
VOLUME 2, NO. 8 MAY 2010

# RESEARCH AT NPS

The Naval Postgraduate School (NPS) was established to serve the advanced educational needs of the Navy. The broad responsibility of the school is reflected in its stated mission: Increase the combat effectiveness of U.S. and allied armed forces and enhance the security of the United States of America through advanced education and research programs focused on the technical, analytical, and managerial tools needed to confront defense–related challenges of the future. To fulfill its mission, NPS strives to sustain excellence in the quality of its instructional programs, to be responsive to technological change and innovation in the Navy, and to prepare officers to introduce and utilize future technologies.

The research program at NPS exists to support the primary mission of graduate education. Research at NPS maintains upper-division course content and programs at cutting edge; challenges students with creative problem solving experiences on DoD–relevant issues; advances DoN/DoD technology; solves warfare problems; and attracts and retains quality faculty.

The NPS Research Program has grown steadily ($32.6M in FY2000 to over $85M in FY2009). In FY2000, research claimed 82% of sponsored program activities; in FY2009, 52%. While the NPS sponsored portfolio has met many DoD challenges, research remains the essential component supporting our primary graduate-education mission.

## BROWN-BAG SEMINAR SERIES

MAE CONFERENCE ROOM
WATKINS HALL, ROOM 302 · 1200-1300

- 15 July, Thursday, Research Initiation Program
- 17 August, Wednesday, Working with NGOs
- 14 September, Tuesday, Use of Human Subjects in Research
- 12 October, Tuesday, Starting the Fiscal Year

## USE OF HUMAN SUBJECTS IN RESEARCH AND NPS INSTITUTIONAL REVIEW BOARD (IRB)

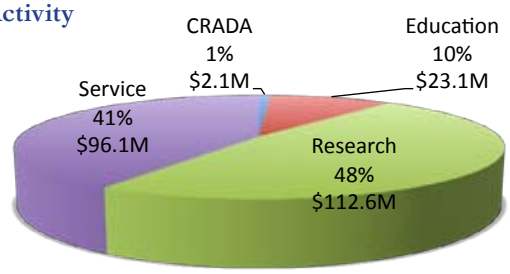
NPS's assurance allowing research involving human subjects has been extended through 30 November 2011. There have been over seventy-five protocols approved this year. The organization of the Human Research Protection Program will be slightly different in the future. The director of the Human Research Protection Program office is being recruited. This individual, along with one administrative position, will monitor compliance with IRB board decisions and assure requirements, including training, are completed. The duties are separate from those of the IRB chair, who will review protocols and head the IRB.

Effective 1 June, the chair of the IRB is Senior Lecturer Lawrence Shattuck (OR); vice chair is Assistant Professor Maiah Jaskoski (NSA). Other IRB members are Research Associate Professor Sue Hutchins (IS); Professor Mark Eitelberg (GSBPP); Associate Professor Simson Garfinkel (CS); LCDR Thomas Statler, USN (NPS Chaplain); LtCol Anthony Tvaryanas, USAF (NPS Student Representative); Professor Stephen Mehay (GSBPP); Donald Lincoln (Office of General Counsel); CPT Richard Brown, USA (unaffiliated member); and Danielle Kuska, Director, Research and Sponsored Programs Office (nonscientist).

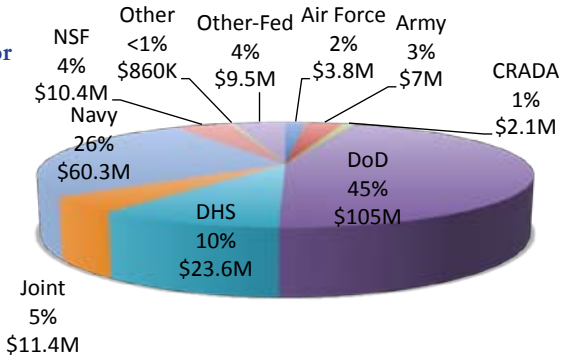
## SPONSORED PROGRAMS STATUS, MAY 2010

FUNDS AVAILABLE: $233.9M

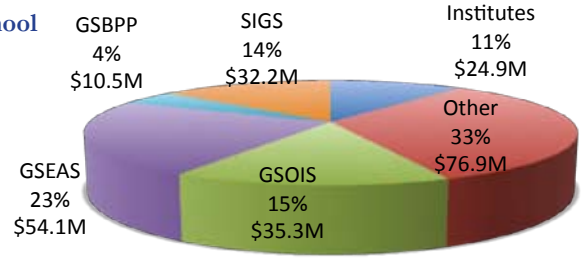
### By Type of Activity




### By Sponsor




### By School



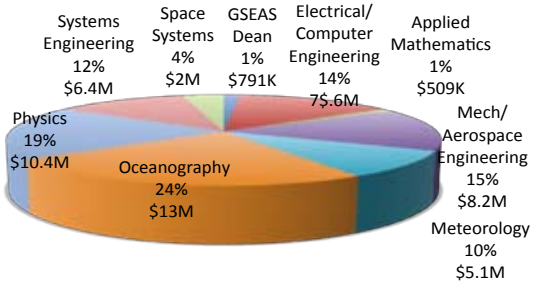

Research and Sponsored Programs Office (RSPO)
Office of the Vice President and Dean of Research
Naval Postgraduate School

Danielle Kuska, Director
Research and Sponsored Programs Office
research@nps.edu

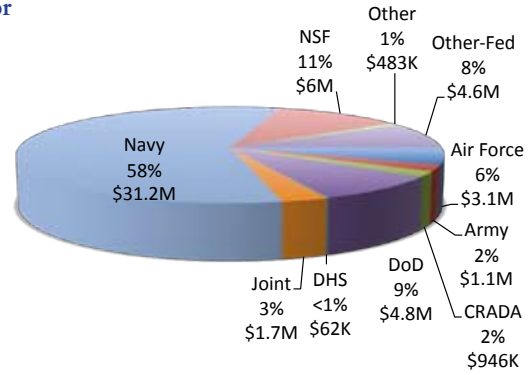
## Graduate School of Engineering and Applied Sciences

Funds available to date: $54.1M

### By Department




### By Sponsor



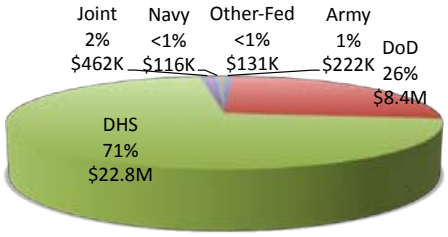

**Projects funded in May:**

- Electromagnetic Aircraft Launch Systems Power Electronics Performance Evaluation, *Robert Ashton, ECE* (NAVSEA)
- Wireless Networking and Communications Research, *John McEachen, ECE* (NSA)
- Extending the Endurance and Capabilities of the Raven UAV Using Advanced Flexible Solar Cells, *Sherif Michael, ECE* (NAWC – Weapons Division)
- Submarine Future EW Working Group 2010, *Philip Pace, ECE* (NUWC- Newport Division)
- Shipboard Calibration Enhancements, *Xiaoping Yun, ECE* (NSWC- Corona Division)
- Observability in Data Assimilation and Optimal Sensor Configuration, *Wei Kang, MA* (NRL)
- Key Technologies for Large Segmented Mirror Space Telescopes, *Brij Agrawal, MAE* (NRO)
- Integrated Tactical Platform Simulator for Maritime High Energy Laser Control Testbed, *Brij Agrawal, MAE* (ONR)
- Particle Imaging Measurements in 2D Slab Burner, *Christopher Brophy, MAE* (ATK Launch Systems)
- Closed-Loop Compressor Development and Testing, *Garth Hobson, MAE* (Ramgen Power Systems, Inc.)
- Competency Education Package for Aircraft Structures, *Ramesh Kolar, MAE* (NAVAIR)
- Study and Characterization of Bio-Derived Fuels for Tactical Navy Gas Turbines and Diesels, *Knox Millsaps, MAE* (ONR)
- SHIPS: Ship-Human Integrated Performance System, *Fotis Papoulias, MAE* (ONR)
- Talon Dark Mirror, *Isaac Ross, MAE* (Space Innovation and Development Center)
- Littoral Oceanography for Mine Warfare, *Peter Chu, OC* (NAVOCEANO)
- SCALABEL Network Monitoring Program, *David Ford, PH* (DARPA)
- Technical Analysis Support to ISSO, *Richard Olsen, PH* (OSD)
- Special Capability Satellite Development of Nanosatellite Program, *Richard Olsen, PH* (USAF Space & Missile Systems Center)
- Support for DOD Access to Data and Information, *Richard Olsen, PH* (OSD)
- Sensors and Dynamic Identification for Naval Aviation Systems T&E and Health Management, *Richard Millar, SE* (NAVAIR)

## School of International Graduate Studies

Funds available to date: $32.2M

### By Sponsor




**Projects funded in May:**

- Raider Leader Language Training, *Thomas Johnson, NSA* (Army Deputy Chief of Staff, G8)
- Master's Degree Program, *Ted Lewis, NSA* (U.S. Army North)
- NPS Asia Conference, *Christopher Twomey, NSA* (OSD)
- Extended Deterrence in the 21st Century, *David Yost, NSA* (DTRA)

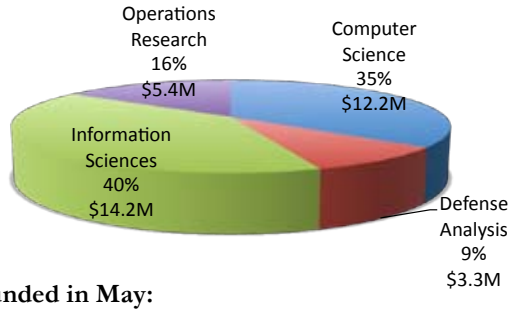
**Additional Research and Sponsored-Program Information is Available Online—**

**NPS Sponsored Programs Annual Report, 2009** www.nps.edu/Research/Documents/AnnualReport_FY2009.pdf
**GSEAS Sponsored Programs Annual Report, 2009** www.nps.edu/Research/Documents/AnnualReport_FY2009_GSEAS.pdf
**GSOIS Sponsored Programs Annual Report, 2009** www.nps.edu/Research/Documents/AnnualReport_FY2009_GSOIS.pdf
**Overview of NPS Research** www.nps.edu/Research/Publications/ResearchPoster.pdf
**Overview of Naval Research** http://www.nps.edu/Research/Publications/ResearchPosterNavy.pdf

## Graduate School of Operational and Information Sciences

Funds available to date: $35.3M

### By Department

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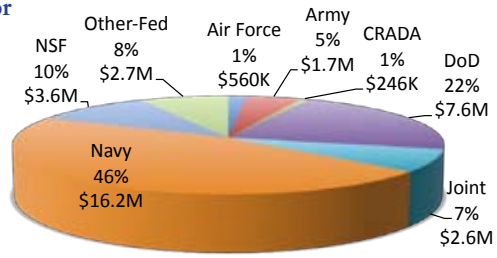



**Projects funded in May:**

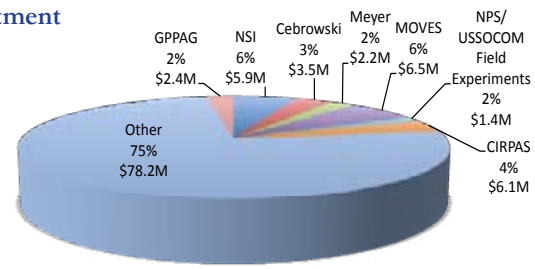
- Navy Certifier Program Special Offering, *Karen Burke, CS* (NSWC–Panama City)
- MYSEA-PHASE VII, *Cynthia Irvine, CS* (NRO)
- Tools for Topic Detection, Craig Martell, CS (NRO)
- Investigation of Cloud Computing for Tactical Systems, *James Michael, CS* (OSD)
- Iranian Futures Workshop I, *Glen Robinson, DA* (U.S. Special Operations Command Central)
- Iranian Futures Workshop II, *Glen Robinson, DA* (U.S. Special Operations Command Central)
- USMC M252X 81MM Lightweight INCONEL Mortar System Analysis, *Alex Bordetsky, IS* (USMC–MARCORSYSCOM)
- SOA Integrated Model Development, *Randy Maule, IS* (SPAWAR)
- Navy Sealift, *Matt Carlyle, OR* (NSWC–Carderock Division)
- Statistical Support to OAD Using CIDNE Afghanistan Database, *Robert Koyak, OR* (USMC – MARCORSYSCOM)
- Human Performance at Sea 2010, *Michael McCauley, OR* (NSWC – Panama City)
- Support of Analyses of Cost and Benefits on Vulture Project, *Daniel Nussbaum, OR* (DARPA)
- Adaptive Precision Adjustment for Efficient Optimization of Complex Systems, *Johannes Royset, OR* (AFOSR)

Historical funding for sponsored programs is available online at www.nps.edu/Research/RSPO/Default.aspx.

## Research and Education Institutes, Centers, and Other

Funds available to date: $101.8

### By Department

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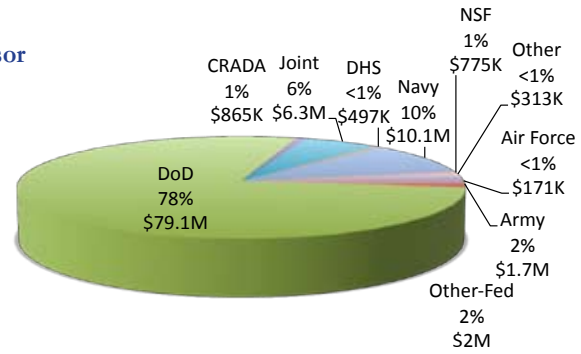



**Projects funded in May:**

- DoD Joint Strategic Communications Workshop, *Ronald Franklin, CEE* (USAFRICOM)
- Strategic Communications Workshop, *Ron Franklin, CEE* (DMDC)
- Understanding Chinese Cultural Organizational Behavior, Decisions & Strategy, *Mie-Sophia Augier, GPPAG* (OSD)
- FY10 Phoenix Express Maritime Operations Facilitated Discussion, *Alan Jaeger, CAW* (USAFRICOM)
- Military Wireless Communications, *Joshua Dixon, Cebrowski* (TRADOC)
- Transformational C2 to Understand Impact of Globalization on Stability and Security, *Sue Higgins, Cebrowski* (SPAWAR)
- Integrating Cell Technology with USMC Tactical Networks, *Geoffrey Xie, Cebrowski* (USMC – MARCOSYSCOM)
- Command and Control Rapid Prototype Capability SOA CONOPS, *Warren Yu, Cebrowski* (SPAWAR)
- Expeditionary and Mine Warfare Chair, *Paul Shebalin, Meyer* (NAVSEA)
- Education and Workforce Capacity in Systems Engineering Among DoD Institutions, *Clifford Whitcomb, Meyer* (OSD)
- Impact of User Input Devices When Training with Vbs2, *William Becker, MOVES* (TRAC – Monterey)
- M&S Catalog Research and Development, *Curtis Blais, MOVES* (SPAWAR)
- Bridging S1000d, X3d, and SCORM for Embedded Performance Assessment, *Don Brutzman, MOVES* (DHRA)
- Flight Testing of RF Equipment, *Robert Bluth, CIRPAS* (SPAWAR)
- NPS SBIR Program Support, *Robert Bluth, CIRPAS* (ONR)
- Enhancements of CIRPAS Twin Otter Measurement Capabilities, *Haflidi Jonsson, CIRPAS* (ONR)

*GSBPP data is found on page 14.*

# UNDERSEA WARFARE AT NPS

Undersea Warfare (USW) comprises multiple areas of keen Navy interest including antisubmarine warfare, mine warfare, submarine warfare, and sub-sea warfare (examples of which include the use of UUV's and undersea networks). Established after the drawdown from the Vietnam conflict to help the nation counter the Soviet submarine threat, the Antisubmarine Warfare Academic Group (ASWAG) was the first academic group at NPS. The goal of the group was to pull together the interdisciplinary expertise needed to solve critical ASW problems. With the emergence of quiet and deadly diesel electric submarines in the last decade, new threats are being confronted in the undersea warfare realm. To respond to these threats, the ASWAG has evolved into the Undersea Warfare Academic Group (USWAG), and will be reinstated with the goal of reinvigorating pure and applied interdisciplinary USW research and promoting the growth and modernization of USW-relevant laboratories and facilities. The undersea warfare program has been long supported by two chair professorships and is strongly integrated into research and academic programs across campus. This article will provide a broad overview of some of the strength areas in USW at NPS.

## ACADEMIC PROGRAM

The NPS USW Curriculum is cosponsored by N87 and N85. It receives guidance from the Undersea Warfare Academic Committee, composed of faculty from nine different academic departments. The curriculum educates primarily U.S. Navy officers along with a small number of naval officers from allied countries as well as DoD civilians. This interdisciplinary program integrates many subjects such as acoustics, signal processing, mathematics, oceanography, physics, operations research, programming and simulation, and unmanned systems. The overarching goal of the curriculum is to provide the Navy with graduates whose understanding of the fundamental science, engineering, and operations analysis of USW will significantly enhance their performance in operational and staff billets.

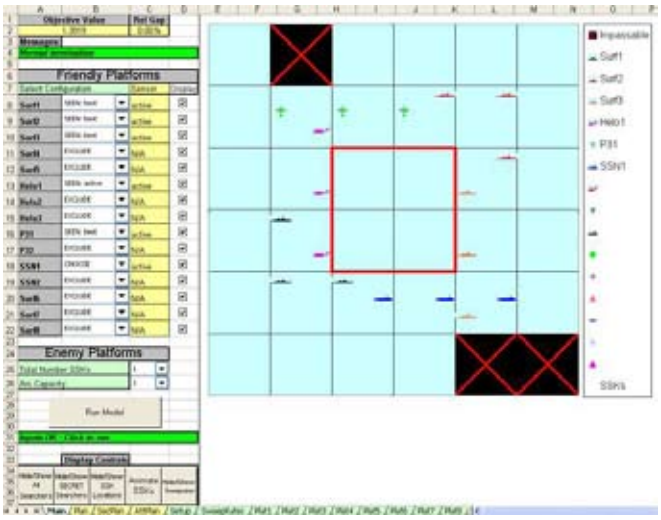
A high point for each degree is authoring a master's thesis on relevant, cutting-edge basic or applied research topics. USW students earn accredited master's degrees in a variety of technical disciplines including:

- Engineering acoustics with emphasis on underwater acoustics, signal processing, hardware design, and acoustic communications
- Physical oceanography with emphasis on the prediction of the undersea battlespace environment, ocean acoustics and environmental effects on sonar performance,
- Electrical engineering with emphasis on signal processing (ABET accredited),
- Operations research with emphasis on tactical applications and decision analysis,
- Mechanical engineering with emphasis on unmanned systems (ABET accredited).

## STUDENT RESEARCH

The operational nature of the USW program coupled with the experience and expertise of our naval officers allows for top quality, military relevant thesis research. Several recent theses are represented in this article.

The Game Theoretic ASW Mission Planner, or G-TAMP, developed in the thesis of LT Adam Thomas, USN, provides area ASW mission planners with air and platform area assignments to best protect high-value ships from underwater threats. This operational planner combines cutting-edge optimization theory with game theory




*LT Adam Thomas's cutting-edge research and ASW planning tool, G-TAMP*

**TRI-LEVEL OPTIMIZATION FOR ANTISUBMARINE WARFARE MISSION PLANNING**
**Adam J. Thomas–LT, USN**
**MS in Operations Research–September 2008**
**Advisors: Gerald G. Brown, Operations Research**
**R. Kevin Wood, Operations Research**
**Second Reader: Jeffrey E. Kline, Operations Research**

We develop the Game-Theoretic ASW Mission Planner (G-TAMP), an operational-level planning aid for the tasking of antisubmarine warfare (ASW) platforms to protect a high-value unit (HVU) from attack by hostile submarines (SSKs). We first present a defender-attacker optimization model in which the defender tasks platforms to minimize the probability that the enemy can reach the HVU, while the enemy observes and reacts to these visible defenses by routing SSKs to maximize this probability. A defender-attacker/defender (D-A/D) model then extends the first model by adding a final "defender stage" to task potentially "secret" platforms. This model also prescribes the optimal sensor mode for platforms that can use passive sonar (for secrecy) or active sonar (for increased detection ranges), in effect, quantifying the value of secrecy for the defender. Five scenarios illustrate the D-A/D model's ability to "shape" the battle space to the defender's advantage using visible platforms in the first stage, and then to exploit the secrecy of hidden platforms for maximum benefit. Model instances are mixed-integer programs with up to 14,000 constraints and 12,000 variables. In each case, an optimal or near-optimal search plan coordinates the actions of multiple, heterogeneous ASW platforms to protect an HVU from an intelligent enemy.

to derive mission-planning solutions. It develops both active sensor and passive sensor assignments as well as demonstrating the most dangerous red submarine approaches.

The Systems Engineering Analysis research project (SEA-14) was conducted in 2007-2008 under the sponsorship of Commander Third Fleet and the Commander Naval Mine and ASW Command. Ten U.S. naval officers and one Singaporean defense scientist applied the systems engineering process to the full range of operational, technical, and organizational issues which were concurrently being addressed across five departments of government. The quality and value of their work was acknowledged in letters of appreciation from Rear Admiral R. P. Girrier, Vice Commander, Naval Mine and Antisubmarine Warfare Command, to each of the SEA-14 students, firmly endorsed the exceptional report results. RADM Girrier wrote, "The work you did in research, on-site study during experiments and at commercial ports, participating in symposia, developing models and articulating clear, rational approaches to solutions has helped move the discussion of this critical area to a new level. Continued national level awareness and discussion of the potential vulnerability of the U.S. maritime transportation system to terrorist attacks is assisted and informed by your work and that of your teammates." Since the publication of the SEA-14 report, there have been over two dozen presentations of the findings to senior Navy, United States Coast Guard, and Department of Homeland Security executives and allied navies and staffs.

## CHAIR PROFESSORSHIPS

Two chair professorships are currently in residence at the Naval Postgraduate School. The Chair of Undersea Warfare, established through a memorandum of understanding with the Naval Undersea Warfare Center, and the Chair of Expeditionary and Mine Warfare, established through a memorandum of understanding among PEO, MIW, N85 and NPS. Both chair professorships were established to enhance the academic and research content in the NPS curricula with USW-related material, and to establish NPS as a major center of excellence for instruction, research and analysis in the field of USW.

The primary undertakings of the current Undersea Warfare Chair, RADM Jerry Ellis, USN (Ret.) are to: 1) review USW curriculum for appropriate content relative to undersea and antisubmarine warfare principles and technology application; 2) ensure curriculum meets educational standards and requirements for subspecialty codes, 3) revise and refine USW curriculum to reflect new curriculum sponsor (N85 and N87) initiatives, 4) liaison with Navy labs, acquisition program managers, program sponsors, and operational commands to identify prioritized needs for research topics in USW area, 5) arrange for funding to support thesis work on USW-related topics and arrange for NPS faculty and students' participation, and 6) teach the course "Undersea Warfare: Yesterday, Today, Tomorrow" which is based on a study RADM Ellis did for the secretary of the Navy when he served as SECNAV's Special Assistant for Undersea Strategy before coming to NPS. The study was twofold: 1) clarify how the different elements of undersea warfare capability fit together, and 2) identify key areas that need leadership attention in order to maintain our degree of dominance in USW. The results of the study were strongly supported by the Secretary and the Chief of Naval Operations.

*RADM Jerry Ellis, USN (ret.), Undersea Warfare Chair*

The incumbent of the Expeditionary and Mine Warfare Chair, RADM Rick Williams, USN (Ret.), is equally involved. He serves as the USW curriculum advisor, coordinates expeditionary and mine warfare thesis topics with NPS students and faculty, conducts war gaming exercises (CONTECH/NMAWC/AUVSI), coordinates the Menneken Lecture Series, reviews requirements and concepts for research areas, and serves as the assistant director of the USW Research Center. RADM Williams has been a key advisor on several of the SEA systems-engineering studies conducted at NPS and is currently leading the NPS Advanced Underwater Weapons Working Group, which brings together campus experts to look at current and future USW requirements. The Ninth International Technology Symposium recently concluded was arranged

*RADM Rick Williams, USN (ret.), Expeditionary and Mine Warfare Chair*

**TAIL SEPARATION AND DENSITY EFFECTS ON THE UNDERWATER TRAJECTORY OF THE JDAM**
**Jillene M. Bushnell–LCDR, USN**
**MS in Meteorology and Physical Oceanography–December 2009**
**Advisor: Peter Chu, Oceanography**
**Second Reader: Brian Almquist, Office of Naval Research**

The Navy is in need of an organic, inexpensive, swift method to neutralize or sweep waterborne mines. This thesis presents an alternative to current mine countermeasure technologies that fulfills this criteria: the use of the Joint Direct Attack Munition (JDAM) to clear a minefield. It updates the general, physics-based, six degrees of freedom model, STRIKE35, to predict the three-dimensional, free-fall trajectory and orientation of a MK-84 bomb (simulating the JDAM) through a water column. It accurately predicts the final detonation position relative to an underwater mine in the very shallow water environment. Input parameters include accurate water impact speed and surface impact angle of attack. Because the model results compare well with experimental data from the Standoff Assault Breaching Weapon Fuze Improvement (SOABWFI) Program, we analyze the trajectory of the weapon with structural failures. This thesis solves for the impact speed and impact angle of attack limitations to remain within the technology transition agreement, the detonation location for each fuze delay setting (to include its 20% tolerance), and the trajectory changes due to different water densities. This gives strike planners a tactical decision aid to clear the minefield accurately and efficiently with existing aircraft and weapons.

by RADM Williams, sponsored by PEO, LMW; OPNAV N-85; the Office of Naval Research; NPS; NMAWC; and NECC, and attended by about 225 Navy, industry, academic, laboratory, government, and international representatives discussing a wide range of technical topics about mine warfare, expeditionary warfare and unmanned systems.

## FACULTY RESEARCH

While this section is titled faculty research, the research of the faculty is well integrated into the upper-division course content of the USW program. The faculty research projects also serve as relevant topic areas for student theses as all funded research at NPS is of particular interest to the sponsoring agency. Several current and recent USW-themed research projects are highlighted in the project summaries below:

**Observability in Data Assimilation and Optimal Sensor Configuration**
**Professor Wei Kang, Applied Mathematics**
**Sponsor: Naval Research Laboratory**

The objective of this project is to develop and validate mathematical concepts and numerical algorithms for the evaluation and optimal design of sensor configuration in data assimilations. The technical objectives include: (1) defining the concepts of observability for the problem of data assimilation; (2) numerically testing the concepts using a midsize model by Monte Carlo simulations, as well as traditional data-assimilation methods; (3) developing computational algorithms that are scalable to large problems; (4) developing problem formulation and computational algorithms for maximizing the observability of forecast models by finding optimal sensor locations.

**Investigation of Acoustic Cloaking**
**Professor Clyde Scandrett, Applied Mathematics**
**Sponsor: Naval Undersea Warfare Center**

The research involves further investigation into the feasibility and optimization considerations of underwater acoustic cloaking. Working with investigators at NUWC, ultimately under the sponsorship of ONR, DARPA, LMW, and PEO in the technical Capability Alignment (Division), NP14 Undersea Warfare Analysis, Professor Scandrett will consider global optimizers for a three-layer acoustic cloak comprising pentamode materials at specified frequencies, as well as optimization of material parameters for a given cloak over a prescribed range of frequencies. This will extend the local, gradient-search techniques employed in FY09, in efforts to improve on the design of a layered cloak as well as to further efforts in finding realizable materials that can be used to find "obtainable" acoustic cloaks.

**Climate Analysis and Long-Range Forecasting for Undersea Warfare Operations**
**Research Professor Tom Murphree, Meteorology**
**Sponsor: Space and Naval Warfare Systems Command**

In this project, we are conducting research and development to improve long lead forecasts of the atmosphere and ocean for use in planning and conducting USW operations. These forecasts provide predictions at lead times of one month to several years into the future of: (a) the atmospheric and oceanic environment (e.g., temperature, winds, tropical cyclones, waves, currents, sound velocity); and (b) the performance of sonar and radar systems. The results from this R&D have been and are being used in operational planning on an experimental basis, and are being transitioned to operational use by the Fleet Numerical Meteorology and Oceanography Center (FNMOC) and Naval Oceanographic Office (NAVO).

**Meteorological and Oceanographic Metrics for Antisubmarine Warfare**
**Research Professor Tom Murphree, Meteorology**
**Sponsor: Space and Naval Warfare Systems Command**

In this project, we are developing, testing, and transitioning systems for real-time and retrospective assessments of: (a) the performance of meteorological and oceanographic (METOC) forecasts that support the planning of ASW operations; and (b) the impacts of these forecasts on the planning and outcomes of ASW operations. The resulting assessments are used to identify opportunities for improving: (a) METOC support, research and development, and education and training; and (b) the use of METOC support and the exploitation of environmental conditions by ASW operators. The systems developed in this project have been transitioned to operational use at the Naval Oceanographic Office (NAVO).

**Atmospheric Performance Surfaces for Submarine Periscope Detection**
**Research Professor Peter Guest and Research Associate Paul Frederickson, Meteorology**
**Sponsor: Space and Naval Warfare Systems Command**

This is a proposal to continue development of atmo-

## USE OF BUBBLES FOR PRESSURE MINESWEEPING

**Jeffrey J. Murawski–LT, USN**
**MS in Applied Physics–December 2009**
**Advisor: Bruce C. Denardo, Physics**
**Second Reader: Andres Larraza, Physics**

The ability to sweep for pressure influence sea mines is one of the U. S. Navy's longest standing capability gaps. Towing a bubble squid, which is an apparatus that emits large numbers of small air bubbles, would lower the pressure below the apparatus by lowering the density of the water column and by entraining the water due to the motion of the bubbles. These characteristics make a bubble squid a candidate for a means of sweeping for pressure sea mines. This thesis presents investigations into the theory and experimentation of the pressure decrease created by a bubble squid. Two proof-of-concept experiments are reported. The first experiment uses a water tunnel and a stationary prototype to categorize the effect of a bubble squid prototype in a small, controllable environment. The second experiment uses a larger in-floor tank with a carriage system to tow a larger prototype in more realistic environment. The data collected from both experiments sets a foundation for understanding how the physical parameters of the system affect the pressure in the water below it. The implications of the data collected are discussed, along with the future work on optimization and larger prototype experimentation.

spheric performance surface (ATPS) products in support of fleet operations. The main focus concerns a visualization product that is essentially a contour plot of radar detection ranges for submarine periscopes and other potential targets or threats. This is a collaborative effort involving the Naval Research Laboratory, Monterey, Fleet Numerical Meteorology and Oceanography Center and Space Systems Command–Pacific. The primary tasks are 1) continue the development and integration efforts necessary for producing operational performance surfaces of increasing usefulness and fidelity for non-acoustic ASW missions, and 2) evaluate the accuracy and usefulness of ATPS products and associated mode and measurements based on in situ measurements of atmospheric conditions and observed radar ranges.

**ITOP 2010 Field Experiment**
**Associate Professor Patrick Harr, Meteorology**
**Sponsor: Office of Naval Research**

The overall objective of the project titled Impact of Typhoons on the Ocean in the Pacific (ITOP) is to increase understanding of the ocean response to tropical cyclones over the western North Pacific Ocean. Tropical cyclones produce a three-dimensional response of the underlying ocean that includes surface currents, upwelling of the thermocline, and formation of a cold wake. The perturbed ocean conditions then become a factor in modifying the intensity and structure of the tropical cyclone. The ITOP program includes a field phase during August–October 2010 in which aircraft from the USAF Hurricane Hunters Squadron will deploy atmosphere- and ocean-sensing instruments ahead, inside, and behind mature typhoons over the Philippine Sea. Meteorology faculty involved in ITOP include professors P. A. Harr and R. L. Elsberry. Additionally, two M.S. students and one Ph.D student will participate in the aircraft operations.

**Very Shallow Water (VSW) Mine Neutralization**
**Doug Horner, Mechanical and Aerospace Engineering**
**Sponsor: Office of Naval Research**

This project provides technical management of the VSW neutralization program. In FY2010, the focus of the program will be development of technologies for the re-acquisition and neutralization of previously detected mine shapes. One goal for the FY2010 program will be the development of algorithms that will permit a flapping foil AUV to use features to re-acquire and hold position on a designated bottom mine shape. The feature-based navigation algorithms that are being developed may be useful in a variety of naval applications.

**Autonomous USW Navigation in Riverine Environments**
**Doug Horner, Mechanical and Aerospace Engineering**
**Sponsor: Office of Naval Research**

The proposal objectives include development and infield testing of 1) surface and subsurface sensing modalities to detect navigational obstacles, 2) a unified stochastic surface and subsurface map of the environment suitable for real-time navigation, and 3) agile planning and control approaches that enable UUV operations over a uniquely wide operating envelope and that encompass the requirements of long-range path planning and exploration, and local trajectory generation and obstacle avoidance. A major goal of this integrated research effort is a demonstration of combined surface and subsurface sensing and real-time navigation in August 2010 at the Pearl River near Stennis Space Center, MS.

*Ranger AUV attaches to mine-like object, using feature-based algorithms to localize and navigate with limited sensors.*

**Herding and Active Force Protection Using Autonomous Agents**
**Professor Isaac Kaminer, Mechanical and Aerospace Engineering**
**Sponsor: Office of Naval Research**

This proposal addresses an issue critical to the USN planners and current and future USN UAV operators, namely, the question of airspace volume capacity that can be populated by multiple UAVs performing a single or multiple missions in a littoral environment in support of the warfighter. Clearly an answer to this question must include more than just a number of the UAVs, but their desired paths

**MODELING A 400-HZ SIGNAL TRANSMISSION THROUGH THE SOUTH CHINA SEA BASIN**
**Chris S. Bernotavicius–LT, USN**
**MS in Applied Mathematics–March 2009**
**Advisor: Ching-Sang Chiu, Oceanography**
**Advisor: Clyde Scandrett, Applied Mathematics**

As part of ONR-sponsored Windy Island Soliton Experimentation (WISE), two deepwater moorings were placed in the northeastern portion of the South China Sea deep basin to conduct an acoustic propagation study. For approximately a year the source and receiver transmitted and received phase-modulated signals to measure the multi-scale variability in the transmission loss induced by the ocean mesoscale variability and the progression of internal tides and waves. A numerical acoustic propagation model based on Hamiltonian ray tracing is utilized to replicate the observed basic arrival structure and transmission loss. Being able to accurately model the basic arrival structure is a necessary first step before modeling the observed variability can be attempted. The comparison of the modeled arrival structure with the actual data was utilized to refine the angular resolution of the ray fan in the model, estimate the geo-acoustic properties of the bottom, and develop transmission loss estimates. Transmission loss measurements from sono-buoy data were used as an independent metric to evaluate the model.

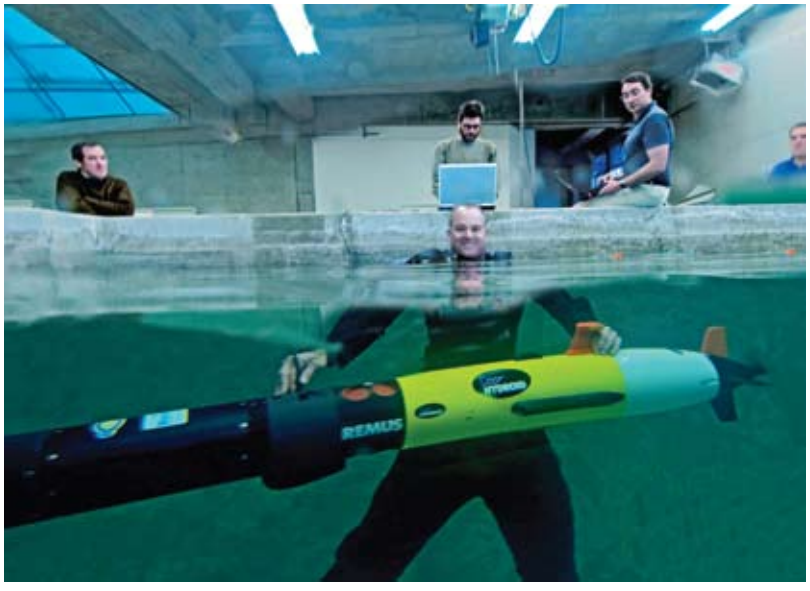
that perform the required mission (s) and stay inside the air box, the algorithms to track these paths and that coordinate between multiple UAVs by using the underlying wireless network. In fact coordination constraints, as is shown in this proposal, must be included in the initial air volume capacity/path planning step. The types of missions considered in this proposal include intelligent surveillance and reconnaissance, coordinated terrain following, support of small SEAL teams to name a few.

**Littoral Oceanography for Mine Warfare**
**Professor Peter Chu, Oceanography**
**Sponsor: NAVOCEANO**

The proposal includes two major tasks: (1) determination of periodicity for MIW route surveys with consideration of influences by natural forcing functions (storms, climate, etc.), and influences by human activity, (2) development of analogous CONUS areas that are environmentally "analogous" to a potential operational area of interest. These CONUS sites would then be useable for more rigorous operational training and evaluation, and (3) underwater bomb trajectory prediction for the Joint Direct Attack Munition (JDAM) Assault Breaching System (JABS) in the very shallow water (VSW).

**Portable High-Efficiency, Wide-Band, Moored Sound Sources for Shallow-Water, Low-Frequency Acoustic Propagation Studies**
**Professor Ching-Sang Chiu, Oceanography**
**Sponsor: Office of Naval Research**

All past acoustic propagation experiments conducted in shelf and slope regions in non-U.S. waters as part of the shallow-water thrust of the ocean-acoustics program of the Office of Naval Research (ONR) have been constrained by the lack of portable sound sources that have frequency ranges covering the upper half (550-1,000 Hz) of the low frequency regime. This limitation has prevented the collection of comprehensive data for studying propagation physics in this upper-half of the band, and for quantifying the boundaries and overlaps in the entire low frequency-range-angle domain within which one or a combination of environmental factors controls the characteristics and statistics in signal intensity and coherences. In a downward-refracting sound channel, these environmental factors include sound-speed variability, bathymetry changes, sediment heterogeneity, and fish schools. In order to fill the data and knowledge gaps, the procurement of two wide-band moored sources, spanning 500–800 Hz and 800–1,200 Hz, is proposed. The design is based on the proven sweeper technology developed by Teledyne Webb Research Company to achieve high efficiency. The dimension of each is compact, with the transducer, electronics and batteries configured in two Slocum-glider hulls mounted in parallel, making them easily transportable and deployable in non-U.S. waters. The first deployment will be in the next multi-institutional shallow-water acoustics experiment that is targeted for FY11–12. Similar to other NPS seagoing acoustic equipment, these new sources will be treated as community assets. Their placement and signaling schemes will be designed in a joined effort to support various scientific objectives including graduate student theses of NPS as well as those of other institutions collaborating in the experiment.




*Doug Horner displays experimental NPS unmanned UUV in the Unmanned Systems Laboratory at NPS*

**Analysis of South China Sea Shelf and Basin Acoustic Transmission Data**
**Professor Ching-Sang Chiu, Oceanography**
**Sponsor: Office of Naval Research**

As part of the Windy Islands Soliton Experiment (WISE), two acoustic propagation studies, one over the shallow shelf and one over the deep basin along the WISE oceanographic mooring transect in the Northeastern South China Sea (NE SCS) were carried out. The purpose of the shelf transmission was to study the physics of sound propagation through nonlinear, elevation and depression internal waves in shallow water, and to quantify the associated fluctuations in the sound intensity. The purpose of the basin transmission was to study and characterize the supertidal- to seasonal-scale impacts of the transbasin, nonlinear internal waves on the long-range transmission loss. The proposed two-year effort is to complete the analysis of both the shelf and basin acoustic transmission data. At the request of the Office of Naval Research Ocean Acoustics Program, a new task is added to an existing two-year reimbursable project titled "Analysis of South China Sea Shelf and Basin Acoustic Transmission Data." The original proposal for this project that has been fully funded is attached. The additional task is to ship equipment to Taiwan for the collection of acoustic data to supplement the shelf acoustic data analysis.

**South China Sea Signal Propagation and Ambient-Noise Data Analysis**
**Professor Ching-Sang Chiu, Oceanography**
**Sponsor: Office of Naval Research**

Acoustic signal transmission and ambient noise time series were measured in the northeastern South China Sea basin for one year. The proposed research for FY10–11 will carry out modeling analyses, including model-data comparisons to understand and quantify the effects of the trans-basin nonlinear internal waves on signal intensity level and elucidate and calibrate the statistical relations of shipping density and wind events to ambient noise level.

Additionally in FY11, it is proposed that the synthesis of the acoustic results from three different transmission experiments in vicinity of the shelf break of the same region be initiated.

**Characterization and Classification of Marine Mammal Vocalization**
**Professor Curtis Collins, Oceanography**
**Sponsor: Chief of Naval Operations, N45G**

This project supports Navy ASW training activities at SCORE (San Clemente Island) by understanding the effects of midrange sonar on marine mammals. Recent activities include 1) developing methods to detect and classify marine mammal vocalizations, 2) determining the spatial and temporal variability of vocalizations in San Nicholas Basin using recordings from an existing array of bottom-mounted hydrophones, and (3) understanding the physical characteristics of the basin that govern the propagation of acoustic energy and affect the behavior of marine mammals. The approach has been to evaluate and predict the performance of inexpensive passive systems for monitoring vocalizing *odontoceti* whales using conditional statistical measures. Performance measures include detection and classification probabilities and range limit against false-alarm rate. Oceanic conditions were observed by coastal moorings and recordings of vocalizations were made using SCORE and autonomous hydrophones. The long-range goal is to measure the response of marine mammals to acoustic energy introduced by anthropogenic means.

**Analysis and Modeling of Oceanic Acoustic Fluctuations and Moored Observations of Philippine Sea Sound-Speed Structure**
**Professor John Colosi, Oceanography**
**Sponsor: Office of Naval Research**

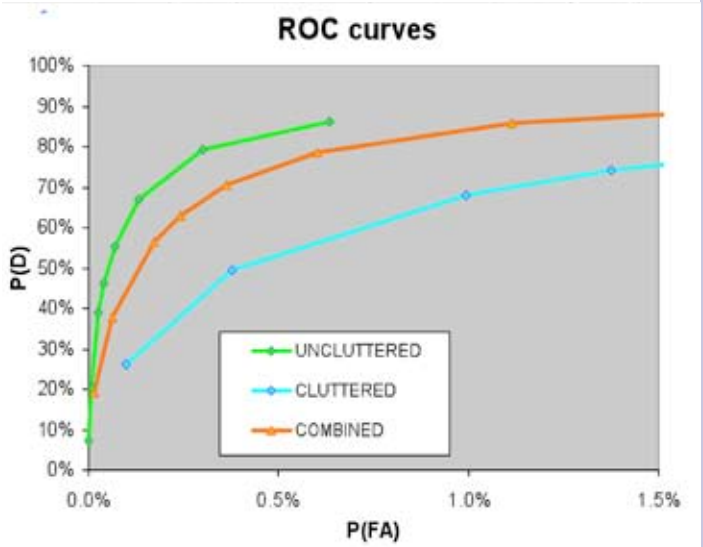
This proposal concerns the 2009–2011 Philippine Sea experiments that will provide acoustic observations with unprecedented geographical and temporal resolution for the validation of path integral and coupled mode theories of acoustic fluctuations. In addition, moored, towed, and seaglider oceanographic measurements will provide comprehensive observations of sound-speed structure to be used with standard models (like the GM spectrum) as inputs to the acoustic fluctuation models. Work will focus on analysis and collection of field data (acoustic and oceanographic) and subsequent comparison to acoustic fluctuation models. The path integral theory, which was developed by Dashen, Flatte and coworkers, has been implemented numerically here at the Naval Postgraduate School for many observables, and coupled mode theory (including attenuation) developed by Morozov and Colosi has been implemented for the estimation of mean field and intensity and vertical coherence. NPS will lead in the instrumentation and deployment of Philippine sea moorings with oceanographic sensors such as MicroCats, MicroTemps, and ADCP to quantify sound speed and current structure and provide a 250 Hz Webb sweeper source with STAR controller/receiver for the acoustic array.

**Wave Current Interactions in Coastal Inlets and River Mouths**
**Professor Tom Herbers, Oceanography**
**Sponsor: Office of Naval Research**

The principal objective is to improve understanding of the interaction between ocean surface waves and shear currents in coastal inlets and river mouths; in particular, to 1) develop observational capability using wave-resolving Lagrangian drifters to study wave–current interactions and contribute to a comprehensive community data set of coastal-inlet and river-mouth processes, 2) determine the role of nonlinearity in wave-current interactions by comparing observations to theoretical models and Monte Carlo simulations, and 3) develop predictive modeling capability of wave statistics in a complex coastal environment with strong currents.

**Autonomous Wide Aperture Cluster for Surveillance**
**Research Associate John Joseph, Oceanography**
**Sponsor: Office of Naval Research**

Seapower 21, the Chief of Naval Operation's vision for the 21st Century Navy, emphasizes antisubmarine warfare (ASW) as a high priority naval capability. This shift in priority requires the calculus




*Receiver operating characteristics for a detector of* Ziphius cavirostris *vocalizations at the SCORE range*

**UNDERSEA NODE LOCALIZATION USING NODE-TO-NODE ACOUSTIC RANGES IN A DISTRIBUTED SEAWEB NETWORK**
**David C. Zinkhon–LT, USN**
**MS in Engineering Acoustics–March 2009**
**Advisor: Joseph A. Rice, Physics**

Seaweb is a wide-area network interconnecting a set of distributed underwater nodes through the use of a DSP-based acoustic communications modem at each node and through-water digital acoustic links between neighboring nodes. As a by-product of Seaweb communications, the distances between neighboring nodes are obtained from the round-trip acoustic travel-time measurements. If the network is deployed in an *ad hoc* distribution, or if an established network is disturbed, the locations of the nodes are unknown to the operator. This thesis uses the node-to-node ranges, which have been compiled at the designated master node, as input to an algorithm for estimating the relative locations of all nodes. Synthetic network geometries serve to evaluate the algorithm with perfect ranges and with imperfect ranges and/or incomplete data. Seaweb networks deployed at sea are the final test of the algorithm.

of ASW to significantly change from the present platform-based approach, using submarines and surface ships, to a distributed, networked force utilizing rapid detect-to-engage capabilities. At issue is the surveillance of very quiet diesel-electric submarines operating electrically in the littoral shallow waters (SW) in and around strategic ports. The environment is very noisy due to local shipping; sound propagation is highly variable in both time and space. Consequently, the performance of current ASW assets with passive sonar systems is unacceptable. The tactical ranges required for efficient operation specify a signal-to-noise ratio that is presently unobtainable. Furthermore, the number of false alarms from local ships prohibits effective fire-control solutions. Thus, the detection, classification, and localization (DCl) of DE submarines requires a new concept of operation based on new systems and technologies. This proposal addresses the use of a cluster of AUVs for adaptive DCl of quiet targets.

**Shallow-Water Autonomous Vehicles**
**Associate Professor James MacMahan, Oceanography**
**Sponsor: Office of Naval Research**

The instrumentation procured through this funding will augment ONR-sponsored core programs and departmental research initiative field efforts focused on obtaining *in situ* observations on macrotidal flat, riverine, and oceanic environments through unique autonomous vehicles. Two instrumentation requests are proposed: 1) purchase of a YSI EcoMapper autonomous underwater vehicle, and 2) purchase of instrumentation for a PI-owned SeaRobotics autonomous surface catamaran system. In addition, the autonomous systems, particularly the EcoMapper AUV, will be integrated into NPS classroom exercises providing hands-on opportunities for naval officer students to use these instruments and to analyze the data. Students will also use this equipment for their thesis projects.

**ATMOSPHERIC EFFECTS ON RADIO FREQUENCY (RF) WAVE PROPOGATION IN A HUMID, NEAR-SURFACE ENVIRONMENT**
**Samuel P. Mason–LT, USN**
**MS in Meteorology–March 2010**
**Co-Advisor: Peter S. Guest, Meteorology**
**Co-Advisor: Andreas K. Goroch, Naval Research Laboratory**

Currently, the meteorological and physical phenomena associated with the various dynamic processes in the very near surface environment (for example, within the surface layer), are poorly understood. By properly characterizing what is happening in the real world, there is potential for obtaining an empirical formula which correlates well with real world data, and thus can be used as a means of quantifying these physical processes. This in turn can be used to more accurately model the effects of the atmosphere on RF waves.

This thesis is an analysis of the propagation loss measurements taken from the Near Earth Propagation-6 (NEP-6), Panama City, FL, experiment in Aug 2009,. In this experiment, propagation loss was measured at 1768 MHz within a few wavelengths.

**Observation of Upper Ocean Temperature, Salinity and pH Structure in the Central Arctic**
**Research Professor Tim Stanton, Oceanography**
**Sponsor: Office of Naval Research**

The Arctic Ocean is currently experiencing a number of environmental changes associated with climate change including rapidly declining summertime sea ice extents and melting of permafrost. Reduced ice cover allows more efficient exchange between the ocean, and atmosphere and permafrost melt leads to larger chemical transports from the land to the ocean. Both of these effects are likely to affect the pH, in addition to salinity and temperature, of the Arctic Ocean surface layer. We propose an exploratory project to measure the spatial and temporal variability of the upper Arctic Ocean to document these ongoing changes and to assess the impact of the changes on the attenuation of acoustic energy in the ocean. This work directly impacts medium and long range acoustic propagation models in the Arctic Region.

**Validation, Verification and Exploitation of Ocean Model Numerical Guidance for ASW Decision Support**
**CAPT (sel) Rebecca Stone, USN, Oceanography**
**Sponsor: Office of Naval Research**

The Naval Oceanographic Office reachback cell (RBC) is ramping up support of ASW operations by developing new ocean model areas, in more areas and at higher resolution than before. The RBC is applying the numerical model output in new ways to support ASW planning. Output is being used to produce predictions of ocean conditions and time-evolving, 3D, threat-specific maps of areas where detection probability is high (or low), and where dynamic ocean conditions can be exploited to provide an asymmetric advantage to our sensors. The new model areas and the reachback cell support are major developments in both technology and CONOPS.

There is an urgent need for validation and verification of these new model areas and products as they are being brought on line over the next one or two years. A full understanding of the uncertainties—the variability of the ocean environment, and the predictive system's ability to portray that variability—is needed in order to make operational plans that hinge on these predictions.

**Investigation of the Effects of Hydro-Reaction During Hypervelocity Impact Penetration**
**Research Professor Ronald Brown, Physics**
**Sponsor: Office of Naval Research**

This investigation explores the effect of exothermic chemical reaction during the hypervelocity impact and penetration of projectiles against submerged targets. The primary issue pertains to the relative rates of reaction and kinetic energy coupling during the penetration process. Light gas gun launching experiments are being conducted at the Ernst Mach Institute in Freiberg, Germany.

**Novel IM Explosive Initiation Technology**
**Research Professor Ronald E. Brown, Physics**
**Sponsor: Office of Naval Research**

Continuing research focuses on enhancing the effectiveness of explosive warheads, specifically shaped charges, for underwater weapons systems. Objectives of current work focus on developing novel techniques for sustaining overdriven detonation conditions, including methods for initiating extremely insensitive explosives

below critical diameter. Experiments confirming theory and computational predictions were performed at the Lawrence Livermore National Laboratory.

**Numerical Modeling Efforts in Support of 3D Environmental Variability and Acoustic Vector Field Studies**
**Professor Kevin Smith, Physics**
**Sponsor: Office of Naval Research**
The goals of this work are multifaceted; one aspect includes continued study of the effects of 3D environmental variability on the flow of energy in a complex intensity field. This builds on work that examined the influence of nonlinear internal wave perturbations in shallow water. Similar modeling efforts will be conducted at URI to support analysis of SW06 data sets. Additional modeling will also include 3D scattering from rough ocean interfaces and other features. Work will support the PhD research of Steve Crocker (NUWC-Newport) involving analysis of SAX04 vector sensor data for the purpose of examining the geo-acoustics of the region.

**Technical Challenge Support for Vector Sensor Array Development**
**Professor Kevin Smith, Physics**
**Sponsor: Office of Naval Research**
The development of arrays of acoustic vector sensors has been supported by the Office of Naval Research, Code 321MS, over the past several years. Recent tests, both in the laboratory and during seatrials, have revealed technical challenges that must be addressed for such systems to prove effective in operational scenarios. This work will provide assistance in the coordination and definition of efforts between various researchers to define and address these technical challenges.

**Seaweb Maritime Network**
**Research Professor Joseph Rice, Physics**
**Sponsor: Office of Naval Research**
This applied research is producing state-of-the-art undersea acoustic networked communication technology (i.e., "Seaweb") for application to maritime sensing in support of intelligence, surveillance, reconnaissance and naval special warfare. Seaweb acoustic networking embodies physical-layer, link-layer, network-layer, and transport-layer functionality as described by the Open Systems Interconnection (ISO/OSI) reference model. Seaweb also provides node-to-node ranging as a by-product of acoustic communications. Seaweb technology advances are achieved through spiral development involving a build/test/build engineering process, with rigorous testing at sea. In 2010, the concept of a "Deep Seaweb" has been advanced through the publication of three theses exploring the potential of wide-area acoustic sensor networks exploiting deep-water features such as reliable acoustic path and deep sound channel.

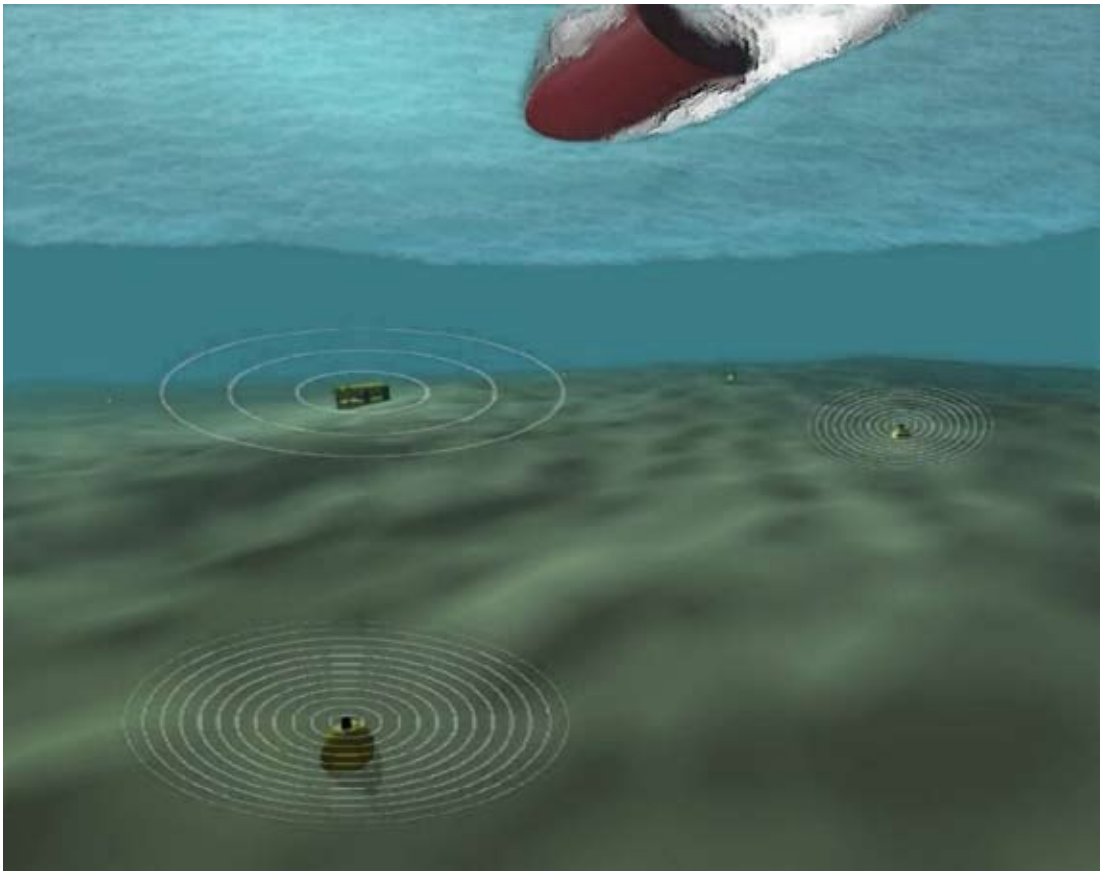
**Operational Adaptation using Seaweb Maritime Surveillance**
**Research Professor Joseph Rice, Physics**
**Sponsor: Office of Naval Research**
In conjunction with the ONR Operational Adaptation (OA) program, this project is demonstrating dedicated maritime surveillance by means of a Seaweb distributed network of autonomous underwater sensors. The Seaweb underwater maritime in situ sensor network is implemented in conjunction with shore-based sensors (fixed and mobile camera systems) and overhead sensor systems (aircraft-based) to demonstrate: autonomous detection, classification and localization (DCL) of maritime targets of interest; delivery of near-real-time contact reports to a tactical operations center; and cross-system tipping and cueing. Maritime surveillance capability in the U.S. intra-coastal waterway was demonstrated in a February 2010 exercise.

**Seaweb Sensor Network**
**Research Professor Joseph Rice, Physics**
**Sponsor: OSD Rapid Reaction Technology Office**
This project implements an underwater network of distributed, autonomous, hydro-acoustic vector sensors for the detection, classification, and near- real-time reporting of go-fast vessels and self-propelled semi-submersible maritime targets. A prototype involving two sensor nodes, six repeater nodes, and an iridium-equipped gateway node was demonstrated during the March 2010 Thunderstorm Spiral-3 exercise at two ocean sites in international waters.

**NATO Next-Generation Autonomous System (NGAS)**
**Research Professor Joseph Rice, Physics**
**Sponsor: Office of Naval Research**
The NGAS joint research project (JRP) involves NATO Undersea Research Center (NURC), Canada, Norway, Italy, and USA. Participating nations are developing deployable ASW sensors for passive detection of submarine acoustic and magnetic signatures. NPS is responsible for integrating these multi-national sensor nodes into a common Seaweb network architecture. Such a Seaweb network including four Norwegian sensor nodes and four U.S. sensor nodes was successfully fielded against a cooperative Italian submarine in 2009. A major engineering trial involving member nations and observers from England and Germany is occurring in June 2010 in Norwegian waters. This engineering trial is in preparation for a 2011 demonstration trial against another submarine target.

**THREE-DIMENSIONAL FEATURE RECONSTRUCTION WITH DUAL FORWARD-LOOKING SONARS FOR UNMANNED UNDERWATER VEHICLE NAVIGATION**
**Nevin McChesney–LT, USN**
**MS in Electrical Engineering–March 2009**
**Advisor: Doug Horner, Mechanical and Astronautical Engineering**
**Co-Advisor: Roberto Cristi, Electrical and Computer Engineering**

Unmanned Underwater Vehicles frequently rely on two-dimensional sensors for information about their surroundings. These sensors do not provide adequate information for obstacle avoidance in cluttered maritime environments. To address that issue, a three-dimensional reconstruction of the environment utilizing occupancy grids and a prototype forward looking sonar will be considered. Providing the vehicle with three-dimensional views of the environment will allow for optimal route planning and an increase in successful missions in complex environments.



*Seaweb is a distributed network of underwater sensor nodes, repeater nodes, and gateway nodes. Digital communications are performed with through-water acoustic modems. The wireless grid of autonomous nodes enables rapidly deployable, persistent, near- real-time, scalable, wide-area, undersea sensing and surveillance. Over fifty Seaweb networks have been deployed and operated in diverse maritime environments around the world, for applications such as antisubmarine warfare (ASW), maritime surveillance, port security, oceanography, submarine communications at speed and depth, mine warfare, and unmanned undersea vehicle (UUV) command and control.*

**TTCP Unet Undersea Networking Key Technology Area**
**Research Professor Joseph Rice, Physics**
**Sponsor: Office of Naval Research**

NPS chairs this four-nation research collaboration involving Australia, Canada, Great Britain, and United States. The Unet collaboration is advancing through-water communications technology and networking protocols for attaining interoperability amongst coalition maritime assets. The Unet collaboration is performed within The Technical Cooperation Program (TTCP). Unet is a key technical area (KTA) of the TTCP Maritime Systems Group (MAR) technical panel for ASW systems and technology (TP-9). Three major sea trials involving multiple component experiments have been conducted during the course of this four-year activity, along with fourteen Unet workshops. At the end of 2010, Unet will transition to a new mission-oriented KTA expected to be called Undersea Distributed Networked Systems (UDNS).

**Seastar Local Area Network**
**Research Professor Joseph Rice, Physics**
**Sponsor: Office of Naval Research**

Seastar is an underwater acoustic local-area network (LAN) concept involving a set of peripheral nodes communicating at short-range and with high bandwidth to a central node. The central node orchestrates operations of the peripheral nodes and serves as a central processing hub for sensor data collected at the peripherals. The near-term application of Seastar is in support of sensitive magnetometers for the purpose of autonomously detecting the passage of submarine targets. The Seastar central node can be a member of the Seaweb wide-area network (WAN) for communications with distant Seastar clusters and with manned command centers. This applied research involves Seastar development through numerical simulation and development of prototype Seastar acoustic modems.

**C4I Track Interoperability for the Antisubmarine Warfare and Mine Warfare Communities of Interest**
**Associate Professor Don Brutzman, Information Sciences**
**Research Associate Curt Blais, MOVES Institute**
**Sponsors: Naval Sea Systems Command Integrated Warfare Systems, PEO Littoral Mine Warfare**

NPS is providing ongoing technical support regarding the design, conversion and effective use of data models in order to maximize the long-term interoperability of software systems supporting antisubmarine warfare and mine warfare. Community-of-interest data-modeling working groups provide the primary forums for these efforts.

Modern interoperability includes the ability to convert between different data models with both syntactic and semantic correctness. Collaboration with multiple Navy commands is especially productive. Long-running partnered work shows that conversion of track data between diverse C4I data languages offers improved interoperability between a variety of deployed tactical systems.

Numerous technical tasks pertain including data-model design rules, evolving Department of Defense policies, XML-based compression and security, conversion correctness, testing, 3D visualization and long-term archivability. Results from this work fit under the NAVSEA Open Business Model to ensure that all software and data products remain re-usable, deployable and extendable for the lifetime of military systems.


*XML-based conversion of track data improves tactical interoperability between diverse Undersea Warfare command and control (C2) systems.*

**Persistent Virtual Environment Infrastructure Development for Undersea Warfare Training and Experimentation**
**Associate Professor Don Brutzman, Information Sciences**
**Research Associate Don McGregor, MOVES Institute**
**LCDR Tariq Rashid, USN**
**Sponsor: Office of Naval Research**

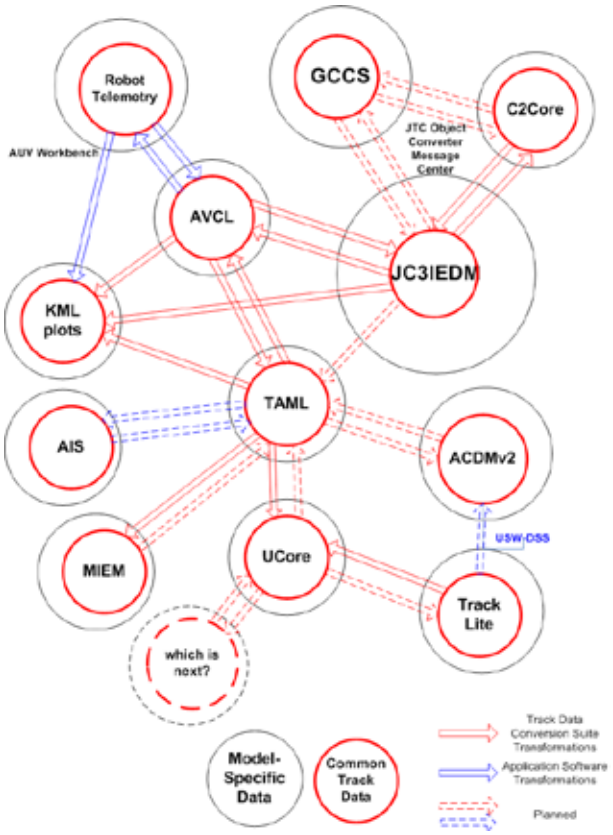
Recently, a great deal of attention has been given to the use of massively multiplayer online games (MMOGs) for both general gaming and military applications. The revenue generated by massively multiplayer online games and the effect that they have on network infrastructure has resulted in significantly more developmental resources being applied to commercial MMOG technology than for military distributed virtual (DVE) development.

All DVEs share a common set of characteristics, and it is possible to exploit these similarities to take advantage of commercial MMOG developments. Specific capabilities of interest include scalability for large numbers of players, capacity for large amounts of network traffic, portability across operating systems, as well as adaptability to connect diverse code bases, network protocols, and data formats.

This work produced and tested an open-source MMOG server, the open-source Project Darkstar middleware, which interconnects heterogeneous simulators in a DVE using locally developed network gateways. The performance of the hybrid system and the character of the network traffic it generates were analyzed.

Multiple interfaces were also developed to allow existing devices and models to interact with this environment. Situational visualization utilizes models student-created models authored using Extensible 3D (X3D) graphics standard.

Specifically the Naval Postgraduate School-developed Scenario Authoring and Visualization for Advanced Graphical Environments (SAVAGE) tools and the NAVAIR TSD-developed SH-60B Mission Rehearsal Tactical Team Trainer (MRT3) were connected using another Naval Postgraduate School-produced resource, an open-source implementation of the IEEE Distributed Interactive Simulation (DIS) protocol. Initial test results were successful, warranting further development and eventual deployment.




*Massively multiplayer, online game servers have the ability to interconnect different tactical, training and three-dimensional visualization systems. These distributed virtual environments hold promise for improved situational awareness.*

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### SPAWAR FELLOWSHIP PROGRAM SUPPORTS USW RESEARCH

The Space and Naval Warfare Systems Command Pacific (SSC Pacific) accepts applications from NPS naval students for research fellowships designed to promote SSC Pacific partnerships with the Naval Postgraduate School.

The fellowships address SSC Pacific research focus areas; lay the groundwork for future technical and project management assignments at SSC Pacific; and foster long-term professional associations with SSC Pacific technical personnel and management.

Applicants are required to be in an engineering or scientific specialty area with long range career objectives in technical management and acquisition for C4ISR systems. Many of the 120+ fellowships awarded have supported USW research.

Fellowship appointments will be made competitively on the basis of the applicant's academic record and evaluations, career technical and management goals, and the quality and relevance of proposed research initiatives.

Fellowship recipients will receive: a stipend of $10,000 to apply towards their research; an assigned senior SSC Pacific scientist or engineer mentor to facilitate close collaboration with prominent government researchers in the participant's specialty area; and access to SSC Pacific laboratory and high-performance computing resources as required.

ENS William F. Jenkins II, USN, received a SPAWAR Fellowship this year for his proposal, "Time/Frequency Relationships of an FFT-based Acoustic Modem." The goal of this research project was to implement multiple frequency-shift keying (MFSK) modulation for underwater acoustic communications in an adaptive manner by exploiting basic time-frequency relationships. Graduating with distinction in June 2010, ENS Jenkins has completed his thesis research.

### TIME/FREQUENCY RELATIONSHIPS FOR AN FFT-BASED ACOUSTIC MODEM

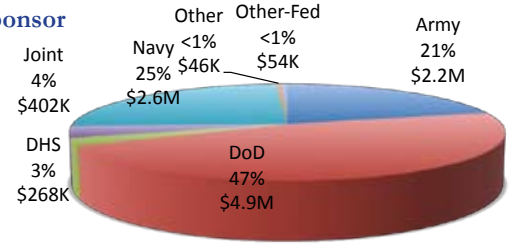
**William F. Jenkins II–ENS, USN**
**Master of Science in Engineering Acoustics–June 2010**
**Advisor: Joseph A. Rice, Physics**
**Second Reader: Lawrence Ziomek, Electrical and Computer Engineering**

This thesis proposes a scheme for short-range (<500m) underwater acoustic communications in shallow water. The proposed scheme is a variation on an existing commercial modem reliably used for medium-range (<5km) communications in the 9-14 kHz band. The proposed scheme exploits a higher carrier frequency at 45 kHz and increased spectral bandwidth compatible with the short-range link, thus achieving an increased channel capacity. Analytical expressions are provided, which combine principles of M-ary frequency-shift keying (MFSK) and orthogonal frequency-division multiplexing (OFDM) in a modulation referred to as multichannel MFSK. The proposed scheme consists of 32 orthogonally spaced channels, each with a 4-FSK pulse train. Existing medium-range modem algorithms are adapted for the higher carrier frequency and candidate variations are implemented with bandwidths of 10 and 20 kHz. Variations involve bandwidth scaling or multiplexing the original 5 kHz spectral bandwidth. Of concern for short-range links in shallow water is multipath interference, causing time-spreading and significant intersymbol interference. Dominant Eigenray paths are determined to estimate the time-spread expected in shallow-water environments. These are analyzed as to time/frequency relationships of multichannel MFSK to comparatively evaluate the candidate variations in terms of protection against ISI. We propose multiplexing 5 kHz MFSK modulation across the larger operating band.

## Graduate School of Business and Public Policy

Funds available to date: $10.5M

**By Sponsor**




**Projects funded in May:**

- Irregular Warfare (IW) Methods, Models, and Tools (MMT) Infrastructure and Essential Services Onthology, *Deborah Gibbons, GSBPP* (TRAC – Monterey)
- Chair of Acquisition and Acquisition Research Program, *Keith Snider, GSBPP* (JTRS AMF)

### UNCLASSIFIED NPS THESIS ABSTRACTS AVAILABLE ONLINE

Unclassified abstracts of theses and dissertations submitted for the degrees of doctor of philosophy, engineer, master of science, and master of arts can be found at http://www.nps.edu/research/MoreThesisAbst.html. This website provides a broad overview of the nature and substance of the student research undertaken at the Naval Postgraduate School.

Theses may also be searched online through the NPS library's BOSUN database, http://bosun.nps.edu/. Search parameters available are title, author, subject heading, branch of service, and degree awarded.

## SEED DATA FARMING RESEARCH


The first meeting of the NATO modeling and simulation task group #088 (MSG-088), Data Farming in Support of NATO, was held 24–28 May in Paris. Participants from eight nations gathered to start the three-year effort to assess the data farming capabilities of NATO and various nations that could contribute to the improvement of decision support to NATO forces. Proof–of-concept explorations involving questions and models of interest to NATO nations will also be undertaken. MSG-088 will recommend and demonstrate a way forward for data-farming methods and processes in NATO M&S contexts. NPS participants included LT Leslie Esher, USN (front row, third from right) and task-force chairman Gary Horne (front row, far right) from the SEED Center for Data Farming in the Operations Research department.

*Schieffelin Awardee Timour Radko, OC*

## 2009 SCHIEFFELIN AWARD RESULTS

Associate Professor Timour Radko of the Department of Oceanography has garnered the Rear Admiral John Jay Schieffelin Award for Teaching Excellence for the 2009 academic year. The Schieffelin is based on student and alumni polling as to outstanding education. Radko's research interests include general circulation of the ocean, the dynamics of mesoscale jets and vortices, double diffusive convection, and wave motion. He is a recipient of the Faculty Early Career Development Award, NSF (2006) and the Schieffelin top five percent in teaching excellence, NPS (2006–2007).

## C41 WORKSHOP

A C41 workshop on common services, application services, communications and networks, and common computing environment was held Monday, June 14–16, in Glasgow 102. The workshop concentrated on

- Communications: SATCOM/Non-SATCOM wireless/tactical data links
- Networks: Wide-area networks, local networks, and network management
- Common computing environments/common services: hardware (CANES), software (core services, tactical edge)
- Application services: business apps, ISR, battlespace awareness, command and control
- Cross-cutting Services: cyber warfare, information assurance, encryption, and informatin ops.

Contact Assistant Professor Rachel Goshorn, SE and ECE, goshorn@nps.edu, for information.

## TORNADO RESEARCH: FOLLOW THE STORM

*The NPS mobile weather radar (MWR) during VORTEX - 2, Nebraska, May 2010 (courtesy Robert Bluth)*

## NON TENURE-TRACK PROMOTION ACTIONS FOR ACADEMIC YEAR 2010... CONGRATULATIONS

**Promotion to Research Professor**

- Peter Guest, MR in recognition of research, instruction, thesis advising and service. He has been a leader in Arctic research and atmospheric measurements in support of the NPS TNT program. Prof. Guest's classroom teaching in atmospheric physics is consistently excellent.
- Oleg Yakimenko, MAE, in recognition of innovative research, classroom instruction, and thesis advising and leadership as director of the Center for Aerodynamic Decelerators. His work in optimal and adaptive control for autonomous vehicles and precision delivery systems has improved military systems and won widespread attention.

**Promotion to Senior Lecturer**

- Greg Miller, SE, in recognition of twenty-nine sections taught and seven capstone projects and three theses advised. He has won the Meyer Award for Faculty Excellence in Systems Engineering five times, published extensively, and developed new courses. Miller attracts sponsored funding from a variety of naval and industrial activities.
- Mark Rhoades, SE, in recognition of thirty-three sections taught and four integrated capstone research projects and six theses advised. Rhoades served as associate chairman for educational technology and as a program officer.

## COOPERATIVE RESEARCH AND DEVELOPMENT AGREEMENTS (CRADAS)

**Title: Cyber Attack and Security Exercise**
**Partner: InfraGard Los Angeles Members Alliance, Inc. NPS POC: Dan Boger, Information Sciences**
Summary: NPS and IngraGard are collaborating to conduct a cyber attack and security exercise. The exercise will examine the consequences of a wide spread cyber attack on the critical infrastructure and private sector, and explore the private sector' role in identifying, countering, and responding to terrorist cyber attacks.

**Title: Development of Airdrop Payload Delivery Capability for Unmanned Aerial Vehicles**
**Partner: Arcturus UAV, LLC.**
**NPS POC: Oleg Yakimenko, Mechanical and Aerospace Engineering**
Summary: The objective of this collaboration is to develop an air-drop payload delivery capability system for unmanned aerial vehicles (UAV). The partners will develop a complete autonomous system for robust and reliable delivery of multiple small payloads/ sensors/ ground robots with pinpoint touchdown accuracy and soft-landing capability. The proposed work will be based on integration of the existing aerial platform Arcturus T-20 with multiple aerial parafoil-based delivery systems (ADS) to assure precise delivery of small payloads/sensors/ground robots on demand.

**Title: Closed-Loop Compressor Development and Testing**
**Partner: Ramgen Power Systems, LLC.**
**NPS POCs: Garth Hobson, Anthony Gannon, Mechanical and Aerospace Engineering**
Summary: NPS and Ramgen will collaborate to mechanically design, build and test a specialized compressor. The compressor will be designed for maximum efficiency for use in the process of geologic sequestration of carbon dioxide (CO2). The ultimate goal is to make available cost effective methods and equipment for the reduction excess CO2 in the atmosphere. The collaborators will first design and build a closed loop compressor testing capability within the NPS Turbo-Propulsion Laboratory. This closed-loop system will be used to evaluate the performance of the test compressor.

**Title: Assessment of Unmanned Systems for Wildland Fire Fighting Partner: Association for Unmanned Vehicle Systems International (AUVSI).**
**NPS POC: Dan Boger, Information Sciences**
Summary: NPS and AUVSI will collaborate to explore the utility of unmanned systems in public safety applications and other potential communities to further the role of unmanned systems in fire fighting operations with a specific focus on civil government capability areas. Additionally, firefighting technologies will be demonstrated and evaluated in a controlled environment. During these demonstrations, data will be collected and analyzed in order to develop, collect and assess metrics, feasibility, safety, business case analysis, and value assessments for unmanned systems in wildland firefighting operations.

## TECHNICAL SERVICE AGREEMENTS (TSAs)

**Title: Particle Imaging Measurements in a 2D Slab Burner**
**Partner: ATK Launch Systems Inc.**
**NPS POC: Christopher Brophy, Mechanical and Aerospace Engineering**
Summary: The Propellant Condensed Phase Characterization work will continue by directly imaging particle behavior inside a two-dimensional slab burner. The objective of this work is to directly image the aluminum oxide formation and behavior as the combustion products flow through a narrow passage between two propellant samples. NPS will test data and deliver a representative video documentation.

## MEMORANDA OF UNDERSTANDING/ AGREEMENT (MOUS/MOAS)

**Partner: Office of the Assistant Secretary of the Navy, Financial Management and Comptroller (Biennial Renewal of Conrad Chair Agreement)**
**NPS POC: John Mutty, Graduate School of Business and Public Policy**
Summary: The objective of this agreement is to provide a direct relationship between the OASN FM&C and NPS in order to provide opportunities for professional development of both faculty and students in financial management. The specific research objective is to enable potential scholars in their applied research on topics.

## PATENT APPLICATIONS AND AWARDS

**Method for Optimal Transmitter Placement in Wireless Mesh Networks,** Navy Case No. 20090005.
Inventors: Capt. Paul Nicholas, USMC and David Alderson (Operations Research)
**Embedded Communications System and Method,** patent issued for Navy Case No. 83890.
Inventors: John McEachen and Maj. William Geissler, USAF (Electrical and Computer Engineering)

## TECHNICAL REPORTS PUBLISHED

| | | |
|---|---|---|
| NPS- SP-10-001 | ACS Air Bearing Test-Bed Design | S. Glitt |
| NPS-PH-10-001 | Consequences of Coaxail Jet Penetration Performance and Shaped Charge Design Criteria | D. Hasenberg |
| NPS-OC-10-001CR | SOCAL-10 Planning Meetings – Notes and Summary | B. Southall |

Technical reports may be obtained at http://www.nps.edu/Research/TechReports.html