramic composite that is transparent in the 3-5 ƒÝm infrared region and has the potential to be superior to sapphire in thermal shock resistance and/or strength. Disks with a thickness of at least 1 mm and a diameter of at least 1 cm shall be produced in Phase I to measure optical transparency as a function of process parameters. Measurements of hardness, fracture toughness, flexure strength, and thermal conductivity are desirable, but not required in Phase I.

PHASE II: Measure hardness, fracture toughness, flexure strength, and thermal conductivity. Adjust the composition and processing parameters to maximize these properties while retaining good transmission in the 3-5 ƒÝm infrared region. Fabricate optically polished windows with a thickness of 2 mm and a diameter of 75 mm. Evaluate the possibility of forming dome shapes by superplastic deformation of the ceramic composite.

PHASE III: Demonstrate commercial production capability for windows and domes made of the durable composite ceramic.

PRIVATE SECTOR USE OF THE TECHNOLOGY: Durable optical ceramics have potential use in the lighting industry and as sensor windows for industrial process monitoring.

REFERENCES:
1. D. C. Harris, Materials for Infrared Windows and Domes: Properties and Performance. Bellingham, WA: SPIE Press, 1999.

KEYWORDS: Sensor Window; Missile Dome; Ceramics; Composite Ceramics; Optical Ceramics; Electro-Optic Sensor Window

N04-T009 TITLE: Extremely Power/Energy Dense Electrical Energy Storage System

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

OBJECTIVE: Extend the state-of-the-art with respect to high power density and high energy density electrical energy storage technology to support high pulsed power weapon systems for submarine and surface ship applications.

DESCRIPTION: The Rotary Electromagnetic Launcher (REML) is a submarine weapon launch system currently under development requiring high pulsed electric power. The system requires four consecutive one second long pulses that provide 2MJ of energy each. System operating voltage is in the 600 to 800 Volt range. System must be capable of recharging within 5 minutes using up to 75 kVA recharge power at 450 VAC. The energy storage system must be compatible with safety requirements specified in MIL-STD-882 and must not be susceptible to a single point failure mode. The fully packaged energy storage system (including all required safety features, charger, etc) must fit into a 70 cubic foot rectangular cabinet.

PHASE I: Develop a system design for an extremely high power/energy dense electrical energy storage system. The concept must be compatible with submarine environmental and safety requirements, be highly reliable over a minimum shelf and cycle life of 15 years/3000 cycles, and capable of remaining operational after a shock input with a 250 g static equivalent.

PHASE II: Manufacture and demonstrate the proposed technology with a series of tests (subscale as appropriate) to verify the power/energy density, charge/discharge performance, and assess compliance with top level requirements pertaining to safety, environmental, shock, etc.

PHASE III: Incorporate any design lessons learned from Phase II and manufacture a full scale prototype system to be integrated with REML prototype hardware for full scale system testing.

PRIVATE SECTOR USE OF TECHNOLOGY: Increasing the state-of-the-art of high density electrical energy storage devices has broad commercial applicability for improving existing technology such as small handheld power tools (electric drills, etc) and electronics (laptop computers, etc). It may also prove to be a key enabling technology in the development of electric cars and other vehicles by improving range and performance.

REFERENCES: MIL-STD-882 (Standard Practice for System Safety Program Requirements), NAVSEA Technical Manual S9510-AB-ATM-01A (Nuclear Powered Submarine Atmosphere Control Manual), Naval Ordnance Center Technical Manual S9310-AQ-SAF-010 (Batteries, Navy Lithium Safety Program Responsibilities and Procedures), MIL-STD-2031 (Fire and Toxicity Test Methods and Qualification Procedure for Composite Material Systems Used in Hull, Machinery, and Structural Applications Inside Naval Submarines).

Due to the closed environment of a submarine, toxicity and flammability are major issues for the energy storage system. The requirements cited above must be satisfied with a technology that uses low toxicity (as defined in NAVSEA Technical Manual S9510-AB-ATM-01A, also refer to MIL-STD-2031) and nonflammable materials.

Once developed, this technology could potentially be applied to other high pulsed power weapon systems under development for use on Navy ships, including Electromagnetic Aircraft Launching System (EMALS), High Energy Laser (HEL), and Rail Gun.

KEYWORDS: Energy storage; Electricity; High Density; Pulsed Power; Submarine; Weapon Launch

N04-T010 TITLE: Miniaturized Ultra-Broadband Antenna

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop and demonstrate a miniature antenna for VHF/UHF/SHF band operation using emerging materials. Antenna gain and overall size and volume are important factors in the design. Proposals can be based upon currently available designs but emphasize/prioritize the utility of emerging material for miniaturization.

DESCRIPTION: This effort is to pursue novel technologies and innovations that are based on the synthesis of new materials (using off-the-shelf, low loss ceramic LTCC - low temperature coal-fired ceramic - substrates: see web site http://www.ltcc.de) and develop innovative new design methodologies integrated with antenna modeling tools for volumetric optimization purposes. Research under the DARPA Metamaterials program led to the development of novel textured substrates specifically designed for antenna miniaturization. These substrates are fabricated using LTCC (up to er = 100) as the raw material and were manufactured using Micro-Fabrication and Co-Extrusion (MFCX) techniques . These techniques can be used to produce any antenna design from several different materials in powder form. Complicated designs with features as fine as 10 100 mm and as long as several millimeters can be constructed by repeating this process of size reduction through co-extrusion and reassembly.

Design methods should be used, which allow for volumetric design optimization subject to pre-specified antenna constraints (gain, efficiency, size, return loss, pattern, loss, etc.). This methodology should permit one to complete a design of a pre-specified antenna volume so that the optimal material and metallization can be used to achieve the objective performance criteria.

PHASE I: Perform a feasibility study and demonstration of important antenna characteristics such as: frequency coverage, gain, and volumetric considerations for an antenna design fabricated using the new low loss ceramic materials.

PHASE II: Using the design and simulation experience in Phase I, a final design of a small antenna should be carried out. A prototype should be fabricated and tested for radiation performance an input characteristics. Feasibility of using this antenna for various applications should be demonstrated.

PHASE III: Successful execution of Phase II will result in a very small antenna for wideband applications. Demonstrate the feasibility of using this antenna for commercial use

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2. D. Psychoudakis et al, Textured substrates for printed antenn miniaturization and bandwidth improvement, 2003 IEEE Antennas and Propagation Symposium, Columbus OH, June 2003.

3. LTCC - low temperature coal-fired ceramic - substrates: see web site http://www.ltcc.de

4. Aaron T. Crumm and J.W. Halloran "Fabrication of Micro-Configured Multicomponent Ceramics", J. American Ceramic Soc. 81 [4], p. 1053-57 (1998)

KEYWORDS: LTCC (low temperature coal-fired ceramic), metamaterials, Antennas, communications, VHF/UHF, LTCC, meta materials

N04-T011 TITLE: <u>Non-Plane-Wave noise source localization for horizontal arrays at low frequency in very shallow water (VSW)</u>

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop a capability to detect, localize and suppress noise using horizontal arrays at low frequency in the very shallow water, nearshore environment where normal mode arrivals significantly degrade the performance of all operational passive sonar systems.

DESCRIPTION: Noise source localization using horizontal arrays in very shallow water at low frequency is significantly degraded by using plane wave beamforming followed by tracking the modal acoustic arrivals and from moving noise sources. A robust, new method of noise source localization in very shallow water at low frequencies using a horizontal line array is desired. Surface ships and surf hot spots are the noise sources to be characterized and contrasted in the beamformer for this effort. Quantitative measures of “non-plane-waveness” will be developed for both surface ships and the surf noise sources as a function of frequency array orientation and shallow water environment. An accurate method of noise source localization using a full wave propagation model and plane wave beamformer will be developed in this effort for both shipping and surf noise sources. Noise suppression algorithms will be developed based on the noise source localization algorithm developed.

PHASE I: Design a very shallow water, low frequency noise source localization algorithm for horizontal arrays operating in the very near shore environment. The plane wave beamformer will be used, along with access to the arrays hydrophone time series. A full wave propagation model will be an integral part of the noise source localization algothim. Test initial algorithm performance on synthetic and measured data.

PHASE II: Take necessary precautions to assure software will be compatible with existing sonar system software. Refine and demonstrate noise source localization and suppression. Build prototype system primarily from commercial off the shelf (COTS) hardware for an at-sea, real time test.

PHASE III: During a scheduled fleet exercise perform prototype system testing incorporating results into final algorithm. Transition algorithm for use with NAVSEA's Advanced Processor Build (APB) program.

PRIVATE SECTOR USE OF TECHNOLOGY: If a non plane wave technique is successfully developed, it can be applied directly to a seismic signal processing algorithm called "Slant Stack Processing". The seismic community currently uses the normal move out and stacking techniques with deconvolution and migration, because Slant Stack Processing performance is degraded by non plane wave arrivals.

This technology could be deployed for numerous homeland harbor defense or drug intervention initiatives. Acoustically radiating ocean based weapon or drug delivery platforms approaching the shore would be detected through the noise localization and suppression capability of the developed technology.

REFERENCES:

1. Wilson, J. H. and R. Veenhuis, "Matched field processing in shallow water using a small aperature horizontal line array."

2. J. Acoust. Soc. Zarnich, R, "A unified method for the measurement and tracking of narrowband contacts from an array of sensors" Doctor of Philosophy Dissertation at George Mason University, March 2000

3. Feder, M. and E. Weinstein, "Parameter estimation of superimposed signals using the EM algorithm," IEEE Trans. Acoust, Speech and Sig. Proc., Vol 36, No. 4, April, 1988, pp 477-489.

KEYWORDS: Shallow water, low frequency, surf noise, shipping noise, signal processing

N04-T012 TITLE: Speech Recognition in a Chaotic Aural Environment

TECHNOLOGY AREAS: Human Systems

ACQUISITION PROGRAM: SSN 774

OBJECTIVE: To develop reliable speech recognition capability for multiple users in a chaotic aural environment such as the control room of a naval combatant during battle stations or emergency casualty response, in a noisy environment such as an open bridge during foul weather, or in an automobile travelling at speed over rough roads in foul weather.

DESCRIPTION: Speech recognition technology has matured to a level where it is used in a variety of commercial applications. However, limited discrimination of intentional speech from background noise and incidental speech continues to limit the application of this technology to relatively benign environments. Reductions in manning for both military and commercial vehicles and other automated or semi-automated machinery impose a requirement on operators to multi-task on a regular basis. Verbal commands could greatly reduce this workload, but they must be reliably interpreted in aural environments that include significant background noise and incidental speech. This effort would develop speech recognition capabilities that are so dependable and capable of discrimination from incidental speech and background noise that they can be used for command and control of vehicles and machines in chaotic and noisy environments. Special emphasis will be placed on identification of technologies with high potential for implementations where unit costs are comparable to functional options for commercial or military workstations, as applicable. For commercial applications the selected technology should be producible for sale integrated into desktop or laptop Personal Computers, as an option for controlling automobile sound systems, or for commercial airplane or ship navigation systems; likely no more than $1000 per copy. For military applications requiring environmentally hardened systems, the technology should be available for no more than $50,000 per copy in small quantities.

PHASE I: Define models (mathematical or analog) of target military and commercial aural environments for application of speech recognition. Identify candidate technologies and assess the feasibility for increased dependability and discrimination of operator speech in a noisy environment using models identified via this task.

PHASE II: Perform a trade-off analysis of technologies identified in Phase I. Design, construct, and demonstrate a prototype speech recognition system.

PHASE III: Integrate the speech recognition technology selected during Phase II into a VIRGINIA Class Submarine Portable Ship Control Unit (PSCU) and a Q-70 console configured as a VIRGINIA Class Submarine Command Workstation. For the PSCU, speech recognition should be enabled for select functions such as steering control, radar display configuration and digital nautical charts. The Command Workstation should be modified to enable speech recognition for selection of data source (radar, sonar, photonics, etc.) and other functions. Each system should be demonstrated using the technology selected in Phase II refined for the specific operational environment (submarine bridge while operating in rough water and high wind, or Command and Control Center during battle stations). Develop a preliminary design package and/or procurement specification for the selected configuration(s).

PRIVATE SECTOR COMMERCIAL POTENTIAL: This system could be applied in any work environment where speech recognition for data entry, or vehicle or machinery command and control is desired. It would be especially useful for situations with reduced manpower and a noisy ambient environment. A successful implementation would allow computer systems of reduced form factor in previously impractical locations by eliminating the need for keyboards and/or pointing devices. This would include installation on moving vehicles subject to continuous road, wind or water noise, or large vehicles where control is kept in rooms with multiple operators. Increased dependability of speech recognition in a cost effective COTS implementation would significantly increase the rate of market penetration for commercial products such as speech controlled automobile entertainment systems and voice activated cell phones. There is also significant potential in the home computer game industry for multi-player gaming. Home and office security systems could also be fitted with dependable verbally activated functions.

KEYWORDS: speech recognition; chaotic aural environment; discrimination; reliability; incidental speech; background noise

N04-T013 TITLE: Advanced Flywheel Energy Storage for Pulsed Power Applications

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

ACQUISITION PROGRAM: Advanced Capability Electric Systems (ACES) FNC.

OBJECTIVE: Develop and demonstrate technologies for significantly improving the system-level energy density of a flywheel-based energy storage system.

DESCRIPTION: Flywheel-based energy storage systems are potentially attractive for some pulsed electrical loads with discharge times from 0.01 to 2.0 seconds. However, the size and complexity of these systems are driven by issues which go beyond the typical considerations of tip speed and material strength. In many cases, the overall system size is dominated by input and output power conversion, motor / generator windings and excitation system, electrical distribution system balance, and thermal management, rather than the rotating mass itself.

PHASE I: Develop a system design for a flywheel-based energy storage system. The design should incorporate innovative technologies for reducing the overall system size, where the system is defined to include all components needed to charge the flywheel from a 60 Hz power source and to discharge into a pulsed load. Assumptions about the characteristics of the power source and load should be incorporated in the system design documentation.

PHASE II: Demonstrate the viability of the proposed technology through detailed design, prototyping, and testing of specific innovative components developed in Phase I. This demonstration can be at scale, and may be of a sub-system rather than a complete pulsed power system.

PHASE III: Design and construct a fully integrated flywheel-based energy storage system based on technology developed in Phase I and Phase II. Demonstrate in a realistic environment incorporating an actual or simulated pulsed power load.

PRIVATE SECTOR USE OF TECHNOLOGY: Technologies developed in this program are applicable to a variety of utility and industrial applications such as power factor correction and uninterruptible power for critical industrial processes.

REFERENCES:
1. Sandia National Laboratories Report SAND99-1854, "A Summary of the State of the Art of Superconducting Magnetic Energy Storage Systems, Flywheel Energy Storage Systems, and Compressed Air Energy Storage Systems," July 1999

2. Future Naval Capabilities (FNCs) website http://www.onr.navy.mil/fncs

KEYWORDS: Flywheel, Pulsed Power, Energy Storage

N04-T014 TITLE: Self-Calibrated Spatial Audio System for Enhancing Immersion in Virtual Training Simulations

TECHNOLOGY AREAS: Information Systems, Human Systems

ACQUISITION OR FNC SPONSOR: Capable Manpower FNC, Virtual Technology and Environments (VIRTE) Component; PMTRASYS

OBJECTIVE: To develop a compact, individually calibrated system for delivering spatialized auditory cues to trainees immersed in Virtual Reality (VR) Military training simulations. The information presented through this device would complement the information presented through the visual display system, as well as through other sensory interface techniques. The inclusion of this information would be evaluated both in terms of technical merits as well as performance-enhancing.

DESCRIPTION: As the Operations Tempo continues to increase, coincident with prolonged stages of deployment, Sailors and Marines will find themselves increasingly removed from opportunities to learn new skills or to refresh existing ones. In response, the Military continues to develop operational models for enhancing the delivery of training to alleviate these conditions, emphasizing the development of training systems that are portable, deployable, and reconfigurable [1]. Among the possible training technologies currently available, only Virtual Reality promises to satisfy these requirements [1,2, 4]. Yet, despite many attempts at demonstrating the training effectiveness of these systems, it has become clear that these training tools are still a long way from being able to provide a level of training that directly enhances real world performance [3].

One of the primary reasons that VR systems do not, as yet, provide a demonstrable training edge is that they fail to fully integrate the wide range of sensory cues typically associated with complex tasks [5, 9]. It is well-known that the quality of the experience provided by VR systems is directly related to the degree to which the range of human sensory modalities is stimulated [6]. Current systems focus primarily on supporting the visual modality, while stimulating other modalities in, at best, a rudimentary fashion. Thus, in the absence of a multi-modal sensory experience, it is only to be expected that training will suffer [8].

One domain which is acutely impacted by prolonged periods away from training opportunities is Close Quarters Battle for Military Operations in Urban Terrain (CQB for MOUT). The primary reason for this is that team members engage in this operation must have a well developed ability to perform in uncertain environments, and to respond, as a team, to a dynamic experience, a practice known as Initiative Based Tactics. This is a high-level cognitive skill, training for which requires a strong degree of metacognitive, or exploratory-like, learning [7]. It can not be learned through more traditional modes of training, such as sandboxing, lecturing or the reading of manuals. VR systems are ideally suited to filling this training need if they can be developed in such a way as to include other sensory modalities. For the CQB for MOUT domain, auditory cues play a pivotal role in providing trainess with an understanding of how a given operation should evolve over time [6].

In order for such cues to be salient when integrated into a VR system, they must be delivered in such a fashion as to preserve both the spatial and temporal qualities of the 'real' cues [10]. Since the information extracted by the human auditory system is dependent on the structure of the individual's receiving organ, models supporting the transmission of these stimuli are typically developed based on individual Head Related Transfer Functions (HRTFs) [11]. Yet, this is often a laborious exercise, requiring specialized equipment. Moreover, a wide range of individuals are expected to utilize these VR systems. In order to support the level of independent operation necessitated by current training needs, a new approach is mandated. This approach must be validated both in terms of the technology, as well as the level of performance enhancement attributable to the inclusion of this modality.

PHASE I: Study a conceptual architecture and framework for developing individualized, spatialized, auditory cues, virtually rendered and perform basic experimental research to demonstrate the feasibility of adding this modality to other ones already supported by VR technology.

PHASE II: Development and testing of the Phase 1system, leading to a capability demonstration based on to-be-determined Measures of Performance. Integration with a VR-based training system, supporting a field evaluation and focusing on training enhancement and system usability will provide the basis for demonstrating level of technology maturity and training efficacy.

PHASE III: Based on the Phase II results develop a system that can be fully integrated with Navy-sponsored Virtual Reality training systems, such as those being developed by the Virtual Technologies and Environments (VIRTE) effort, which is part of the ONR sponsored Capable manpower Future Naval Capability (FNC).

PRIVATE SECTOR USE OF TECHNOLOGY: An easily calibrated Spatial Audio cueing system would, if validated from both a technology and performance perspective, support essentially any military simulation system, as well as providing the gaming and entertainment industry with a unique tool. Potential medical applications include identifying decrements in hearing as well as providing a tool for validating a range of hearing loss treatments [12]. Finally, the science of Audiology would benefit greatly from such a tool [13].

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KEYWORDS: Auditory; HRTF, Close Quarters Battle; Virtual Reality; Training; Visual;

N04-T015 TITLE: Advanced Blast Packaging Materials

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

ACQUISITION PROGRAM: Littoral Combat and Power Projection FNC, Expeditionary Logistics (ExLog)

OBJECTIVE: The objective of the project is to study highly innovative technologies and alternative processes in order to contain the blast effects of an accidentally detonated weapon to allow full up weapons to be safely stowed handled. The packaging shall be lightweight and fire resistant.

DESCRIPTION: Weapons are currently handled, transported, and stowed in a variety of different ways in the Naval supply chain. Small explosive initiating devices such as detonators and fuzes cannot be safely shipped with larger explosive devices such as bombs. They frequently cannot be stored in the same location or transported in the same vehicle due to the relative hazard classification between initiator and bomb. The ability to package a full up weapon that does not have to be assembled and which has a favorable hazard classification would have a significant improvement on the weapons logistics chain for the Navy.

The goal of this effort would be to use new and highly innovative materials and processes to develop a lightweight container that could withstand the accidental detonation of weapon. A 2,000 lb MK-84 bomb shall be assumed to be the weapon for this effort. This is a standard bomb and is frequently use as the explosive base for precision guided munitions. The target weight for a container to hold one MK-84 shall be 650 lb, which is an aggressive target requiring a high level of innovation While no specific minimum cost will be required, the acquisition and life cycle cost of the container shall be minimized. The material of the container shall be fire resistant to both internal and external fires. The container shall be reusable as weapons are expended. An additional benefit, though not a requirement, would be to have the container be collapsible for ease of retrograde handling. The container would also have to be strong enough and rugged enough to be handled by forklift trucks using standard tines in pockets beneath the container. Materials within the container shall not harm the weapon stowed within, including the potential for precision guidance equipment. The container shall be easily unloaded.

The following approach is proposed:

PHASE I: Identify candidate highly innovative technologies and containment strategies that will provide lightweight blast containment. Develop conceptual alternatives that will meet the defined performance requirements and perform a preliminary tradeoff study to evaluate the merits of the concepts. Develop a method to analyze all aspects of the blast phenomenon in order to perform more detailed trade off studies in the next phase.

PHASE II: Perform detailed analyses in order to conduct trade off studies. Perform required assessment of the manufacturing methods in order to ensure that the containers will be affordable. Certain key elements of the containment strategy shall be produced if required to demonstrate producibility. Develop strategies to test the blast containment of the containers in the next phase.

PHASE III: Build breadboard containers for testing. Perform testing with instrumentation as required to demonstrate capability.

PRIVATE SECTOR USE OF TECHNOLOGY: The technology developed under this program could be applicable to the airline industry. Other areas within the transportation industry where containment of explosives is desirable may also be a potential opportunity.

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2. Future Naval Capabilities (FNCs) website http://www.onr.navy.mil/fncs

KEYWORDS: Packaging, blast, explosive, containment, materials

N04-T016 TITLE: Multi-Band / Multi-Threat Warning Sensor

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors, Weapons

ACQUISITION PROGRAM: Fleet/Force Protection FNC

OBJECTIVE: This effort will develop a compact, low-cost threat warning sensor capable of sensing the hot plume emissions from missiles and rocket propelled threats while simultaneously sensing the emissions from laser designators and rangefinders. The sensor must be able to identify the threat (laser designator or rangefinder at 1.06 micrometers or 1.55 micrometers wavelengths, or a missile in flight) and determine the direction of the threat over a near-hemispherical field of view. Threat identification will be based on spectral and temporal processing of the detected optical signals. Key innovations required for the envisioned system are the ability to detect and identify four bands of spectral information simultaneously, to maintain spatial registration of all the bands, and to produce such a system with size, weight, and power requirements similar to a simple broad-band mid-wave infrared (MWIR) or long-wave infrared (LWIR) imaging sensor. An affordable and robust multi-band / multi-threat sensor will enhance the situational awareness of warfighters under hostile fire and improve the survivability of Navy vessels; Marine Corps and Army ground vehicles; and Navy, Marine Corps, Army, and Air Force aircraft.

DESCRIPTION: Threat warning is key to increasing survivability of military platforms. Rocket-propelled threats generate hot CO_2 gas in their exhaust plumes which emit optically in the mid-wave infrared spectral band. Broadening of the CO_2 emission line at 4.3 micrometers allows significant radiation to transmit through the much cooler atmosphere at around 4.0 micrometers (the so-called "blue spike") and around 4.5 micrometers (the "red spike"). Independent sensing of these two emission spikes provides a highly reliable method to detect potential threats using a ratio of the two measurements. A system sensitivity (NEI - Noise

Equivalent Intensity) of better than 50 picowatts/cm2 in these spectral bands is required to permit threat plume detection at tactically significant ranges.

Laser threats using neodymium-doped solid state lasers, emitting at wavelengths around 1.06 micrometers, have long been used for rangefinders and target designation of laser-guided munitions. An increasing number of laser threats operate at wavelengths around 1.55 micrometers using technologies based on erbium-doped crystals or wavelength shifting techniques, so an effective laser threat warning system would need to operate at both these wavelengths. To increase detection probabilities while minimizing false alarms, relatively narrow-band detection around each of these laser wavelength bands can be combined with appropriate signal processing to minimize background signals and uniquely identify the threats. In order to be tactically significant it is necessary to detect laser rangefinders and designators out to a range of at least 7 kilometers for ground vehicles.

Simultaneous detection and identification of exhaust plumes and laser threats, as well as determining the direction of the threats to an accuracy of about 1-degree over a field of view of 360-degrees in azimuth and 70-degrees in elevation (–10-degrees to +60-degrees), will provide significantly enhanced threat warning over current sensors. All threat detections and required processing (threat declaration, ID, azimuth, and elevation) should be performed at high frame rates (100 Hz or better) to enable cueing of external counterfire or countermeasures systems. (The specifics of these external systems are not germane to this topic, except that the sensor processing system should include the ability to generate a generic cueing signal or "trigger pulse" that can be synchronized with the time of detection to an accuracy of 10 milliseconds or better.) To facilitate tactical implementation, design considerations should include techniques to detect threats in the presence of background clutter and solar radiation; minimizing false alarms; decreasing size, weight, and exposed cross-section; and enhancing robustness against vibration, shock, and thermal variations.

PHASE I: Perform trade studies and preliminary design of the multi-band / multi-threat warning sensor. Determine predicted performance against laser designators and hot exhaust plumes. Show that the sensor can be designed for operation on military vehicles, and produced at costs appropriate for moderately priced platforms, e.g., amphibious assault vehicles. Identify suppliers of key components and verify their ability to meet moderate production capability (hundreds to thousands of units).

PHASE II: Perform detailed design of the multi-band / multi-threat warning sensor, including optical, mechanical, electronic and software components. Generate detailed drawings and bills of material for easy transition to Phase III production. Provide to the Navy a working prototype of the sensor and evaluate its operation against available threat hardware and simulators.

PHASE III: Perform modification of the Phase II prototype sensor for inclusion in a specific military vehicle. Work closely with a military sponsor to militarize the sensor and to provide appropriate outputs for integration into the vehicle. Modify the Phase II system design to conform to the military vehicle installation constraints.

PRIVATE SECTOR USE OF TECHNOLOGY: With the proliferation of shoulder-fired missiles, terrorist threats to commercial transportation, whether via ships, vehicles, or aircraft, have become a real concern. Development of this low-cost 360-degree field of view threat warning sensor will provide a means for Homeland Defense agencies to protect commercial transportation systems without an undue cost burden.

In addition to the threat detection application of this technology, the development of low-cost, real-time, high-frame rate sensors with exact image registration across multiple spectral bands has a number of uses for machine vision and automated inspection applications. By simply modifying the filtered wavelengths in the imager and using a broad-band IR illuminator, the system could be readily adapted to surface quality inspection by identifying surface contaminants prior to material processing. Examples of this application and the industries affected include:

- Airline manufactures currently have no easy reliable method to verify surface cleanliness prior to painting. This technology would allow high-speed inspection of entire airframes or bulk components for surface contaminants that would interfere with paint adhesion and bonding.

• Production of composite parts leaves a layer of mold release agents on the surface which must be removed prior to coating. Parabolic reflectors for spacecraft antennae, for example, require significant cleaning time to ensure all release agents are removed prior to application of space-qualified coatings. No fast method currently exists to ensure that theses composite surfaces are free of such contaminants before undergoing this costly procedure. The ability to quickly visualize areas in need of cleaning would decrease processing times and increase the yield and reliability of such coatings.

• Anti corrosion conversion coatings for maritime use require testing in salt-spray chambers to verify correct application and performance. Currently the industry has no way to quickly verify coating performance. Simple adaptation of the imaged spectral bands would provide manufactures a method to reduce corrosion inspection times from hours to seconds, quickly revealing areas of coating breach that would otherwise be invisible to the eye. This improvement in inspection capability would result in decreased manufacturing costs, increased profitability and reliability, and increased component lifetime for both the military and commercial users of these items.

REFERENCES: Quantitative information on the types of systems being combined is classified. There are numerous articles on the web of commercial examples of these systems. Examples of relevant references are:

1. Naval Researchers Pursue Electronic Warfare Gains
http://www.us.net/signal/Archive/Aug97/naval-aug.html

2. Laser Warning http://www.nycedo.com/edocorp/page42.htm

3. Threat Warning Systems http://www.avitronics.co.za/Airborne/laser1.htm

4. Chris F. Carter and Nicola Cross, "Combustion monitoring using infrared array-based detectors" Measurement Science and Technology, Volume 14 (July 2003), pp.1117-1122.
http://www.iop.org/EJ/abstract/0957-0233/14/7/329/

KEYWORDS: Threat warning; laser designator; infrared; low-cost; multi-band; red-spike/blue-spike

N04-T017 TITLE: Modeling & Simulation of Storage Area Networking in an Enterprise Services Environment

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: Knowledge Superiority & Assurance FNC

OBJECTIVE: Define and investigate various methods for efficient and secure handling of data storage within the framework of net-centric enterprise services. Develop a modeling and simulation tool that implements these methods to be used for experimentation and trade-off analysis.

DESCRIPTION: Net-Centric Enterprise Services (NCES) will provide DoD components with the ubiquitous access and reliable access to mission-critical information for the warfighter on the Global Information Grid (GIG) from anywhere at anytime. Storage Area Networks have emerged as an important means to manage data on different kinds of storage devices as part of enterprise services. NCES needs to provide SANs capabilities for commands and access to SANs information at the edge. The design of NCES with SANs capabilities is complex because of DoD requirements for security, mobility, ruggedness, and interoperability. It is especially important to understand the behaviors of SANs and data storage in NCES for tactical and operational environments quantitatively and thoroughly. Of particular importance are the issues of:

1) data storage schemes and interfaces, such as object-based storage;
2) a choice of security and cryptographic methods or architectures (on disk, in transit, end-to-end);
3) adaptable data storage devices that can learn characteristics of the environment to better organize and secure the data;
4) a variety of protocols and interface designs;
5) architectures and attributes of system components for the entire network environment;
6) specialized NCES services for the GIG;
7) communities of interest;
8) quality of service, speed, and scalability;
9) information security;
10) heterogeneity of equipment;
11) low-bandwidth networks; and
12) sustainment and maintenance.

PHASE I: Identify storage area network methods and attributes for modeling as apply in enterprise services environments. Validate these models and their relevance for the DoD NCES and GIG. Define a suite of software tools that enable quantitative analysis of these models, the specification of environment conditions, and the presentation of essential results that facilitate trade-off studies.

PHASE II: Develop, implement, and validate a prototype M&S tool suite building on Phase I. Benchmark the prototype against known cases and anticipated cases important for DoD purposes. Perform algorithm and prototype testing using network data.

PHASE III: Implement the models and algorithms in a comprehensive package that would include an intuitive graphical user interface (GUI) where the user can interactively change the storage area network model (e.g., parameters of the entities, security schemes, configurations, etc.) and observe and quantify the impact on the performance of the network.

PRIVATE SECTOR USE OF TECHNOLOGY: The problem of efficient and secure data storage is important to any industry that relies heavily on networks. The ability to model and simulate various storage area network schemes for trade-off analysis would benefit financial institutions, telecommunications companies, and many others.

REFERENCES:
1. Mesnier, Mike, Gregory R. Ganger, & Erik Riedel, “Object-based storage,” IEEE Communications Magazine, August 2003, pp. 84-90.

2. Kim, Yongdae, Maithili Narasimha, & Gene Tsudik, “Secure group key management for storage area networks,” IEEE Communications Magazine, August 2003, pp. 92-99.

3. http://www.disa.mil/

4. http://www.don-imit.navy.mil/esi/

5. http://www.fcw.com/fcw/articles/2003/0609/news-dod-06-09-03.asp

6. Future Naval Capabilities (FNCs) website http://www.onr.navy.mil/fncs

KEYWORDS: Storage area networking; object-based storage; intelligent storage technology; enterprise storage systems; secure storage technology; modeling and simulation

N04-T018 TITLE: Automated Processing For Distributed Undersea Sensor Systems

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

ACQUISITION PROGRAM: Littoral ASW FNC

OBJECTIVE: To automate processing for distributed undersea sensor systems to the greatest extent feasible while maintaining high levels of detection performance and low false alarm rates.

DESCRIPTION: Advances in signal processing, sensor miniaturization and communications offer significant potential for transforming the way that undersea sensors are employed and for significantly improving their capability to aid Fleet operations. At the same time, manpower costs are becoming increasingly expensive. Automation of distributed undersea sensor systems offers potential for achieving a revolution in undersea sensing that would allow effective remote surveillance of important operational areas with minimal manpower costs. While the far future goal is complete automation of the sensors, associated networks and processing systems; it is likely that, in the near term, men and women will play a key part in system operations. However, it is believed that current technology developments can provide a significant degree of automation to reduce the required number of operational personnel while maintaining a robust level of system performance across a wide variety of operational environments.

Automation at sensor nodes can significantly reduce the amount of data that needs to be carried over communications links, automated sensor fusion algorithms that fuse the outputs of similar and diverse types of sensors can contribute to the rapid formation of an accurate common undersea tactical picture, algorithms for the automated detection/classification and tracking of undersea targets help direct attention to potential threat targets, automated algorithms to reliably classify surface ship contacts help reduce false alarm rates and assist in maintaining situational awareness, and automation of sensor field processing and tracking algorithms offers potential for improving the detection and tracking of difficult to detect targets.

Potential system applications include automated processing for future Advanced Deployable Systems, submarine, air, and surface ship sonar systems; Deployable Autonomous Distributed Systems, distributed systems of sensors deployed on USVs/UUVs/AUVs, and processing for large fields of distributed undersea sensors. Topics of interest include automated detection/classification and tracking algorithms, intelligent agents to improve sensor utilization; algorithms for automated directed search; automated data fusion algorithms, data compression algorithms, improved feature extraction algorithms, automated field processing algorithms and others which would improve overall system performance through reliance on a higher degree of system automation. Algorithms must be computationally efficient if they are to be used in deployed sensor nodes as both processing capability and power are often limited in availability.

The Navy is looking for proposals that are innovative, advance the technical state of the art and have the potential for achieving significant performance and cost improvements in undersea sensor systems.

PHASE I: Provide an initial development effort that demonstrates the scientific and technical merit of the proposed work. This can include simulations, studies and laboratory scale demonstrations using simulated data. The goal is to demonstrate the soundness of the proposal and its potential for achieving its stated goals.

PHASE II: Complete full development of the proposed concept and demonstrate its operation on both simulated and actual data. This may include integration into an existing sensor processing string or use as a stand alone processing algorithm, dependent on the type or work and concept being pursued. Demonstrate achievement of agreed upon metrics in areas such as hold time, time to detection, probability of correct classification, power consumption, false alarm rate, tracking accuracy, etc. as appropriate to the proposed development.

PHASE III: Demonstrate the performance of the algorithm in actual at-sea environments to the extent feasible. Produce a final product for integration and application to a Navy system.

PRIVATE SECTOR USE OF TECHNOLOGY: Automated detection and classification algorithms have many potential uses in the medical field including improved diagnostics for ultrasound, EEG and EKG monitors that would reduce the need for highly trained personnel in the initial screening of patients. Intelligent agents have potential application in fields such as data mining, order tracking, and data search.

REFERENCES:
1. www.onr.navy.mil/sci_tech/ocean/321_sensing/prog_us.htm

2. W.H. Payne, Sonar Automation Technology Working Group Final Report, MIT Lincoln Laboratory Special Report 103-1003, 4 March 2002.

3. Task Force ASW: Team A Technology Panel Report.

KEYWORDS: Sensor Automation; ASW; Data Fusion; Detection/Classification/Localization (DCL); Distributed Sensor Systems

N04-T019 TITLE: Precision Radio Frequency Emitter Location

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Sensors

ACQUISITION PROGRAM: Team Portable Collection System (TPCS) Project; Intelligence Systems Pgm

OBJECTIVE: Precision location of Radio Frequency emitters on the battlefield using advanced Time Difference of Arrival (TDOA) techniques.

DESCRIPTION: The proposed research will address three critical issues known to prohibit effective use of TDOA in a tactical environment.

1. For Time Difference of Arrival techniques to work, there must be at least three TDOA measurements for locating an RF emitter. TDOA collection sites must be precisely synchronized to a global time reference to within nanoseconds, depending on desired geolocation resolution. With current commercial off the shelf components, we are limited to 1 microsecond for a form factor compatible with portable and semi-portable equipment, which is insufficient.

2. The correlation of waveform requires a high bandwidth communication pipeline between collection sites, which is not available for tactical situations.

3. The precise location of the antennas must be known to within several millimeters. This is not possible with GPS or any other positioning system.

To improve existing intelligence sensor systems and increase capabilities of tactical Signals Intelligence and geo-location systems, the U.S. Navy is interested in developing and characterizing a TDOA solution to the three critical technical challenges stated above.

PHASE I: Provide an initial development effort that demonstrates scientific merit and capabilities of the proposed technical approach that could be demonstrated through presentation of technical research, or a limited laboratory demonstration.

PHASE II: Fabricate and characterize, in laboratory or field environment using existing fielded geo-location hardware, a technical solution to short baseline TDOA.

PHASE III: Fabricate a complete, self contained TDOA positioning system using interfaces to the existing Team Portable Collection System design.

PRIVATE SECTOR USE OF TECHNOLOGY: The technology can also be applied to any commercial requirement to track very precise locations of equipment and personnel. Examples of application would be maintaining precise accountability of high value equipment across a relatively large construction site or within a city or other large region, accountability and tracking of key personnel in a large densely populated area, or tracking high value shipments throughout transition across a region or state. Law enforcement, firefighters, border patrol and other similar non-military agencies would also benefit from this research.

REFERENCES:
1. Office of Naval Research, “Time Difference of Arrival and Frequency Difference of Arrival – Decision versus Threat Research Paper,” 09 July 2003.

2. Unal Atkis, “Time Difference of Arrival Estimating Using Wavlet Based Denoising,” Post Graduate School Thesis; http://stinet.dtic.mil/str/tr_fields.html

3. Future Naval Capabilities (FNCs) website http://www.onr.navy.mil/fncs

KEYWORDS: Direction Finding; Geo-location; SIGINT Sensors

N04-T020 TITLE: Smart Tether for Relative Localization of Moored and Towed Bodies

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

ACQUISITION PROGRAM: Organic Mine Countermeasures FNC

OBJECTIVE: To develop the means to measure, in real-time, the location and orientation of one body relative to another body when the two are connected by a cable or tether. The applications require ranges to 100 feet, maximum, with operation in saltwater.

DESCRIPTION: There are many applications where it is advantageous to track the position and orientation of a moored device with respect to its anchor, a tethered surface-born float with respect to its tow vehicle within the water column or on the bottom, or a tow body (e.g. sonar) with respect to its tow vehicle.

A prime application is a Long Base Line (LBL) navigation transponder that provides a range/position measurement for unmanned underwater vehicles (UUVs). The LBL could precisely geo reference itself using differential GPS if it was able to measure the watch circle error relative to its anchor. The smart tether device would provide that reference measurement. Another application for a smart tether would be for unmanned crawling robots that tow a tethered float for GPS positioning. The crawlers require a 60-70 foot fixed-length tether but can move into water less than 10 feet deep, creating a large watch circle error. Using GPS the crawler could navigate without transponders and localize targets. Watch circle errors are currently much greater than GPS errors obtainable with WAAS or DGPS, however the smart tether would allow the watch circle error to be corrected.

Another application for a smart tether would involve creating differential GPS (DGPS) base stations anywhere on the ocean surface. The smart tether would provide a motion measurement that could be incorporated into the GPS estimator to enable the DGPS buoy to estimate its position regardless of motion on its mooring.

Candidate technologies for this device include sonar, magnetic field sensing, and fiber-optic shape measuring techniques such as Shape Tape(tm) (see www.measurand.com). It is unnecessary for the smart tether to determine the shape of the tether, however the shape can be used as a means of determining the relative position/orientation between the two ends. The technology chosen should provide a measurement system that could become low-cost (<$1,000 per application), provide update rates of at least 1 per second, be compact (<220 in3), and low power (<5W).

PHASE I: Provide an initial development effort and construct a prototype for a reduced range (20 foot) device that demonstrates scientific merit and capabilities of the proposed system. The prototype¡¦s performance should be characterized.

PHASE II: Fabricate and characterize a smart tether suitable for a DGPS sea buoy or crawler, with 75 feet maximum range capability. Characterize performance of the device moored at sea. Adapt the device to a crawling vehicle to demonstrate navigation via DGPS (from a land differential station). This devic should target low power and size requirements to the extent possible.

PHASE III: Produce a set of 10 refined developmental systems for test applications on LBL transponders and gateway buoys, tow bodies, and sub-sea robots. Develop GPS algorithms to include the motion measurement in the estimator.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Successful development would enable moored DGPS stations to be inserted anywhere in the sea, supporting shipping as well as military-amphibious operations. Watch circle error correction would enable precise geo-location of unmanned systems used in undersea construction, oil exploration, and marine research anywhere in the world without the need for placing acoustic LBL systems. Alternately the device would enable acoustic LBL systems to reference themselves accurately and automatically. The device would provide improved tracking of sonar tow bodies used in sea floor mapping and mining operations.

REFERENCES:
1. http://www.onr.navy.mil/fncs/mcm/

KEYWORDS: tether, moored, DGPS, Long Base Line, transponder, geo reference

N04-T021 TITLE: Patient Warming Device for Casualty Care

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: To develop a technology that will prevent hypothermia and maintain normothermia in critically ill patients at temperatures typically encountered in the field and during transport onboard aeromedical evacuation aircraft (≈10ºC).

DESCRIPTION: A major medical problem identified in Operation Iraqi Freedom (OIF) was patient warming, including maintenance of normal body temperature of vented, paralyzed patients during air transport. Hypothermia as a result of hemorrhage remains a significant clinical challenge in critically injured patients and is associated with an increased incidence of cardiac arrhythmias and aggravation of life-threatening acidosis and coagulation deficiencies. The Marine Corps currently lacks certain capabilities to safely transport critically injured patients to higher echelons of care considering the times and distances expected in an expeditionary warfare environment. A necessary capability identified in OIF is a unit/system which provides warming (convective or other) to maintain normothermic body temperature under conditions typically encountered in the field (temperatures of 0°C and above) or during air transport (10°C). The device must provide some method of monitoring, and displaying, core/body temperature. The device must also be small, lightweight and of minimal volume (size), be capable of easy calibration and maintenance. If dependent upon batteries as a power source, then the batteries should be non-proprietary and commercially available, and provide a minimum of 2 hrs continuous operation at maximum output. Operation of the device must require minimal training and maintenance by the operator/corpsman. Hardware development must include shock, vibration, environmental, and electromagnetic compatibility testing to assure the receipt of airworthiness certification. Food and Drug Administration 510k clearance must also be obtained.

PHASE I: Provide an initial development effort that demonstrates scientific merit and basic capabilities.

PHASE II: An operational prototype will be delivered for field testing, aeromedical testing, and review by the FDA.

PHASE III: Produce final device and obtain FDA 510k approval and airworthy certification

PRIVATE SECTOR COMMERCIAL POTENTIAL: Successful development of device will have applicability to both military and civilian medical markets since neither military nor civilian transport vehicles have adequate patient warming capabilities.

REFERENCES:

1. Armand R, Hess JR. Treating coagulopathy in trauma patients. Transfus Med Rev. 2003 Jul;17(3):223-31.

2. De Waele JJ, Vermassen FE. Coagulopathy, hypothermia and acidosis in trauma patients: the rationale for damage control surgery. Acta Chir Belg. 2002 Oct;102(5):313-6.

3. Lynn M, Jeroukhimov I, Klein Y, Martinowitz U. Updates in the management of severe coagulopathy in trauma patients. Intensive Care Med. 2002 Oct;28 Suppl 2:S241-7.

4. Future Naval Capabilities (FNCs) Warfighter Protection website http://www.onr.navy.mil/fncs

KEYWORDS: Hypothermia; Prevention; En Route Care

N04-T022 TITLE: Energy Scavenging

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: Advanced Capability Electric System FNC

OBJECTIVE: To develop regenerative power and sensor devices for installation in propulsion rotating components and propulsors. Power will be efficiently extracted from the ship's propulsion train components and used to power sensors that will monitor the performance and health of system components as part of condition based maintenance implementation.

DESCRIPTION: Options to extract electrical energy from the rotational energy of impeller and propeller (air and water) blades need to be explored and developed. This electrical energy can be used to power auxiliary systems, sensors, or other items that might be embedded within the propeller or its associated hub, ducting, or shaft. These systems might include: strain gages to monitor blade strains; accelerometers and vibration inducers to accomplish active vibration control; and pressure sensors to direct active blade pitch modification for cavitation reduction. Energy generated directly at the site of the sensor or system being powered eliminates the cost and maintenance of cabling and cable channels, and the need to transfer energy from the stationary platform located source to the rotating impeller or propeller components.

PHASE I: Provide an efficient energy scavenging feasibility concept inlcuding energy regeneration devices and sensor systems.

PHASE II: Develop a prototype demonstration of the feasibility conept from Phase I.

PHASE III: Conduct further in-situ tests of the prototype demonstrator developed in Phase II to prove transitionability.

PRIVATE SECTOR USE OF TECHNOLOGY: Energy scavenging technology can be applied to electrical and mechanical systems across the Department of Defense as well as the commercial energy utilities to power sensors for condition based maintenance health monitoring and vibration control.

REFERENCES:

1. http://www.onr.navy.mil/sci_tech/engineering/334_shiphull/

KEYWORDS: regenerative energy; propulsion system; condition based maintenance

N04-T023 TITLE: Electrical Power Systems Management

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: Advanced Capability Electric System

OBJECTIVE: Electrical Power System Management consists of several components among which intelligent load shedding, voltage and line security, and isolation for grounded systems during battle conditions are of primary interest. This research will enable a solution to problems encountered in ship electrical power systems that may lead to complete loss of power in critical electrical buses when abnormal load or damage conditions are encountered. This research will provide a tool to enable reliability, and fight through capability of the shipboard electrical power system.

DESCRIPTION: Circuit theory and ship electrical system one-line diagrams have shown that the magnitude of voltage at some electrical buses in the ship may decrease as a result of excessive loading, such as from the loss of generation capacity or system faults, such as from battle damage. The undesired electrical bus voltage decrease – that may lead to complete loss of voltage at some electrical buses in a ship– could be prevented by intelligently reconfiguring the power plant including energy storage, shifting loads, or shedding loads that are non-critical to combat operations.

PHASE I: Provide a feasibility concept for an intelligent algorithm that will communicate necessary actions to ship personnel for power management.

PHASE II: Using feasibility conept developed in Phase I provide a prototype demonstrator to show ability of the algorithm to control and manage electrical power.

PHASE III: Incorporate the prototype demonstrator shipboard for application.

PRIVATE SECTOR USE OF TECHNOLOGY: This technology can be applied to electrical distribution lines in the utilities industry to help ensure that future power outages are avoided through the management of loads.

REFERENCES:
1. http://www.onr.navy.mil/sci_tech/engineering/334; www.iee.org; www.epri.com

KEYWORDS: electrical systems; power management; load shedding; modeling and optimization; ship design; intelligent systems

N04-T024 TITLE: Multi-disciplinary Computational Tools for Naval Design

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

ACQUISITION PROGRAM: NAVSEA 05P Ship Survivability

OBJECTIVE: Develop a multi-disciplinary computational design tool that will improve the accuracy or decrease the computational cost of design prediction for Naval platforms in the area of ship hull and damage control.

DESCRIPTION: Currently the practice in place for designing ships is the ‘spiral design’. This methodology looks at one aspect of the ship (such as survivability), designs to a requirement then looks at another aspect of the ship (such as power) and continues around the spiral hitting one technical aspect of the ship each revolution. The ability to design with a multi-disciplinary approach (interactively and simultaneously) would lead to an immediate improvement to innovations for ship design. Many of the advanced computational techniques for specific disciplines such as structural acoustics, electromagnetics, and magnetic signatures, fluid-structure interaction, shock response, explosive damage, penetration and fragmentation, and implosion have already been developed by the research community. This research would take these tools and their parameters and implement them into a tool that would enable designing the ship in a multi-disciplinary fashion (i.e., hull structures, hydromechanics, signatures, and damage control) bringing about a revolution in ship design.

PHASE I: Provide a feasibility concept for a design tool to improve the viability and accuracy of the algorithms via a research code.

PHASE II: Using the Phase I feasibility concept provide a prototype demosntrator of the computational code.

PHASE III: Using the prototype demosntrator, evaluate the design tool's performance against actual design problems. Adapt and refine the tool.

PRIVATE SECTOR USE OF TECHNOLOGY: commercial aircraft interior and exterior noise reduction; noise, vibration, and harshness design tools for the auto industry; commercial security industry

REFERENCES:
1. www.onr.navy.mil/sci_tech/engineering/334_shiphull/; www.sname.org; www.asne.org

KEYWORDS: computational design tools; acoustics; electromagnetic signatures; fluid-structure interaction; explosive damage; implosion

N04-T025 TITLE: Hybrid Inference System for Data Fusion and Decision Support

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Investigate and develop an intelligent inference structure and related algorithms that seamlessly integrate reasoning in numeric and symbolic domains involving both continuous and discrete variables, with an emphasis on data fusion and decision support applications.

DESCRIPTION: Many complex analytic problems and decision support tasks are better solved using and integrating different reasoning paradigms and problem-solving strategies. In terms of the variables involved in a reasoning process, the inference techniques can be roughly divided into two categories: one that is featured with computations on continuous variables in numeric domain, and the other that is featured with manipulations of discrete variables that operate in either numeric or symbolic domains. Inference structures that operate in the continuous domain include Bayesian Networks (BN), Hidden Markov Models (HMM), Neural Networks (NN), to name a few. Inference structures that operate in discrete domains include predicate logics, discrete networks, cellular automata, etc. The current state-of-the-art in reasoning seldom combines these two inference paradigms together due to the distinct nature of the computations. To have them function together, it is necessary to devise a structure of inference that allows the dissimilar reasoning and representational techniques to cooperate within a common framework. Two major issues to be addressed by the research are the abilities of the inference structure to deal with uncertainties and the computational efficiency of the reasoning processes where the continuous and discrete inferences interact and cooperate seamlessly. The highest priority application area is Navy multi-source intelligence analysis for battlespace C2 assistance.

PHASE I: Investigate the various existing inference structures in both continuous and discrete domains. Identify or develop a proper structure of inference and related algorithms that seamlessly integrate reasoning involving both continuous and discrete variables. The new structure needs to take proper account of uncertainty and efficiency issues. Develop a prototype to demonstrate the feasibility of the structure and its application to one or two selected problems in data fusion and decision support.

PHASE II: Develop and demonstrate a prototype tool suitable for testing the capabilities and limitations of a hybrid inference structure. Provide metrics for measuring improved decision support and data fusion performance.

PHASE III: Validate models and algorithms through a collection of performance data in an experimental or simulated operational environment. Prepare guidelines and documentation for tool transition to an operational setting.

PRIVATE SECTOR USE OF TECHNOLOGY: The hybrid inference technology has substantial dual-use potential and will impact competitiveness and performance of the commercial sector as well as the military sector. In particular, this hybrid inference system would be of use in the financial and marketing sectors, where complex and decision support based on continuous and discrete variables is required.

REFERENCES:
1. H. Dai, et al (1997), "Intelligent inference within objects using constraint rules," Proceedings 1997 IEEE International Conf. on Intelligent Processing Systems, Vol. II, pp. 1067-1071.

2. D. Koller, U. Lerner, and D. Angelov (1999), "A General Algorithm for Approximate Inference and its Application to Hybrid Bayes Nets," In Proceedings of the 15th Annual Conference on Uncertainty in AI (UAI), Stockholm, Sweden, August 1999, pages 324--333.

3. U. Lerner, E. Segal, and D. Koller (2001), "Exact Inference in Networks with Discrete Children of Continuous Parents," Seventeenth Annual Conference on Uncertainty in Artificial Intelligence (UAI), Seattle, Washington, August 2001, pages 319 - 328.
KEYWORDS: Intelligent inferences, Reasoning under uncertainty, Hybrid systems, Bayesian network, Discrete networks, Data fusion

N04-T026 TITLE: <u>A Human-Centric Architecture for Net-Centric Operations</u>

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Combine existing peer-to-peer collaboration infrastructure and available middleware (such as CoAbs) with developmental cognition-based knowledge management tools to test and demonstrate enhanced team situational awareness in distributed, mixed-discipline, information-intensive decision-making environments.

DESCRIPTION: The change from platform-based warfare to quick-response asymmetric warfare has driven the requirement for distributed situational awareness. Future operations will be unique, one-of-a-kind actions that must integrate warriors, sensors, networks, platforms and weapons. Operations will be distributed, have quickly changing participants, uncertain data/intelligence and more automated and agent-based interfaces. Some examples of capabilities required to respond to this new environment include:

- Quick development of shared understanding among participants
- Quick analysis of uncertain and open source data
- Agents that leverage the human cognitive process
- Tools to facilitate distributed collaboration
- Use of performance metrics to assess team performance.

Team shared understanding is central to many tasks faced by the military in which multiple operators who are separated by space and time interact to make time-critical decisions in a complex data-uncertain environment. A key issue to be addressed is the ability to represent and transfer meaning to others on the network. New group knowledge building computational models are being developed. These show how people organize and relate information for the purpose of problem solving. These computational solutions can facilitate user collaboration in large, distributed and decentralized teams across organizational boundaries while maintaining individual ways of working. Initial progress has been made in the MIT "EWALL" project which provides technology for the automatic conversion of user generated spatial information arrangements into computer understandable networked information for the automatic exchange and prioritization of contributions between collaborating users. Such a process could employ algorithms to manipulate, relate and visually display contextual information and provide automated agent negotiated distribution of information for both individual and team interaction. Provided with a supporting infrastructure, these models could produce significant gains in net-centric collaborative team decision-making. Models could be tested and validated in government lab, university or industry network simulation sites.

PHASE I: Develop a feasible concept. Analyze and select a cognition-based knowledge management tool set that can transfer meaning (commander's intent) in net-centric operations. Combine with a collaboration supporting infrastructure. Develop a demonstratable model or architecture for improving multi-disciplinary team decision making.

PHASE II: Develop and demonstrate a prototype tool or model for supporting team situational awareness development. Provide metrics for measuring improved team situational awareness and improved collaborative performance.

PHASE III: Validate model through collection of performance data in an experimental or simulated operational environment. Prepare guidelines and documentation for tool transition to an operational setting.

PRIVATE SECTOR USE OF TECHNOLOGY: This technology product could be applied to any collaborative or team problem solving situation where it is necessary to develop a team consensus on an issue or product.

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2. ForceNet: Turning Information into Power: Vice Admiral Richard W. Mayo, U.S. Navy, and Vice Admiral John Nathman, U.S. Navy; Naval Institute Proceedings, February 2003

3. http://ewall.mit.edu/abstract/

KEYWORDS: Human-centric, analysis, situational awareness, problem solving, human performance metrics, agents, cognitive processes

N04-T027 TITLE: <u>Development of Battlespace Information Flow and Content Methodology</u>

TECHNOLOGY AREAS: Information Systems, Battlespace, Weapons

OBJECTIVE: To investigate and develop an information model methodology to enable the assessment of new concepts for battlespace information flow and content. This model will be used to assess the information content exchanged in the battlespace and support development of process automation approaches. Work will focus on data needed for target/object detection, tracking, classification, and identification (level 1 data fusion).

DESCRIPTION: Today, information is passed in the battlespace through a number of dedicated communication systems using disparate data structures and classifications/caveats. This results in technical problems with data integration, and necessitates manual assembly of tactical pictures by warfighters. Sensor proliferation, products, and delivery rates are far out stripping the ability of operators to digest information and make decisions. Data fusion studies indicate potential value of establishing common data elements, standard measures of uncertainty, information pedigrees, and semantic content descriptions. A system engineering process is needed to investigate data requirements, performance trade-offs, and reach conclusions that will enable more efficient use of information flow and exchange. Data transfer involves both reported tracks and retrieval from database repositories.

The automation of information distribution and collection requires a top down look at Information Technology (IT) processes. Typically, sensors are controlled, and data disseminated, from platforms manually by highly trained operators. Once data is packaged in the form of messages, automated computer processing can occur. Unfortunately, different message standards have evolved to support various communication systems and information types that have made fusion – particularly multi-intelligence discipline – difficult. The generation of a Common Operational Picture (COP) requires fusion to be effective. A lack of consistency exists in message sets used for target tracking, target classification, and threat identification (i.e., adversary, own force, and neutral). Furthermore, uncertainty representation is limited, target reporting rates are not variable, pedigree of data is lacking, and databases do not support new sensors. Nevertheless, all the ingredients exist for construction of a FORCEnet concept. The proposed approach would both complement existing systems and add advanced sensor signatures, incorporate dynamic networks, and use intelligent agents for process automation. The concept is based on data movement through an Internet-like environment with access of platforms through gateway agents.

New data content and approaches for exchange will be identified through analysis and Monte Carlo simulation. Data content includes raw data (e.g., image files), metadata (e.g., track data), and derived products (e.g., intelligence). Exchange approaches include media access via publication and subscription methods made possible by data pedigree. Scenarios will be constructed and simulation used to investigate information flows and impacts on sensor, environment, and communication systems. Targets will be studied that present a challenge to time critical missions such as missile defense. A Single Integrated Picture (SIP) will be output to a situation display for an operator. Quantifiable metrics will be defined and used to assess the value of existing and future sensor data exchanged through the battlespace. This effort will contribute to the technology roadmap for FORCEnet implementation being developed at SPAWAR.

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

PHASE I: Analysis and Simulation Requirements. Provide an initial development effort that demonstrates the capabilities of the methodology to adequately represent new technology insertions (such as data pedigrees, new sensor attributes, imagery annotation, XML, DAML, or speech-to-text conversions) and show reasonable effects of those technologies on the SIP. Representation of these technologies in the model needs to be explored. Rationale for model and methodology selection based on characterization of the technology insertions will be required. In addition, metrics need to be defined to measure performance gains. Statistics on the data content and flow should be defined in order to support metrics and analysis. The contractor shall outline requirements for a simulation to support automation of a SIP.

PHASE II: Simulation Test-bed implementation: This task consists of building the model and developing the tools to make trade-off experiments, run different operational scenarios, and collect and analyze the data. It will build on the results of Task 1 to identify the feasibility of technology insertion. The objective of this task is to ensure that information flows in the battlespace are realistically modeled in the simulation. The test-bed used may leverage other simulation work or take a fresh start. Monte-Carlo simulations will be performed with human performance modeled by scripts where possible. Simplifying assumptions will be made with respect to target motion, sensor performance, and communication capability.

PHASE III: Product Demonstration and Transition: A product demonstration is needed to show the impact of information flow on the SIP when applied to specific military applications. This will build on the result of tasks 1 and 2. A computer workstation will be used to illustrate potential gains in information distribution as follows: 1) recommended additions/changes to existing message data elements, 2) recommended changes/additions to information routing and 3) visualization of associated message and database information. If possible, a laptop version will be constructed with synthetic data to remain unclassified and permit the demonstration to be taken on the road to show potential transition sponsors. Product transition to a military or commercial program will be assisted by the Space and Naval Warfare Systems Command.

PRIVATE SECTOR USE OF TECHNOLOGY: This tool will aid decision makers on investment of process automation and information content technologies for their business processes. Commercial applications might include command and control technology for airport and ship port uses. As examples of non-military government entities, emergency response and homeland security agencies can also benefit from this technology.

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2. Scott McGirr, "Resources for the Design of Data Fusion Systems", ISIF Fusion 2001 Conference on Information Fusion, Montreal, Canada, Aug 10, 2001.

3. James Llinas and Dave Hall, Handbook of Multisensor Data Fusion, CRC Press, 2001.

4. Richard T. Antony, Principles of Data Fusion Automation, Artech House, Inc., 1995.

KEYWORDS: Battlespace; information architecture; modeling; simulation; data fusion; information content

N04-T028 TITLE: Intelligent Imaging System

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: To develop an imaging sensor integrated with a programmable image processing computer on a single chip using semiconductor VLSI technology. Programmability and adaptive response of the imaging sensor for use in visible and infrared surveillance applications will be implemented.

DESCRIPTION: Demonstrations of image processing functions based on cellular array technology prove that chip level, teraops performance can be achieved for processing images produced by focal plane arrays or similar 2 dimensional sensors. The VLSI technology for the cellular computers has been validated using semiconductor foundry production services. This technology, described as Cellular Nonlinear Networks (CNN)-Universal Machine, incorporates analog and digital functions to operate as an image processing supercomputer on a chip. Input and output control, local memory, and stored programs are integrated on the chip. High level programming languages have been developed, such that only a few lines of code are needed for any given function. Teraops speeds are indicated by tests performing complex image processing procedures at over 10,000 frames per second on 128x128 pixel size images. Tests indicate that the CNN-UM technology is over 100 times faster than the performance of digital PC computers and uses over 100 times less power. The new opportunity is to integrate the sensors directly onto the computer. Sensors could include, IR or visible Focal Plane Arrays, miniaturized millimeter wave antennas, and various MEMS arrays.

The CNN-UM computer can be programmed, locally or remotely, and the sensor arrays can be adjusted in real-time based on the output of the computer, thus providing a measure of adaptation, such as tuning individual pixel sensor operation. Procedures for hyperspectral and image fusion operations are in place. Targeting and tracking algorithms of multi-target scenarios have been developed. Integration of sensor and computer, provide a revolutionary technology for the Navy. Low power, very high speed, very small size combine to suggest a wide variety of new applications. These include: UAV surveillance; micro-air vehicles; ground based surveillance; smart weapons such as self-guided missiles; autonomous vehicle navigation combined with terrain mapping; mine detection; collision avoidance; autonomous robots; facial recognition and other identification systems; targeting and tracking; target identification and IFF. "At sensor" image processing will dramatically reduce streaming video and bandwidth requirements for remote viewers.

PHASE I: Select specific sensor technology for demonstration in the intelligent sensor program. Design the materials technologies required for integration of sensor with the silicon based VLSI CNN-UM. Specify the image processing functions necessary for demonstrating the intelligent sensor concept.

PHASE II: Design CNN chip for integration with sensor array which can demonstrate the specified image processing function. Develop the lithography and materials processing technology. Fabricate and test prototype chips.

PHASE III: Develop advanced CNN-UM/Sensor designs for foundry level manufacturing. Provide prototype systems for Navy programs involving surveillance and targeting and tracking operations.

PRIVATE SECTOR USE OF TECHNOLOGY: Intelligent sensors involving greatly reduced power and size requirements, elimination of slow digital electronics methods, reprogrammability of operation, and combined with versatile design possibilities indicate an enormous spectrum of applications. Facial recognition, fingerprint identification, collision avoidance, home security, area security, letter and script recognition, monitoring manufacturing processing, and label reading are possible applications.

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2. Chua & Roska, "The CNN Paradigm", IEEE Transactions on Circuits and Systems, I, 40, 147.

3. Roska, Computer Sensors:Spatial-Temporal Computers forAnalog Array Signals, Dynamically Integrated with Sensors, Journal of VLSI Signal Processing, Vol. 23, pp. 221-237, 1999.

KEYWORDS: Teraops; Image-processing; focal plane arrays; surveillance; intelligent-sensors; smart weapons.

N04-T029 TITLE: SiC Epitaxial Growth by Halo-hydrocarbon Precursor Growth

TECHNOLOGY AREAS: Materials/Processes, Electronics

OBJECTIVE: To explore and develop a technology for growth and doping control of epitaxial SiC films using halogenated-hydrocarbon/silane precursor gases

DESCRIPTION: To date SiC epitaxial films are grown by subliming (PVT) industrial abrasive corundum powder, or by reactive thermal cracking silane and propane. Powder sources change shape and surface area during growth which translates to non-uniform and unpredictable growth rates. In addition, PVT does not allow rapid changes in donor or acceptor doping. Because of the very high temperatures required to sublime SiC for epitaxial growth (~2,200C) only graphite can be used for containers and heater elements. Graphite sheds particulates, and undesired impurities at high temperature, generating micropipes, high background doping concentrations and other electronically deleterious defects. Large temperature excursions to room temperature, after growth, build severe stresses into the crystal boule. This translates to large dislocation densities and the initiation of stacking faults which, at present, degrade bipolar SiC devices almost immediately they are turned on. Increasingly SiC is grown epitaxially from silane and propane precursors, however temperatures are still very high >1,600.

By Substituting Halogenated hydrocarbons for propane it is expected that growth temperature can be reduced by ~3-500C, to ~1,000C, allowing container, heater element and substrate mounts to be made from more conventional high purity materials, and reducing the residual thermal stresses of grown films.

The Navy will only fund proposals that are innovative address the described R&D and involve a measure of technical risk.

PHASE I:
1. Construct or modify existing laboratory scale epitaxial SiC equipment for the growth and controlled

doping of high purity SiC epitaxial films, from highly purified halogenated hydrocarbons and silane gas sources. Silane and halocarbon sources should be replenishable without compromising the growth of bulk crystals. Investigate epitaxial growth temperature reduction (> 500 Centigrade degrees) by use of halogenated hydrocarbon precursors.

2. Determine the most effective halogenated hydrocarbon, (e.g CHCl3, CH2Cl2, CH3Cl, etc….)

3. Investigate the purity, uniformity and growth rate, as well as polytype as a function of growth temperature halocarbon species and flow rates, ratios, and substrate vicinality.

PHASE II:
1. Develop a commercial multi-wafer epitaxial growth equipment capable of > 4" diameter, high-purity, reduced defect density SiC epitaxial films, from highly purified halogenated hydrocarbons.

2. Demonstrate Simultaneous reproducible uniform multi-wafer epitaxial SiC film growth on >3" diam. substrates, and demonstrate control of free electron and or hole concentrations in the range 1014 through 1019 cm-3

3. Demonstrate the ability to grow bulk 4H, or 6H SiC significantly (>300C) below conventional epitaxial growth temperatures

4. Deliver grown epitaxial films to ONR for independent testing and characterization.

5. Grow high purity semi-insulating SiC epitaxial films on 4 inch dia.C-plane SiC and >1inch dia. A-, or M- plane substrates with reproducibility better than 2 % in thickness and growth rate, and better than 30% in doping levels. Supply wafers to NRL, and research facilities to be designated by the Technical POC.

PHASE III: Produce commercial scale > 4" diameter halo-hydrocarbon epitaxial growth system and commercially supply up to 4" diameter SiC epitaxial device structures, with reduced background impurity, dislocation and micropipe densities.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The power electronics industry has enormous potential need for SiC devices to replace Si. This need will only be realized if low defect SiC materials are made possible by the reduced temperature growth offered by halo-hydrocarbon/silane epitaxy.

REFERENCES:

1. J. D. Parsons, and G. B. Kruaval, Electrochem. Soc. J. 1412, 771, (1994)

2. M. S. Saidov,. K. A. Shamuratov, and M. A. Kadyrov, J. Crystal Growth, 87, 519 (1988)

KEYWORDS: SiC epitaxy, semiconductor, film growth, halo-hydrocarbon precursor,

N04-T030 TITLE: Halo-hydrocarbon Growth of Bulk SiC

TECHNOLOGY AREAS: Materials/Processes, Electronics

OBJECTIVE: To explore and develop a technology for growth of large diameter >3x longer single crystal SiC boules using halogenated-hydrocarbon/silane precursor gases.

DESCRIPTION: To date most SiC crystal boules are grown by subliming (PVT) industrial abrasive corundum powder, or by reactive thermal cracking silane and propane. Powder sources change shape and surface area during growth which translates to non-uniform and unpredictable growth rates. In addition, at the high temperatures required to sublime SiC for bulk growth (~2,400C) only graphite can be used for source and seed containers and heater elements. Graphite sheds particulates, and leaches undesired impurities at these temperatures, generating micropipes, high background doping concentrations and other electronically deleterious defects. Large temperature excursions to room temperature, after growth, build severe stresses into crystals boules. This translates to large dislocation densities and the initiation of stacking faults in subsequent epitaxial devices. More recently, Okmetic (a Swedish company), is now producing commercially viable SiC with much higher crystalline perfection than US domestically produced PVT crystals, by growing from externally replenishable and controllable gaseous sources, namely silane SiH4 and propane C3 H8, however growth temperatures are still very high > 1,900C.

By Substituting halogenated hydrocarbons for propane it is expected that growth temperature can be reduced by > 500C degrees to between 1,200 and 1,600C, allowing container, heater-element and substrate-mounts to be made from a wide variety of high purity materials, and reducing the residual thermal stresses of subsequent substrates, epitaxial films, and implants..
The Navy will only fund proposals that are innovative, address the described R&D, and involve a measure of technical risk.

PHASE I:
1. Construct or modify existing laboratory scale epitaxial SiC equipment for the growth of high purity 4H, 6H, and/or 3C SiC crystals, from halogenated hydrocarbons and silane sources. Silane and halocarbon sources should be replenishable without compromising the growth of bulk crystals.

2. Investigate boule growth temperature reduction (> 500 Centigrade degrees) by use of halogenated hydrocarbon precursors.

3. Investigate the most effective halogenated hydrocarbon, (e.g CHCl3, CH2Cl2, CH3Cl, etc….) for bulk SiC growth.

4. Investigate the purity, uniformity and growth rate, as well as polytype as a function of growth temperature halocarbon species and flow rates, ratios, and substrate vicinality.

PHASE II:
1. Develop a commercial bulk SiC growth equipment capable of > 4" diameter, 6" long, high-purity, reduced defect density SiC crystals, from highly purified halogenated hydrocarbons.

2. Demonstrate reproducible 2, 3 and eventually 4" diam SiC boule growth at rates in excess of 1mm per hour,

3. Demonstrate growth of bulk 4H, 6H, and / or 3C SiC significantly (>>300C) below conventional bulk growth temperatures.

4. Deliver sliced and double side-polished substrates to ONR for independent testing & characterization.

5. Demonstrate better than 5% reproducibility in growth rate, and boule length >3"

6. Supply wafers to NRL, and research facilities to be designated by the Technical POC.

PHASE III: Produce commercial scale > 4" diameter halo-hydrocarbon bulk growth system and commercially supply up to 4" diameter SiC substrate wafers with reduced background impurity, dislocation and micropipe densities.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The power electronics industry has enormous potential need for SiC devices to replace Si. This need will only be realized if low defect SiC materials are made possible by the reduced temperature growth offered by halo-hydrocarbon/silane bulk (and epitaxial) crystal growth.

REFERENCES:
1. "Morphological Structure of SiC, Chemically Vapor Deposited on ……..", J. D. Parsons, and G. B. Kruaval, Electrochem. Soc. J. 1412, 771, (1994)

2. "Study of Growth Conditions of Silicon Carbide Epitaxial Layers", M. S. Saidov,. K. A. Shamuratov, and M. A. Kadyrov, J. Crystal Growth, 87, 519 (1988)

KEYWORDS: SiC bulk crystal growth, SiC substrate, semiconductor, film growth, halo-hydrocarbon precursor

N04-T031 TITLE: Advanced Robust Modulation (ARM)

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: SPAWAR PEO C4I&Space, PMW-173, PMS 401, PMA 264/290, NSG

OBJECTIVE: To develop, prototype, evaluate and demonstrate new advanced modulation techniques that simultaneously possess the features of robustness, security, high capacity, rapid synchronization and ad-hoc configuration for high bandwidth mobile platform communications.

DESCRIPTION: OSD has mandated a communications architecture for the future of the US military; the Global Information Grid is to be connected by buried fiber, space-based lasers, and RF/laser links. The Navy also requires diverse, reliable, secure, and robust communications for submerged platforms, such as submarines, UUVs and manned mini-subs. Undersea communications utilize acoustic, radio frequency and optical propagation phenomenon to transfer information. Due to the harshness and dynamics of sea water on these phenomenon, the product of communications rates and communications range is relatively small, even for acoustics [1] which has the only relatively long range performance. Undersea communications from OSD systems employing lasers and high frequency (but very broadband) RF sources requires a revolutionary approach; existing systems cannot realize adequate performance to securely communicate between OSD's GIG network and the Navy's undersea assets.

To enhance the Navy's unique undersea communication demands and utilize OSD's "ubiquitous communications" systems, new undersea communications systems are required. These undersea communications techniques must realize secure, robust, reliable, high data-rate communications in the harsh/dynamic undersea environment. The new communications techniques must utilize the extreme bandwidth in both the RF and optical realms offered by the OSD infrastructure and exploit the valuable bandwidth commodity to realize enhancements undersea. One example of an advanced modulation that possesses these multiple features simultaneously is Scale-Time Offset Robust Modulation (STORM) [2-3]. This new waveform can supplement traditional modulation techniques in existing radios by employing an embedded reference signal that is offset in both time (delay) and time-scale (compression/dilation). This differential modulation scheme offers a tradeoff to enhance robustness and reliability without sacrificing security or data-rate; other schemes may work as well. Instant synchronization is desired to supplement traditional burst/ad-hoc communication strategies; STORM achieves this by adding the embedded synchronization. The rapid synchronization is required to enhance data-rate and security, but also substantially aids in multi-user detection and multi-user interference mitigation. This advanced robust modulation should be characterized, evaluated and prototyped for wireless RF and optical links and examined for enhancing undersea communications performance.

The Navy will only fund proposals that are both innovative and involve technical risk.

PHASE I: Deliver an initial design for a prototype transceiver using an advanced robust, secure modulation waveform and demonstrate the scientific merit and capabilities for both RF wireless and optical communications. Identify and quantify the primary communications measures of performance that will be employed to characterize the value added by the modulation. Deliver the prototype design for both RF and optical experimentation.

PHASE II: Fabricate/prototype one or both of the RF and optical robust, secure waveforms in communications transceivers. Employ programmable logic elements that allow for rapid and easy transition into existing communications systems. Configure and execute experiments that characterize and quantify the undersea communications performance enhancements due to the new modulation. Recommend design modifications and improvements to further improve the modulation's performance.

PHASE III: Implement the new modulation's performance enhancements in programmable logic. Characterize and quantify the value-added undersea communications performance enhancements. Perform design tradeoffs for transitioning the new modulation into existing and future Navy RF wireless and undersea communications systems/architectures.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Successful development and characterization of the new advanced robust, secure modulation technique should result in another tool for wireless RF/optical and undersea communications and performance tradeoffs. Subsurface laser communications has potential impact in undersea geo-exploration. Additionally, characterizing the dispersion of broadband light sources after passing through diverse materials, including human tissue, has many potential commercial applications of high interest. The advanced modulation waveform is a communications technique that offers potential beyond just robust, secure RF wireless and optical undersea communications.

REFERENCES:
1. J. G. Proakis, E. M. Sozar, J. A. Rice, M. Stojanovic, "Shallow Water Acoustic Networks," IEEE Communications Magazine, November 2001

2. P. S. Wyckoff, R. K. Young, D. N. McGregor, "Scale-Time Offset Robust Modulation (STORM)," MILCOM 2003, October 2003

3. R. K. Young, P. S. Wyckoff, D. N. McGregor, " Robust Communications for Post-launch Weapon Links," MILCOM 2003, October 2003

KEYWORDS: Modulation; Robust Communications; Secure Communications; Undersea Communications; Laser Communications; Optical Communications

N04-T032 TITLE: VCSEL Laser Source for CPT Atomic Clock Program

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Electronics

ACQUISITION PROGRAM: Navigation Technology Program

OBJECTIVE: The objective of the CPT Atomic Clock Program is to develop a miniature Coherent Population Trapping, CPT Atomic Clock, with high temporal stability and with a physical size of ten cubic centimeters. Key to this development is the availability of a Vertical Cavity Surface Emitting Laser, VCSEL, source operating in the interval 780 to795nm.

DESCRIPTION: The performance of the CPT Atomic Clock has been demonstrated and has been shown to deliver highly stable temporal signals when configured in small size, recently 40 cubic centimeters. Central to the performance of this clock is a laser source that operates at the CPT absorption frequency within the wavelength range 780 and 795nm. This source must produce at least one milliwatt of optical power, possess a maximum threshold current of 2.0 mA, have a tunability of +/- 0.25 nm., be able to be modulated up to 4 GHz., have a life time of 100,000 hours at 85 degrees centigrade, and must exhibit low RIN noise. The application of this device will be to a small, ten cubic centimeter, CPT clock now under development.

Clocks of this kind can be used to supplement timing signals derived for the Global Positioning System (GPS), providing a robust back-up if GPS service is intermittent. A precision time source that is small, and low cost, can be readily incorporated into a wide rage of Navy and DoD platforms, greatly increasing the effectiveness of these platforms in terms of Navigation, Secure Communications, Precision Attack, and CEC.

PHASE I: Explore design concepts for the VCSEL source described above. Define form factors, anticipated power levels, life expectancy, RIN noise spectral intensity, etc. Determine suitability of the proposed device to the general application defined above.

PHASE II: Incorporate technology ideas explored in Phase I into a new VCSEL source. Fabricate the VCSEL source and demonstrate performance at the required optical frequency, with sufficient power, and with acceptable RIN noise levels. Estimate time-dependent performance degradation through tests that can be extrapolated to 100,000 hours at 85 degrees centigrade. Report upon projected time-dependent performance. Deliver operating prototype to the Navy.

PRIVATE SECTOR USE OF TECHNOLOGY: Availability of a compact, low-cost atomic clock can be of significant value to the private sector where precision time synchronization is needed. Areas of top priority include: communications networking, when high speed data routing is employed. And, utilization in electronic systems that require either precise time or precise time differences, as in Radar Systems.

REFERENCES:
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2. Navigation Science and Technology Annual Program Review: Contractor reports need for domestic VCSEL source 14 May 2003

3. Vulnerability of US forces to GPS Jamming. Reports by IDA, NSB, NIST, and ONR.

N04-T033 TITLE: Small Footprint High Power High Frequency Acoustic Sensors

TECHNOLOGY AREAS: Sensors, Electronics, Weapons

ACQUISITION PROGRAM: PEO-SUB PMS-415, Undersea Defense Warfare Systems (Submarine&Surface Ships)

OBJECTIVE: To develop broad bandwidth, high power, single crystal based acoustic sensors for target detection and homing of small diameter (less than 7-inch) undersea weapons.

DESCRIPTION: The use of new high performance active single crystal piezoelectric materials has gained much attention in the last five years [1, 2]. These materials have already been demonstrated to provide reduced length and diameter transducer structures. Further developing these materials for incorporation into undersea weapons is a technological challenge and will require an intense program of affordable single-crystal device development and demonstration. The material will be required to meet operational goals such as small foot-print (less than 7-inch diameter), bandwidth of 15-125 kHz, high acoustic source level, duty cycle, temperature stability, pressure stability, and mechanical shock resistance. In addition to meeting all the technical and performance requirements, the cost of this technology must be significantly reduced to make it practical for weapons applications. Due to the intended applications for developed devices, the Phase II and Phase III portions of this effort could require classification of the work for national security reasons.

PHASE I: Conduct feasibility study for developing high performance material compositions and prototype transducers capable of being used as detection and homing sensors for small diameter undersea weapons. The sensors should fit into the nose of a small diameter (less than 7-inch) vehicle. Develop a digital model and quantify the performance of a full single crystal acoustic array.

PHASE II: Design and develop acoustic sensors and associated electronics for sonar processing and guidance and control of an undersea weapon. Conduct experiments and testing in the laboratory on acoustic elements and sub-arrays to demonstrate the capabilities for detection and homing.

PHASE III: Extend the Phase II effort to incorporate acoustic sensors into a full scale closed-loop weapon or test vehicle with associated signal processing. Conduct in-water testing of this full-scale demonstrator.

PRIVATE SECTOR USE OF TECHNOLOGY: The acoustic sensor technology developed from this effort could be applied to the private sector. The commercial applications include acoustic sensor array for fishing vessels, bio-medical imaging, therapy applications, automotive sensors, acoustic speakers, electromechanical actuators, and ultrasonic cleaning/welding applications.

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KEYWORDS: Acoustic Detection & Homing Sensor Array, Single Crystal, Piezoceramic Materials, Smart Materials & Structures; Undersea Weapons, Transducer, Sonar

N04-T034 TITLE: Compact Fuel Reformer for Undersea Vehicle Fuel Cells

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

ACQUISITION PROGRAM: PMS 403: Mission Reconfigurable Unmanned Undersea Vehicle

OBJECTIVE: Develop and demonstrate a compact fuel reformer that operates on zero-sulfur, energy dense hydrocarbon fuels. The system should demonstrate rapid startup and shutdown and be capable of generating hydrogen over a range of gaseous hydrogen delivery rates. The hydrocarbon fuel should possess high hydrogen content by weight, and be amenable to mechanical recharge or replenishment under submarine and surface ship operating conditions.

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

Fuel cells operating on hydrogen or more complex fuels and oxygen are attractive as underwater power sources because they are efficient, quiet, compact, and easy to maintain. The total energy delivered by a fuel cell system is limited only by the amount of fuel and oxygen available to the fuel cell energy conversion stack. Unlike ground and air transportation fuel cell systems, underwater vehicles must carry both the fuel and the oxygen source because of insufficient oxygen concentration in the ocean. The need to include oxygen storage and generation in undersea vehicle fuel cell designs imparts significant weight and volume constraints on the other components, increases the need for very high energy content and must be considered to maintain safe handling and storage onboard submarines and surface ships.

Applications of fuel cells as propulsion power for undersea vehicles will require reliable system designs that deliver high energy densities. One simple design would incorporate a proton exchange membrane (PEM) fuel cell with hydrogen and oxygen storage. However, current hydrogen storage technologies cannot provide adequate fuel energy densities for long-endurance undersea vehicle missions, and current logistics fuel reforming systems are too large for size-constraints, due to the need for desulphurization. Hydrogen delivery systems based on renewable hydrocarbon fuels that are sulfur-free and possess high energy density would be smaller and simpler than logistics fuel reformer counterparts, and could meet undersea vehicle needs.

Therefore, innovative approaches for compact fuel reforming systems for sulfur-free, high energy density hydrocarbon fuels, excluding liquefied gases, are desired. To meet nominal undersea vehicle power requirements, throttleable hydrogen delivery rates should be sufficient to power a typical fuel cell stack from 50 W to 5 kW. The available hydrogen capacity should be maximized on a total system weight basis (including the fuel tank), while maintaining a high volumetric density for the overall system. Fuel flash point and safety are issues that should be addressed in the proposal.

PHASE I: Demonstrate the feasibility of the proposed technology to efficiently reform sulfur-free, high energy density hydrocarbon fuels, excluding liquefied gases.

PHASE II: Demonstrate the viability of the proposed technology to efficiently reform sulfur-free hydrocarbon fuels at the laboratory bench scale. Construct and evaluate a compact reforming system. Demonstrate controlled hydrogen generation rates, start/stop/restart /throttle capabilities, and fuel recharge or replenishment capabilities. Demonstrate adequate purity of the hydrogen stream at various generation rates for PEM fuel cell applications. Make system available for attachment to a fuel cell for Naval laboratory testing.

PHASE III: Design and construct a fully integrated hydrogen storage and delivery system (fuel + fuel tank, reformer, auxiliaries) for operation in a Navy-designated undersea vehicle powered with a fuel cell.

PRIVATE SECTOR USE OF TECHNOLOGY: High-density hydrogen storage and generation systems will make it possible to power commercial underwater vehicles with fuel cells, and have potential use for other portable fuel cell applications such as automobiles and DoD surface vehicles. Advanced reforming technologies for hydrocarbon fuels will also benefit automotive fuel cell and other power source technologies that require high energy density fuels.

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