

NAVAL POSTGRADUATE SCHOOL RESEARCH

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THE NAVAL POSTGRADUATE SCHOOL'S UNIQUE ABILITY FOR CLASSIFIED RESEARCH ALLOWS FACULTY AND STUDENTS TO PROBLEM-SOLVE CRITICAL AREAS FOR THE DEPARTMENT OF DEFENSE

The Naval Postgraduate School's primary mission is graduate education. As in any graduate level institution, research is a vital component of the education process. At NPS, the student body is composed mainly of active duty officers from the military services—Navy, Marine Corps, Air Force and Army. Coupled with upper level graduate courses with an emphasis on DoN/DoD problems are the experience of these officers and unique facilities that allow research up to the Secret Compartmented Information (SCI) level. These assets allow for a dynamic "classified research environment." This article contains an unclassified overview of some of the unique efforts being undertaken by the faculty and students at the Naval Postgraduate School.

As you peruse these examples of classified research consider how much more closely the projects are aligned to *military* activities than to *academic* disciplines. In recent years the four NPS Schools and three research Institutes have gone to extraordinary lengths to cross traditional boundaries with teams doing interdisciplinary

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WARRIOR'S ACADEMIC RESOURCES NETWORK (WAR Net)

Associate Professor Ray Buettner

Department of Information Science

At first glance it appears to be just another website like so many others on the SIPRNET. Upon closer inspection the user will notice that it looks better, something about it is more professional, more functional, yet still its true utility is not apparent. It is easy to use, and it subtly offers information related to the user's task. Yet only after using it for some time might the user realize that they have stumbled upon something genuinely different. Even then – the user is unlikely to truly understand what is happening and the extent to which the site differs from most others on the net. What is this new site? It is the Warrior's Academic Resources Network (WAR Net), located in cyberspace and accessed via the Naval Postgraduate School's SIPRNET.

The mission of the NPS is to “increase the combat effectiveness of U.S. and Allied armed forces and enhance the security of the United States through advanced education and research programs focused on the technical and managerial tools needed to confront defense related challenges of the future.” WAR Net is intended to support this mission by providing the SIPRNET user and NPS students with the

highest quality and education and research materials available.

WAR Net is designed to serve three functions in support of the NPS mission. First, it is a communal knowledge resource and repository for NPS students and SIPRNET users. Officers can seek cutting-edge research and information in the form of theses, white papers, slide presentations and websites, to enable knowledge creation and inspiration. Advanced search features and functionalities tailored to the staff planner or intelligence analyst will be provided.

Second, WAR Net serves as a meeting place by providing the warrior with a single source of up-to-date information about NPS research and faculty expertise in the classified arena. NPS faculty listed on WAR Net are all government employees with security clearances and access to the full range of secure communications technologies. WAR Net will also let users know of other recent queries that relate to their own, increasing the probability that knowledge workers in different agencies and/or organizations will be able to share information and “connect the dots.”

Finally, WAR Net is an educational and research tool in and of itself. NPS students will design and test new technologies for improved functionalities “live” on WAR Net. Experiments can be run, metrics evaluated, and new processes implemented on this site under carefully controlled conditions.

WAR Net development was funded as part of the Center for Defense Technology and Education for the Military Services' (CDTEMS) project on “Influence Modeling Support for the Global War on Terror.” One deliverable of the project was to provide access to the NPS research via the SIPRNET. When considering adding yet another plain-vanilla web site to the hordes already existing on the SIPRNET, the project team was convinced that a better vehicle could be designed that met the needs of the project yet could also be a better mechanism for knowledge creation and sharing.

The Principal Investigator, Associate Professor Raymond Buettner, wanted to move beyond the simple information-sharing view of knowledge management that drives conventional website design and create, instead, a web site that takes advantage of both the connectivity and communal aspects of the web to enhance knowledge creation. It is Buettner's belief that this shift in emphasis is required if the full advantages of the network-centric paradigm are to be

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INTRODUCTION, *continued from page 1*

studies that touch most aspects of naval—and often military—operations. You will see classified investigations of networks that better tie sensors, weapons and command systems together cohesively. You will also find studies to defeat the enemy with better management of knowledge while striving for assured information security across our networks.

Interdisciplinary study is as focused as the creation of a virtual submarine control room and as broad as the campaign analysis of a fleet of new aerial vehicles and warcraft to support expeditionary warfare and littoral operations. The research spans the gamut from system components, to totally engineered system designs, to systems of systems to create a navy that will be an integrated “fighting machine.”

NPS explores problems and opportunities that no other university could undertake and yet our military students and civilian faculty conduct their classified work in secure facilities with the same scientific rigor found in the best universities.

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WARRIOR'S ACADEMIC RESOURCES NETWORK, *continued from page 2*

realized.

Research Associate Kristen Tsolis (Department of Defense Analysis) and Web/Multimedia Producer Ryan Stuart worked to create a layout that would permit a fast download but still maintain a distinctive aesthetic. The WAR Net logo is intended to represent a network, interconnected and dynamic. The choice of the logo's typefaces was meant to be bold, attention getting, but not to overwhelm the remainder of the layout. The wide letterspacing is to serve as a subtle reminder that the "WAR" in "WAR Net" is in fact an acronym for "Warrior's Academic Resources" Network. Little color was used in the overall design to present a clean, clear look that allows for quick scanning without unnecessary distraction.

The 2/3—1/3 layout was chosen so that the site conveys a magazine feel. Users of this site will want to be able to rapidly scan for subjects of interest, yet also have longer articles of interest presented as well. The 2/3—1/3 layout facilitates both scanning and in-depth reading. The 2/3 column of this layout is intended for the latter use; long articles can be easily read in this space, yet the reader does not have to contend with wide blocks of

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“LAYING THE KEEL” FOR A VIRTUAL NAVY: BUILDING A VIRTUAL SUBMARINE CONTROL ROOM

LT Kenneth Curtin, United States Navy

LCDR James Park, United States Navy

Associate Professor Don Brutzman, Department of Information Science

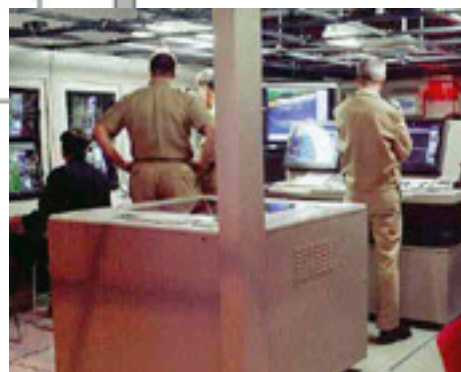
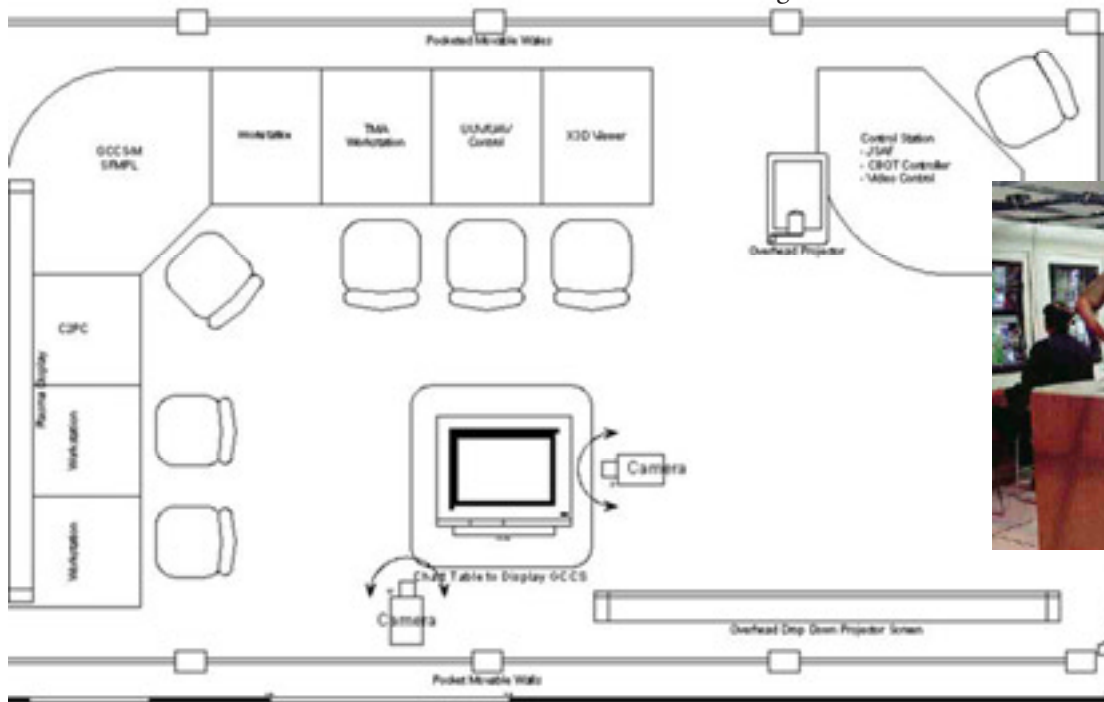
Erik Chaum and Dr. Lynee Murray, Naval Undersea Warfare Center, Newport, RI

The Naval Postgraduate School in collaboration with Naval Undersea Warfare Center (NUWC) have proposed building a Virtual Naval Asset (VNA) (vSSGN #2) at NPS to further interdisciplinary collaboration and experimentation. Building a VNA at NPS will leverage capabilities from NUWC's Warfare Systems Presentation Facility (WSPF), a reconfigurable virtual naval platform. The

NUWC WSPF has been a player in Fleet Battle Experiments as well as other experimental exercises. Building and operating a second VNA at NPS will demonstrate a broad set of actual and simulated warfare capabilities that can further directed research and development in Network-Centric Warfare and FORCENet. A substantial savings from the original cost estimate has been achieved in the final proposal

by using strictly commercial-off-the-shelf (COTS) hardware, which

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(Above) WSPF in action.

(Left) NPS Virtual Naval Asset floor plan.

WARRIOR'S ACADEMIC RESOURCES NETWORK, *continued from page 3*

type, nor with a lack of whitespace. The 1/3 column is intended to offer related items of interest, such that a user can scan quickly down the column to see or search for relevant information.

WAR Net was also designed to be easily manageable. NPS student **Captain Dan Boersma**, USMC, created a database-driven back-end for the site that makes it possible for most content management to be accomplished via

simple forms that can be filled in by content providers. This eliminates costly format translation issues and enhances the sense of ownership for those pushing information onto the site. Captain Boersma's design makes it easy for follow-on students to build on the basic functionality of the WAR Net for the design and testing of new capabilities.

Professor Buettner anticipates migrating technologies and processes from WAR Net to the OSD supported Information Operations Technology Alliance (IOTA) site to enable the use of WAR Net concepts by the larger defense communities.

CLASSIFIED RESEARCH

NAVAL POSTGRADUATE SCHOOL TO DEVELOP TACTICAL MEMORANDA FOR FLEET USE

CAPT Jeffrey Kline, USN, and Administrative Associate Kathie Cain
Wayne E. Meyer Institute of Systems Engineering

The Naval Warfare Development Command (NWDC), Commander Cruiser Destroyer Group Twelve (COM-CRUDESGRU TWELVE), and Commander Patrol Reconnaissance Force Pacific (CPRFP) have tapped NPS to assist

LCDR Russ Gottfried, USN, Operations Research Military Faculty and experienced surface warfare officer, will be leading the effort to develop a TACMEMO to aid deployment of Unmanned Vehicles (UV) in support of Maritime Operations.

In addition to creating a network portal to capture COMCRUDESGRU TWELVE'S lessons as they deploy with a suite of Unmanned Vehicles and provide a line of communication to other fleet users, LCDR Gottfried will be tapping experienced students and UV researchers on campus to accomplish his work. LCDR Gottfried has an impressive operational background, is a talented Operations Research analyst, is an experience UV researcher, and is known campus-wide. He is the right man for the job!"

The second TACMEMO under development is sponsored by Commander Patrol Reconnaissance Force Pacific and focuses on tactics for hunting diesel submarines with Maritime Patrol Aircraft (MPA). Dr. Jeff Crowson, Operations Research faculty and the current COMTHIRDFLT/NPS Desk holder, and Lecturer Matt Boensel, Systems

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Maritime Patrol Aircraft and Diesel Submarine Hunter. U.S. Navy photo by Photographer's Mate 2nd Class Damon J. Moritz.

in developing two Tactical Memoranda to address pressing tactical issues faced by our Maritime Forces. Tactical Memoranda (TACMEMO) are tactical aids or recommendations to address immediate operational problems. If tested satisfactory in the fleet, tactical memoranda are further developed into naval doctrine.

"Naval Postgraduate School's unique combination of operationally experienced students and defense oriented faculty make us very well suited to address several issues facing the fleet today" said CAPT Jeff Kline, USN, NWDC's Operations Research Chair of Warfare Innovation. "For example,



USS Gettysburg underway and deploying with an Unmanned Surface Vehicle "Spartan Scout" will provide valuable lessons for the development of a TACMEMO on deploying UVs in Maritime Missions.

JOINT CAMPAIGN ANALYSIS COURSE LOOKS AT COMBINED JOINT TASK FORCE SEA TIGER

CAPT Jeff Kline, United States Navy

Wayne E. Meyer Institute of Systems Engineering

Dateline 10 Nov 2016 Manila Philippines --A crisis of world-war proportion is emerging from the South China Sea. After disputing for decades various territorial and maritime rights, the South China Sea's perimeter nations have begun hostilities.

This July, in an attempt to maintain territorial seas integrity, a Philippine helicopter warned, then fired, on a People's Liberation Army (PLA) Navy destroyer that was conducting gunnery exercises two nautical miles off Palawan's coast. Ten Chinese sailors were killed.

Two months later, claiming self-defense for the Philippine incident, and citing the need to establish a "safety" perimeter around the South China Sea due to increased tensions, the PRC invaded Kepulauan Natuna (Indonesia) with a division of Chinese infantry. They further threatened to invade Palawan Island Philippines if any of the ASEAN nations reacted. In coordination, the PLA Navy began to quarantine Puerto Princesa port on Palawan. The PRC government immediately called for a treaty with Philippines and Indonesia to establish a New Era of South China Sea Cooperation among perimeter nations. They gave the governments of the Philippines and Indonesia one month to respond.

Led by the United States, ASEAN nations condemned China's action and submitted a joint U.N. resolution to establish sanctions against the PRC. This resolution was vetoed in the Security Council.

The U.S. National Command Authority (NCA), through SECDEF, directed COMPAC to establish a Combined Joint Task Force (SEA TIGER) with Indonesia, Philippines, Singapore, and Australia in order to prepare alternative courses of action to deter Chinese action and protect Philippine and Indonesian sovereignty. If deterrence failed, the CJTF Commander was to be prepared to repel invasion of Palawan Island with follow-on operations to re-establish Indonesian sovereignty over Kepulauan Natuna. Due to nuclear escalation concerns, no strikes on the Chinese mainland or Taiwan would be approved.

As forces for CJTF SEA TIGER began to flow into theater, China invaded Palawan Island with two air-borne divisions and one Maritime Division. The mission of CJTF SEA TIGER was immediately changed to re-establishing Philippine sovereignty over Palawan.

The 2016 China/Philippine scenario is being presented to NPS's Joint Campaign Analysis class. Composed of Army, Navy, and Marine officers from MOVES (Modeling, Virtual Environments, and Simulation), OR (Operations Research), and SEA (Systems Engineering and Analysis) curricula, the class' task is to act as the initial analytical core staff for CJTF SEA TIGER and conduct broad-level quick-turn around analysis to highlight important logistics limitations, force capabilities, challenges, and costs associated with various operational level courses of action to achieve their mission.

Using a variety of analytical tools; including stochastic modeling, network analysis, decision theory, simulation, and gaming; the joint-class team is formulating important considerations about the scenario and studying issues such as



the operational impact on Guided Missile Nuclear Submarines, the potential benefits of a proposed C-130 float-plane, employment flexibility of the Littoral Combatant Ship (LCS), and requirements to defend the Sea Base.

The Joint Campaign Analysis course's objective is to prepare officers' to serve as analysts on various Unified Combatant Commands', Joint Task Forces', and the Joint Chiefs' staffs. In addition to presenting students with proven analytical methods to use in the campaign level project, the course is designed for them to bring skills learned in all their curricula courses and "test" them against a scenario.

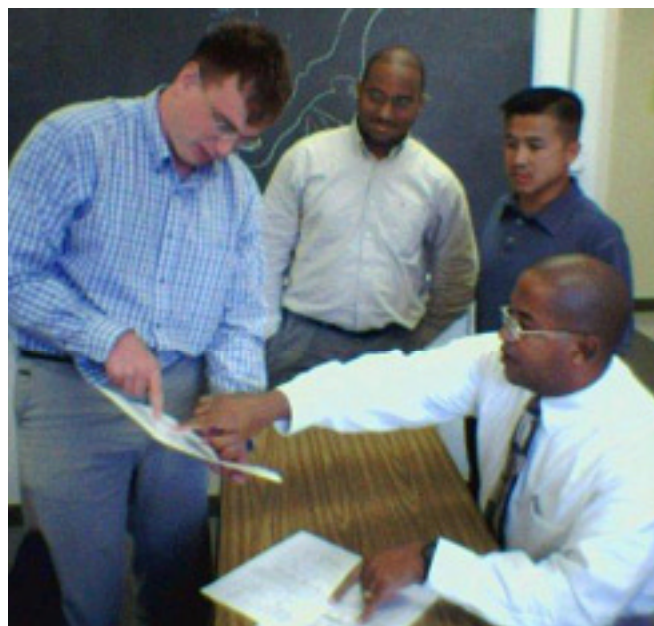
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COMBINED JOINT TASK FORCE SEA TIGER, *continued from page 7*

By having three analytical and technical curricula represented, combined with the operational experience from joint officers ranging in grade O3 – O5, the Joint Campaign Analysis class becomes a unique analytical laboratory to wrestle with future capability challenges within a joint force.

Past mini-study results have been used to analyze current operations, provide foundations for NPS's interdisciplinary projects, and to provide information to DoD-wide study initiatives. In addition to the capability proposals' sponsors mentioned above, this year's study will be providing input to NPS's interdisciplinary project focusing on defense of the Sea Base. Many of the students, and the scenario, will be progressing to the Joint Wargaming Course where they will focus their evaluation efforts using war gaming and combat models. This work will be part of a collaborative effort with Lawrence Livermore Labs and Joint Forces Command (J-9).

Members of the CJTF SEA TIGER "staff" address an issue in their analysis outside of class time.



BUILDING A VIRTUAL SUBMARINE CONTROL ROOM, *continued from page 4*

has cut the proposal cost in half.

A key enabler for transformation in the DoD and in the Navy resides in the smart implementation of Sea Power '21 and FORCENet. FORCENet is defined as netting of existing capabilities, initiatives and programs to improve combat power and effectiveness. To achieve these goals, a platform for research, development and experimentation are critical in maturing new capabilities and concepts before they are put to use.

NPS has teamed with NUWC and Naval Warfare Development Command (NWDC) in leveraging virtual training capabilities to create a virtual presence in furthering FORCENet concepts. Creation of the VNA not only helps in the transformation of the Navy via experimenting and exercising FORCENet concepts, but future possibilities will include the Modeling & Simulation (M&S) capabilities and opportunities at NPS. This facility will provide a ready resource for qualified Naval Officers to interact with NUWC WSPF at any time and with the fleet during selected exercises. This facility further provides a realistic tactical test bed to assess, integrate and operate diverse NPS research projects.

The VNA at NPS will enable advanced concept experimentation and collaboration. It will leverage M&S capabili-

ties and integrate other NPS resources to create a focal point for NPS interdisciplinary investigations. It will foster future NPS-NUWC collaboration tying the VNA to the WSPF. This collaboration will also allow for experimentation with manned and autonomous virtual platforms in a supporting virtual environment and an ongoing technical collaboration and evaluation forum.

Some key benefits from this collaborative effort will be an evolving operational and tactical showcase for NPS vision, technology, and applied work. It will encourage platform and network-level design and integration, allowing student projects to become part of a larger whole and will directly benefit Fleet and Joint Experimentation. Additionally it will be extensible to other partners and allow access to underwater test-range facilities and provide a NPS virtual environment to others.

Some typical operations in the VNA will be networked team operations to include opposing forces (sub-on-sub, ship-on-sub), collaborating Forces (sub+sub, sub+UUVs, sub with off-board sensors like UUV, UAV, USV), Concept of Operations testing, tasking, executing, and monitoring robotic assets, net-centric sensor integration, decision support, command & control, and integration with battle-group common tactical picture.

INFORMATION OPERATIONS PLANNING AND ANALYSIS LAB AT NAVAL POSTGRADUATE SCHOOL

Lecturer Steven J. Iatrou

Department of Information Science

The terms “Information Operations (IO)” and “Information Warfare (IW)” have fully infiltrated national defense rhetoric in the 21st century. Ironically, although these terms are on the tips of everyone’s tongues and quills, there is still no completely accepted, universal definition for these titles. More disturbing, however, is that there has been no universally accepted method of planning and integrating the myriad disciplines associated with IO and IW into a cohesive battle plan; a globally understood battle plan capable of exploiting the best of physical and virtual weapons. What would be more discomfiting is if this trend were allowed to continue. Rest easy, that trend stops here, at NPS.

The Naval Postgraduate School, in cooperation with the Navy’s Fleet Information Warfare Center (FIWC) and the Joint Information Operations Center (JIOC), is developing a laboratory environment where U.S. military officers can test and evaluate IO and IW planning options available in two advanced IO/IW planning tools: Information Warfare Planning Capability (IWPC) developed by General Dynamics, and Information Operations Navigator (ION) developed by JIOC. These tools have been used extensively in different exercise planning environments at different levels of military operations. ION functions at the strategic and operational planning levels; IWPC focuses on the operational and tactical levels. To date, however, these tools have not been closely evaluated in an isolated laboratory environment to explore their strengths and weaknesses when brought together in a joint planning environment. The NPS Information Operations Planning and Analysis Laboratory (IOPAL) provides a benign environment where military and computer experts can exercise these planning tools from the strategic level to the tactical level of engagement and provide solutions to issues as they arise.

The Information Warfare Planning Capability is an automated set of tools designed to integrate Information Warfare capabilities into the overall targeting and weaponizing effort of a campaign. It is a software suite of independent software applications that provides tools for developing plans, identifying and nominating targets, interfacing with TBMCS (Theater Battle Management Core System—the current joint command and control system), and collaborating with reach-back resources. IWPC had its beginnings in the Air Force Information Warfare Center and has evolved from a planning tool

developed in support of an Advanced Concept Technology Demonstration (ACTD) to this integrated suite of planning tools capable of supporting the full spectrum of Information Operations and Information Warfare. The IWPC was born and nurtured by the Air Force and has been embraced by the Navy through their Fleet Information Warfare Center. The development of the NPS IOPAL will help take the IWPC to its next level of maturity – integration across platforms, across services, and across levels of conflict.

In contrast, the Information Operations Navigator is a dedicated computer application focused on the strategic and operational levels of IO planning. This application enables Joint IO planners to generate IO plans and integrate them into the JOPES (Joint Operations Planning and Execution System) planning process for deconflicting and consolidating with other elements of military power.

The NPS IOPAL provides the DoD with an environment where these two essential IO planning tools can be run through their paces across the spectrum of conflict (from peace to war), across the spectrum of engagement (from strategic to tactical), and across weapons systems (from physical to virtual).

NPS TO DEVELOP TACTICAL MEMORANDA FOR FLEET USE,

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Engineering Department and experienced MPA Naval Flight Officer, are the team’s leads to address this important issue. CAPT Kline comments, “Again we have selected two talented people to head this effort. Dr. Crowson has experience with addressing fleet operational problems in previous research work and Matt Boensel’s operational Anti-submarine warfare experiences, combined with his analytical capabilities, make him exceptionally qualified to develop this tactical aid. Diesel submarines are a challenging threat and I’m glad we have two great researchers to help the MPA community refocus their efforts in hunting them.”

Both efforts are being coordinated through the Wayne E. Meyer Institute of Systems Engineering and will be conducted throughout 2004. They are considered inclusive research efforts and both teams welcome any fleet input for their work.

COMBATSS AT NPS

LT Ray Elliot, United States Navy

Lockheed Martin (LM) COMBATSS capability has been integrated into a collaborative secure/classified lab environment at NPS as part of a Collaborative Research and Development Agreement between NPS and Lockheed Martin (see *NPS Research*, Vol. 13, No. 2). COMBATSS is a modular Combat Information Center (CIC) with thin design display consoles, reduced manning and a small footprint. The COMBATSS suite is comprised of an application framework and select components which provide the backbone of a maritime command and control (C2) system. It enables plug-in of components which "customize" the system, i.e., sensors, weapons and networks to perform joint and naval warfare missions. It is a scaleable and dynamic framework, platform-independent and functioning with standards-based code. COMBATSS represents how future command, control, communications, computer and intelligence (C4I) spaces aboard warships will be configured. It will introduce NPS students to the latest information systems technology used in the Fleet.

COMBATSS' main feature is its scaleable C4I system, operating at the SIPRNET/Secret level, affording NPS the capability to "plug n' play" and collaborate with fleet battle experimentation, operations, tactics and knowledge superior-

ity in a secure lab environment. This capability will allow NPS to evolve with the Fleet and directly participate in how we will fight as a transformed Navy across the four major pillars of Seapower 21: Sea Shield, Sea Strike, Sea Basing and FORCENet, where fleet units are virtually linked in a networked, global information grid irrespective of geographic location. With COMBATSS, NPS will fully function as a participatory node in the Navy's FORCENet grid.

COMBATSS has been integrated into the classroom environment. The students of CC 3000 (Summer 2003) did an in-depth hands-on and theoretical study of COMBATSS to include History, Operations, Technical Connectivity, and Systems Engineering. The students produced papers and presentations that will be fused to produce educational aids for future students.

COMBATSS is aggressively adding network connectivity to take advantage of both fixed plant (hard wired) and satellite connections to the fleet. An Architectural and Engineering (A&E) contract should be obligated before the end of the fiscal year to engineer communications and power cabling, and a satellite pad to provide UHF, SHF, and EHF tactical connectivity.

Ensign Patricia Leyland, USN, Joint C4I Systems curriculum graduate, demonstrates the potential of the COMBATSS console for the Superintendent, VADM Mayo (NAVNETWARCOM Commander), and visiting VIPs from Lockheed-Martin.



NPS INFORMATION SCIENCE SUPPORT TO FORCENet

Research Associate Professor Shelley Gallup and Associate Professor Bill Kemple,
Department of Information Science

The Chief of Naval Operations, ADM Clark, has said he wants to take the Navy from being able to prosecute “war at sea” to fighting “war from sea.” In order to do so, the U.S. “must have the capability of operating from the maritime domain where we do not need a permission slip...to climb in the ring with the enemy and be able to stay there long enough to get the job done.”¹ NPS is involved in designing the 21st Century Navy in many ways. Information Science is one of the key players and is building leading edge capability in knowledge management (KM) in the process.

In support of the CNO’s guidance over the last several years, the Navy has defined its force structure of the future as being supported by four key pillars:

- Sea Strike, which signifies a comprehensive offensive capability
- Sea Shield, which provides a force-wide defensive capability, including to forces ashore
- Sea Basing, which involves having sufficient and appropriate Navy platforms to permit independent U.S. global action without reliance on foreign support or concurrence
- FORCENet, which is the unifying network of the other three pillars.

The concept of FORCENet was first developed in 2000 by the Navy’s Strategic Studies Group (SSG) XIX within their report, “Naval Power Forward,” and continued in 2001 by SSG XX. These reports proposed a revolutionary transformation in Naval methods of warfare using emerging technologies for sensors, information, decision aids, weapons technologies, and supporting systems. Today, those proposals are becoming reality. The Navy is building a revolutionary capability in network-centric operations one step at a time.

FORCENet can be thought of as being the operational construct and architectural framework for Naval warfare in the information age. It integrates warfighters, platforms, sensors, weapons systems, and all aspects of command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) into a networked, distributed combat force which is scaleable across the spectrum of potential conflict from seabed to space and from sea to land. Its purpose is to provide the warfighter with the best knowledge and information possible, by using collaboration and sharing the maximum amount of available data and information, so the warfighter can make the best decisions possible in the

situation.

A practical example of FORCENet integration has been provided by VADM Mayo, Commander, Naval Network Warfare Command (NETWARCOM), and the person responsible for the successful development of FORCENet:

Envision a Marine in combat, with a wireless GPS capable communications device, which when he turns it on, automatically authenticates and registers him in the master database, and streams situational awareness (SA) and target data to him. The Marine sees a target, designates it as to what effects he wants to use against it and the time to engage it. He has no idea of the weapon and doesn’t care what weapon will be used against the target, as long as the effect on the target is achieved. The weapon could come from an aircraft, it could be a Navy or Air Force launched cruise missile, or even be an information operations (IO) weapon. All coordination for the weapon is the responsibility of the Joint Battle Management Center, which has been fully cognizant of all aspects of the Marine’s target request. At the time the Marine specified, the weapon arrives at the target and activates. The Marine reports his battle damage assessment (BDA), the SA is updated accordingly, and with the neutralization of the target, the Marine stops his transmissions and returns to receive-only operations. Meanwhile, the logistics system notes the expenditure of the weapon; passes the information back to CONUS; and a new weapon is automatically programmed for shipment to the battle theater to replace the one expended.²

Somewhat more formally stated, FORCENet is a fully integrated, tiered network of platforms, sensors, weapons, vehicles, people, processes, and capabilities operating from the seabed to space and from sea to land. It is the enabler for Sea Strike, Sea Shield, and Sea Basing. It will enable battlespace dominance through comprehensive knowledge, focused execution, and coordinated sustainment shared across fully netted maritime, joint, and combined forces. The “21st Century Warrior” concept will extend this philosophy to address various human-related aspects for FORCENet, such as the technical skill sets and programs required to train,

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NPS INFORMATION SCIENCE SUPPORT TO FORCENet, *continued from page 10*

educate, and develop people for future operations within this revolutionary warfare environment, and the cognitive processes associated with sharing and distributing knowledge, and visualizing data. NPS faculty and staff have substantial expertise in many, if not most of these areas.

Building on its leading edge expertise and previous experience in knowledge management (KM), data collection, and the analyses of the complex Fleet Battle Experiments, a team of NPS researchers is now applying their collective talents to assist NETWARCOM with the FORCENet development. The Information Science team is led by Research Associate Professor Shelley Gallup and Associate Professor Bill Kemple and is composed of Research Professors Randy Maule, Steve Pilnick, and Nelson Irvine; Research Associates Rich Kimmel and Bryan McClain; with support from Emeritus Professor Gordon Schacher, Jack Jensen, and Kristina Hamill. Key members of the team participated in a trial run at sea, Regional Test #2, in early September and subsequently in Trident Warrior 03, in late September aboard the *USS Essex* (LHD 2) off Okinawa.

In support of TW03, the NPS team led the development of a Data Collection and Analysis Plan; was responsible for much of the collection of TW03 data and all of its archiving; and is coordinating the analyses for all of the initiatives. In addition, the logic and organized structure ("taxonomy") of the entire data collection process, the data collected, and the results of the analyses become part of the knowledge base contained in the NPS KM system and will be available to augment, compare, or contrast with any future data set.

Trident Warrior 03 included the FORCENet Integrated Prototype Demonstration (IPD), a NETWARCOM / Commander, Pacific Fleet (COMPACFLT) sponsored initiative to demonstrate an initial baseline of potential FORCENet capabilities. The event was executed in conjunction with the Expeditionary Strike Group Limited Objective Experiment (ESG LOE) and the Joint Task Force wide-area relay network (JTF WARNET) fall pre-deployment exercise (PDX).

The IPD integrated joint and Naval fires capability with expeditionary command, control, communications, computers and combat systems (EC5S) transport, intra-battle group wireless network (IBGWN) connectivity, web-enabled capabilities, JTF WARNET joint situational awareness (SA) capabilities, and Blue force tracking. The packaged capability delivered and analyzed in this supportable prototype established a current baseline and is helping to define future requirements for FORCENet capabilities in dynamic and multi-path survivable networks and distributed collaborative command and control (C2).

Along with the integrated prototype capability provided by the IPD, the ESG LOE provided the CONOPS and tactics, techniques, and procedures (TTP) to implement the IPD capabilities into warfighting applications, specifically ESG C2, Naval fires and knowledge management (KM). The NPS team analyzed ESG LOE Fires time sensitive target techniques and requirements for the support of joint forces. This evaluation examined the management of assets and procedures, deconflictions, and safeguards.

The NPS team has taken a long view toward FORCENet analyses and support. The data taxonomy built for TW03, for example, will be tailored and improved for application in Trident Warrior 2004, for which planning has already begun. Meanwhile, the data collected from TW03 and the strengths and weaknesses observed in the associated operational processes by the analyses, become a snapshot of fleet operational capabilities in time. Most importantly, they form a quantitative baseline from which the Navy can measure and validate its progress toward achieving the aggressive goals inherent in the overall development of the FORCENet concept in support of Sea Power 21.

References

1. *Jane's Defence Weekly*, December 11, 2002
2. VADM R. Mayo's welcoming remarks to IPD Initial Planning Conference, 22-23 April 2003.

FORCENet can be thought of as being the operational construct and architectural framework for Naval warfare in the information age. It integrates warfighters, platforms, sensors, weapons systems, and all aspects of command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) into a networked, distributed combat force which is scaleable across the spectrum of potential conflict from seabed to space and from sea to land.

UNCONVENTIONAL WEAPONS OF MASS DESTRUCTION AND TERRORISM

Dr. Robert C. Harney

Department of Systems Engineering

The more or less recent resurgence of terrorist activity directed against Americans has prompted extraordinary measures on the part of the U. S. Government to provide increased security at home and abroad. A prospect of significant concern is that an organized and well-financed terrorist group, such as Al Qaeda, will acquire or possibly even develop weapons of mass destruction (WMD) and use them against the United States or its overseas assets. Vivid scenarios have been painted of the detonation of a stolen nuclear warhead in the District of Columbia (or Baltimore or Denver), of chemical weapons attacks on subway systems, of epidemics of smallpox or Ebola being spread from coast to coast and from city to suburbs to rural areas by an air mobile populace, and of dirty bombs being exploded in Manhattan, among others. The prior use of chemical weapons by terrorists, successful and aborted attempts to use biological weapons, threats to use dirty bombs (backed up by proof of possession of radiological materials), and validated attempts to acquire nuclear weapons have exacerbated these concerns.

Terrorists have also demonstrated an ability to innovate and adapt, as well as an ability to plan a coordinated campaign of terror. The 9/11 terrorists not only selected a relatively novel weapon system (using a passenger airplane as a cruise missile), and not only conducted coordinated attacks on multiple targets to heighten the terror generated, but also they demonstrated that they had learned from earlier failures that commercial airline pilots will not be willing accomplices to suicide and underwent pilot training to eliminate this failure mode.

Terrorism is an unconventional mode of warfare, so it should not be expected that terrorists would act or think conventionally. Because conventional weapons of mass destruction are often difficult to obtain and hard to use effectively, there is a strong possibility that innovative terrorists might find unconventional WMD more readily available and just as satisfying in terms of the terror produced. This potential new threat has not received adequate attention or review.

Unconventional WMD (UWMD) include: 1) weapons that use materials or agents that are new or that are not considered suitable for use in military weapons; 2) military grade weapons or materials used in new ways, used against new target types, or delivered by novel methods; and 3) military weapons acquired or produced by novel techniques. Despite their unconventionality, UWMD are WMD nonetheless and are as potentially devastating as conventional WMD.

For the last half dozen years NPS has pursued studies of UWMD and terrorism. The first phase involved identification of the possibilities available for use as unconventional WMD. Over 20 different classes of unconventional weapons were identified that spanned the spectrum from nuclear to biological to chemical to radiological to new explosive weapons. In most cases, each class was found to contain dozens, if not hundreds, of specific examples. Perhaps, scariest of all, was the fact that all of the information collected in this phase was extracted from open literature sources. All of it is available to those who bother to look.

The vast number of possibilities makes it almost impossible to address this problem on a case-by-case basis. To assist prioritization efforts a model of terrorist activity was developed that proceeds step-by-step through the sequence of events from organization to planning to preparation and ultimately to execution of a terrorist attack. The model includes key decision points and sensitivities to internal and external influences, such as resources available, the mix of critical skills that might be expected among the organization's personnel, and the objectives of the organization. By assigning relative probabilities of occurrence to each event, those weapons more likely to be developed and used by a specific terrorist group may be identified and given higher priority with respect to counter-terrorism resources. The second phase of the NPS program elaborated this model and identified at least 15 different types of "terrorist" organizations that due to different motivations, different personnel, and different resource availability are likely to make different selections from the mix of UWMD options.

A third phase of the activity involved generation of detailed scenarios that described in detail how hypothetical terrorist organizations went about selecting a specific UWMD agent or approach and developing it into a useable weapon. Details of employment and aftermath were also included. Such scenarios assist in determining the probabilities that must be input to the model.

The preceding work was documented in a classified book (Robert C. Harney, *Unconventional Weapons of Mass Destruction and Terrorism* (Naval Postgraduate School, Monterey CA, 22 January 2001), available from the NPS Dean of Research as NPS Report NPS-97-03-001). Reviewed at relatively high levels in the U. S. Government, this document spurred a substantial follow-on effort. These post-9/11 activities are funded by the Office of Net Assessment in the Office of the Secretary of Defense. Research Professor Michael Melich, is

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JOINT ONLINE THESIS AND RESEARCH SYSTEM (JOTARS)

Lt Col Dave Overton, United States Marine Corps

Maj Brandon Johnson, United States Marine Corps

Joanne Kim, Cebrowski Institute of Information Innovation and Superiority

Since 1975, students attending the Naval Postgraduate School have been conducting warfighting-related, relevant research in areas with TOP SECRET (TS) / Sensitive Compartmented Information (SCI) classification. Until recently, the TS/SCI theses and papers were published and distributed to the study sponsor(s) and a minimal set of DoD addressees. Once the initial distribution process was completed, the findings were stored in the NPS Sensitive Compartmented Information Facility (SCIF), unavailable to TS/SCI online users.

In contrast, the very capable BOSUN system at the NPS Knox Library allows online access to unclassified theses and research papers dating back to 1946. So why doesn't a similar capability exist for SECRET and TOP SECRET theses and papers? **Joanne Kim**, the Cryptologic Chair at the Cebrowski Institute, asked this very question and found herself on a mission to get just such a capability started for NPS. When she proposed her concept for an online, TS/SCI research portal to the main sponsors of TS/SCI theses, Space and Naval Warfare Systems Command (SPAWAR PMW189) and the National Security Agency National Cryptologic School (NSA (NCS)), they expressed excitement and contributed matching funds to the Center for Defense Technology and Education for the Military Services (CDTEMS) seed money to get the project started.

In April of this year, Kim presented the project to Department of Information Science **Senior Lecturer Rex Buddenberg's** Architecting Information Systems class, CC-4221. A student team consisting of five Marine officers and one Navy officer eagerly took on this project and within days began tackling the tasks to make online TS/SCI thesis and research reports a reality. In addition to the technical challenges associated with this project were significant resource hurdles to overcome. These included a requirement for a trained librarian with TS clearance to act as application manager for the system, an upgraded Joint World-wide Intelligence Communication System (JWICS) node, and a systems administrator to manage the servers and other related system hardware. The new system was designated the Joint Online Thesis and Research System (JOTARS). **LtCol Dave Overton, USMC, Maj Brandon Johnson, USMC, LtCol Will Goldschmidt, USMC, Capt Dan Boersma, USMC, LT Jeff Dyer, USN, and Capt Jason Gross, USMC**, delivered JOTARS Phase 1 products in June.

JOTARS is an evolutionary development project, with

a long-term goal to extend its capabilities as a true online research system with tentacles reaching into the major research centers in the U.S., both internal and external to the DoD. For Phase 1, the team designed an n-tier architecture with active server pages (ASP) on the front end, an MS Access relational database for the bibliographic data, and a file server for the theses and papers stored in portable document file (pdf) format. They adopted the Dublin Core Standard Element Set (DCSES) to standardize the bibliographic data. The Dublin Core Standard is widely used in industry. Search capabilities for Phase 1 are by Author, Department or Advisor. Outputs are the bibliographic references as well as the theses themselves. Users can print and email the search results.

In their initial requirements research the students traveled to visit the primary sponsors, SPAWAR and NSA. Armed with a comprehensive interview questionnaire, they gained insights into the near-term and strategic vision of JOTARS as a mechanism to facilitate TS/SCI knowledge sharing – a key ingredient to Defense and Intelligence transformation.

One of the key deliverables from the Phase I development was the Project Report that captured the full scope of requirements and identified the remaining hurdles to get JOTARS up and running. As students in the Information Technology Management curriculum, they applied their cross-discipline education in systems architectures, business management, informa-

In Spring 2003, LtCol Goldschmidt graduated with distinction and received the RADM Grace Murray Hopper Information Technology Management Award. He is assigned to Marine Corps Manpower in Quantico, Virginia working in the Information Technology area of Manpower, putting his skills from NPS to work.

In Summer 2003, LtCol Overton graduated with distinction and received the Marine Corps Superior Service Award. He has Orders to Marine Corps Systems Command in Quantico working in the Information Systems Technology Directorate. LtCol (sel) Johnson graduated with distinction and has orders to the Marine Corps Tactical Systems Support Activity (MCTSSA) at Camp Pendleton. Capt Boersma received the RADM Grace Murray Hopper Information Technology Management Award. He has orders to the Defense Information Systems Agency (DISA) working in the Joint Network Management Systems.

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UNCONVENTIONAL WEAPONS OF MASS DESTRUCTION AND TERRORISM, *continued from page 12*

co-investigator on this latest phase of the work with Professor Harney.

Several classes of UWMD suggested themselves as being potentially “nation threatening.” Despite the significant loss of life, property damage, impact to the economy, and psychological impact, the events of 9/11 were not nation threatening. The Government did not fall; the Bill of Rights was not rescinded; social order was not significantly disturbed (even in New York City); little visible damage persisted beyond the cleanup efforts. However, detonation of a few nuclear weapons in major cities might produce sufficient disruption that one or more of the above might occur. Novel fission weapons and binary poisons were selected for further analysis. Novel fission weapons are nuclear weapons that: a) use materials other than U-235 and Pu-239 as the fissionable isotopes, or b) use U-235 or Pu-239 obtained from new sources or processes. Binary poisons are pairs of relatively benign chemicals that become highly toxic when an individual is simultaneously exposed to both. The use of two components complicates their use, but makes detection, diagnosis, treatment, and forensics more difficult.

For each of these choices, the study focused on answering the following six questions:

- How close to weaponization is this class of UWMD? (Is this really a serious threat?)
- What would it take to make the weapon fully operational – in terms of developing both technology and operational concepts? (What skills, resources, and facilities are needed?)
- What are the resource allocation implications of pursuing the option? (Is it likely any terrorist group could or would spend what it takes to weaponize the UWMD?)
- Who are the potential users and customers? How well does the option fit their objectives, culture, and modes of operation? (What specific groups might try this form of UWMD?)
- What are the observable events associated with pursuing the option? (What intelligence do we need to detect that terrorists are pursuing this path?)
- What exploitable vulnerabilities can be expected in a) the development process, and b) the fully operational weapon? (What can be done to prevent terrorists from successfully pursuing this path?)

To address these questions, multi-disciplinary teams were assembled from NPS faculty and augmented with a number of outside subject matter experts. The teams included economists, political scientists, experts in military operations, and

medical personnel, in addition to a number of systems engineers.

Specific results from this study cannot be discussed here. However, in the area of novel fission explosives, one can readily identify more than a dozen isotopes other than U-235 and Pu-239 that can be used to make nuclear weapons. A few of these exist in large quantities, are able to be processed with relative ease, and are not adequately protected under existing protocols. In addition, modern technology makes it possible to enrich uranium at modest production rates (one bomb per year) without requiring the establishment of a “Manhattan Project.” The needed facilities and infrastructure could easily remain hidden from National Technical Means. The threat from terrorist nuclear weapons may be worse than currently projected. Recommendations to address this problem have been formulated and presented to appropriate individuals in the Departments of Energy and Defense.

In the area of binary poisons, it does not appear that they are nation threatening, although they can be used with tragic effects. However, during study of this threat at least one previously unrecognized vulnerability in the “food supply” was identified. This could prove nation threatening, as millions of people could be affected. Details of this vulnerability have been disclosed to appropriate officials.

JOINT ONLINE THESIS AND RESEARCH SYSTEM, *continued from page 13*

tion systems development and computer science to move the JOTARS project forward. This report has provided a blueprint for NPS to begin transforming their respective processes for the automation of TS/SCI thesis processing.

Upon Phase I conclusion, Capt Boersma furthered the project by adding the capability for TS/SCI sponsors to submit research thesis requests to JOTARS. With a search capability, JOTARS offers a two-fold useful service to students and the TS/SCI community. In addition to providing online search capabilities for completed research, now students looking for thesis topics can search JOTARS for research requirements. On the other hand, members of the TS/SCI community can search for others who may be interested in the same or a similar topic, thus opening up the possibility of collaborative research sponsorship. This is one small step in cyber-facilitation laying the groundwork for virtual teaming.

STUDENT RESEARCH

A MULTI-YEAR AMMUNITION PROCUREMENT MODEL FOR DEPARTMENT OF THE NAVY NON-NUCLEAR ORDNANCE

Major John H. Bruggeman, United States Marine Corps
Master of Science in Operations Research – September 2003
Advisor: Associate Professor W. Matthew Carlyle and Distinguished Professor Gerald G. Brown, Department of Operations Research

The Navy Non-nuclear Ordnance Requirements (NNOR) process determines annually the preferred inventory levels for most Department of the Navy munitions. This process is unrestricted by cost. Procurement planners must then apply current budgetary constraints to determine actual purchasing recommendations. This report introduces a metric for quantifying the capability provided by a given inventory of a munition. It then describes an optimization model, the Assessment and Investment Model (AIM), which will generate multi-year purchasing recommendations in order to maximize the capability of the inventory subject to constraints in terms of budget, industrial base, maintenance, and NNOR requirements.

The Navy Ammunition Logistics Center (NALC) is working to replace the current process of generating munitions procurement recommendations. The effort documented in this report was initiated by, and has the support of, NALC as a potential decision-support tool. Initial results show that AIM procurement recommendations are superior to recommendations generated by the current process and will result in a more combat-effective munitions inventory for any given (and, currently, almost \$2 billion) Department of the Navy weapon procurement budget.

AN OPTIMIZATION OF THE BASIC SCHOOL MILITARY OCCUPATIONAL SKILL ASSIGNMENT PROCESS

Lt Col Willie R. Goldschmidt, United States Marine Corps
Master of Science in Information Technology Management – June 2003
Capt Daniel J. Boersma, United States Marine Corps
Master of Science in Information Technology Management – September 2003
Advisors: Samuel Buttrey, Department of Operations Research, and Lecturer Dale Courtney, Department of Information Science

The reduction of attrition in the junior officer ranks has constantly presented a challenge to manpower planners. The desire of an officer to remain on active duty is influenced by his or her satisfaction with their military occupational skill. The assignment of an MOS to Marine lieutenants has essentially remained unchanged for the past 30 years.

This thesis presents an interdisciplinary solution to the problem of assigning Military Occupational Skills to lieutenants at The Basic School. The thesis captures the requirements analysis, testing, implementation, operation and maintenance of two-tier decision support system architecture. This thesis presents an alternative business process centered on

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MODEL-DATA COMPARISON OF SHALLOW WATER ACOUSTIC REVERBERATION IN THE EAST CHINA SEA

LT Robert M. Hill, United States Navy
Master of Science in Engineering Acoustics – September 2003
Advisors: Associate Professor Kevin B. Smith and Senior Lecturer Daphne Kapolka, Department of Physics

In this thesis, the Monterey-Miami Parabolic Equation (MMPE) model is used to generate predictions from numerical analysis of the reverberation loss structure and peak vertical correlation structure generated by the water/bottom interface, the bottom/sub-bottom interface, and the bottom volume for a shallow water environment. These predictions are then compared to the peak vertical correlation analysis of recorded data collected in an actual shallow water environment similar to the modeled environment. This experimental data was recorded by a 32-element vertical line array (VLA) that recorded the reverberant return generated by charges detonated over the continental shelf in the East China Sea as part of ASIAEX. A comparison is made between predictions and recorded data by analyzing trends in peak vertical correlation with decreasing bandwidth. The influences of interface roughness, bottom volume perturbations, and water volume turbulence on peak vertical correlation is also determined.

STUDENT RESEARCH

MULTI-AGENT SIMULATIONS (MAS) FOR ASSESSING MASSIVE SENSOR COVERAGE AND DEPLOYMENT

Capt Sean E. Hynes, United States Marine Corps

Master of Science in Computer Science – September 2003

Advisors: Professor Neil C. Rowe, Department of Computer Science, Research Associate Curtis Blais, Modeling and Simulation Institute, and Associate Professor Don Brutzman, Department of Information Science

The thesis presents the design, development, and implementation of a multi-agent simulation that models coverage and deployment of mobile and non-mobile sensors performing collaborative target-detection missions. The focus is on sensor networks with enough sensors that humans cannot individually manage each sensor. Experiments investigate novel search, coverage, and deployment algorithms, and compare them to known methods. The experiments show algorithms productive for area coverage are not useful for detecting unauthorized traversals and vice versa. Obstacles, sensor mechanisms, mission parameters, and deployment schemes are analyzed for their effect on coverage quality. This work facilitates further research in sensor coverage and deployment strategies using sensor agents.

INTEGRATION OF THE FREE ELECTRON LASER, RAIL GUN AND ELECTROMAGNETIC AIRCRAFT LAUNCH SYSTEM ON A NAVAL SURFACE PLATFORM

LT Seth A. Miller, United States Navy

Master of Science in Physics – September 2003

Advisor: Distinguished Professor William B. Colson and Associate Professor Robert L. Armstead, Department of Physics

The objective of this thesis is to study the feasibility of sharing energy generation, storage and cooling systems between the Free Electron Laser (FEL), railgun and Electromagnetic Aircraft Launch System (EMALS) on all-electric ships. This thesis outlines the basic components and the theory of operation of the FEL, railgun and EMALS. A discussion of energy requirements is also provided in order to provide a basis for comparison between a shared energy storage device and the individual power supplies currently under development. A systems engineering study is then conducted to select the best type of power supply for use as a shared energy source for the FEL, railgun and EMALS. Based on the tradeoffs and assumed operational requirements of a naval surface platform, a flywheel energy storage device is suggested as the optimal choice when comparing batteries, superconducting magnetic energy storage (SMES), capacitors and flywheels as potential energy storage mechanisms. A brief discussion on the possibility of sharing cooling components between these systems and the IPS is also provided. The remainder of this thesis focuses on a possible implementation of these devices in a shipboard environment using a ship design, an expeditionary warfare ship named the SEA FORCE, that was completed by students at the Naval Postgraduate School in the Total Ship Systems Engineering Program.

OCEANS APART: THE UNITED STATES, THE EUROPEAN UNION AND THE INTERNATIONAL CRIMINAL COURT

2LT Jason T. Monaco, United States Air Force

Master of Arts in National Security Affairs – September 2003

Advisors: Associate Professor Daniel Moran and Professor David S. Yost, Department of National Security Affairs

Both the United States and the European Union (EU) support the promotion of international justice yet disagree over the utility of the International Criminal Court (ICC). The controversy that the Court has generated among members of the long-standing trans-Atlantic partnership is indicative of deeper differences between the United States and EU members and it has the potential to threaten alliance cohesion. This thesis examines American policy toward the Court and its foundations, as well as the actions taken since the May 2002 withdrawal of the U.S. signature to the Rome Statute establishing the ICC. It then reviews EU policies toward the Court and their foundations, focusing on reactions to American policies and to the controversy associated with U.S. actions since the May 2002 withdrawal. The thesis analyzes the dispute between the United States and the EU over the ICC, focusing on the disparity in power, the roles of sovereignty and the UN Security Council, disagreements over means of achieving agreed ends in international law, the dispute's politicized nature, and the degree to which both sides seem to be "talking past one another." Finally, the thesis evaluates scenarios for the Court's development and their potential effects on European-American relations, and offers recommendations.

STUDENT RESEARCH

THE U.S. NAVY AND EUROPEAN SECURITY: FROM THE COLD WAR TO THE WAR ON TERRORISM

LT Michael J. Rak, United States Navy

Master of Arts in National Security Affairs – September 2003

Advisors: Professor David S. Yost, Department of National Security Affairs, and Kenneth J. Hagan, Naval War College

This thesis analyzes the determinants of change in the doctrine and force structure of United States naval forces in Europe from the publication of the Maritime Strategy in 1986 to the contemporary post-11 September 2001 security environment. Four factors are examined as possible determinants of change: (1) geopolitics, including changes in the political and security environment in Europe; (2) inter-service competition for resources, influenced by congressionally mandated jointness in military operations; (3) the influence of key policymakers in the United States political and military command structure, including the U.S. Navy, the Department of Defense, and elected officials of both the executive and the legislative branches; and (4) relations between the United States and its NATO Allies. The thesis concludes that certain factors were more influential than others in specific circumstances, but all contributed to shaping doctrine and force structure.

AN OPTIMIZATION OF THE BASIC SCHOOL MILITARY OCCUPATIONAL SKILL ASSIGNMENT PROCESS,

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“MyMOS.” MyMOS is a web-based decision support system for use by the lieutenants and staff of The Basic School. This thesis incorporates the use of commercial-off-the-shelf linear programming tools to present and compare an alternative to the existing heuristic assignment methods. The results of this research found that by utilizing optimization techniques you could decrease the number of lieutenants who did not receive one of their first five choices by an average of 66% and reduce the average choice number assigned from 2.9 to 2.1. The incorporation of e-commerce technology increased the return on knowledge associated with the MOS education process and presented the lieutenants with a consistent and familiar interface.

POTENTIAL SPACE CONTROL CAPABILITIES OF THE U.S. NAVY AND MARINE CORPS (U)

Lt Col Eric B. Treworgy, United States Marine Corps

Master of Science Space Systems Operations – September 2003

Advisors: Associate Professor I. Michael Ross, Department of Aeronautics and Astronautics, and Senior Lecturer Charles M. Racoosin, Space Systems Academic Group

(U) The purpose of this thesis is to make accessible the Navy and Marine Corps' current and potential space control capabilities at the secret level. This document catalogs the Navy and Marine Corps' current space control capabilities, addresses potential capabilities, and discusses the policies and technologies that may result in the achievement of the potential capabilities. The method utilized for this document was to conduct literature research and interviews with personnel in space control and space related organizations.

(U) Space control is shrouded in secrecy and the services' capabilities are hidden from the warfighter in compartmented areas. Hypothetical scenarios were developed in this thesis to illustrate the difference space control can make to the warfighter. Information needs to be made available to the warfighter so that space control can be fully integrated into all operations. Space control efforts appear to be disjointed with each service working on its own space control items and agendas. The Air Force, as the Executive Agent for space, should coordinate all space control efforts of the services to reduce duplication of effort and to ensure that all aspects are being adequately addressed.

(U) It was determined that the Navy can provide significant contributions to the U.S.'s space control efforts. The Navy should retain its space research and development capabilities to ensure naval requirements are met and to spawn innovation in space technologies. The Marine Corps offers niche space control capabilities that enhance the overall space control capabilities of the U.S. Together, the naval services can potentially provide responsive and persistent global space control capabilities.

OPEN HOUSE PROVIDES UPDATE ON MOVES ACTIVITIES

The MOVES (Modeling, Virtual Environments, and Simulation) Open House, held 5-7 August 2003, afforded over a hundred registered visitors and several dozen university students a look at MOVES' research and development. MOVES provided thirty-five talks and twenty-two demos on a variety of topics ranging from cross-cultural personality assessment to perspectives on distributed simulation, persistent worlds, command and control. Twenty-seven of the talks and demos were by NPS students. Guest speakers at the



Michael Zyda

open house included David Pratt, Chief Scientist of Modeling & Simulation for the SAIC Corporation, Jack Thorpe, special advisor to OSD, Dennis McBride, President of the Potomac Institute, and LCDR Phil Pournelle, USN, of N81.

In opening remarks, Director **Michael Zyda** cited the following progress in MOVES' major fields of concern:

3D Visual Simulation & Networked Virtual Environments

MOVES created the extensible modeling and simulation framework (XMSF), in an effort that has been named the most important strategy for connecting all DoD modeling and simulation to C4I systems.

The World Technology Network (WTN) selected MOVES as one of the top finalists for the 2003 Work Technology Award in Information Technology-Software. Industry experts like NASDAQ, Microsoft, and TIME magazine in association with WTN distinguished MOVES from amongst companies like IBM, Sony, Apple computer and Google. MOVES received this honor in part for its research in the application of modeling, virtual environments and simulation, as well as its mission in educating mid-career military officers from all branches of the U.S. Armed Forces and foreign militaries.

MOVES faculty member **Associate Professor Don Brutzman** and colleagues Mark Pullen of George Mason University, Katherine Morse of SAIC, and Andreas Tolk of Old Dominion University hosted an intensive daylong XMSF symposium in advance of the open house, reporting that demos of XMSF capability are underway and interest among agencies and organizations is growing.

Computer Generated Autonomy

MOVES' terrorist behavior modeling effort, Project IAGO (Integrated Assymetric Goal Organization), has been listed as

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STUDENT RESEARCH, *continued from page 17*

SOFTWARE DEFINED RADIO DATALINK IMPLEMENTATION USING PC-TYPE COMPUTERS

Capt Georgios Zafeiropoulos, Hellenic Air Force

Master of Science in Electrical Engineering and Master of Science in Systems Engineering – September 2003

Advisors: Research Associate Professor Jovan Lebaric, Department of Electrical and Computer Engineering, and Professor Curtis Schleher, Department of Information Science

The objective of this thesis was to examine the feasibility of implementation and the performance of a Software Defined Radio datalink, using a common PC type host computer and a high level programming language. Dedicated transceivers were used, plugged on the PCI bus of host PCs running Windows 2000. Most of the functionality was programmed using the Microsoft Visual C++ language. The tasks to be performed included the channels configuration (number of active channels, center frequencies, sampling and data rates, choice of the appropriate up and down conversion filters), the management of the data transfer between the host computer and the transceiver, the baseband data modulation and

demodulation, and the data organization into packets with appropriate headers in order to achieve phase and time synchronization solely by software. A part of the transceivers' configuration was achieved using a configuration utility running in Excel, provided by the manufacturer. Several combinations of M-PSK modulation schemes, channel numbers and data rates were tested in order to measure the performance limits of the system and its ability to perform the required tasks in real-time. The received data streams were further analyzed with the use of Matlab, in order to verify the proper functionality of the communication scheme.

INSTITUTES

OPEN HOUSE PROVIDES UPDATE ON MOVES ACTIVITIES, *continued from page 18*

one of the top ten in the world in a Defense Threat Reduction Agency survey of two hundred and sixty five existing terrorist behavior models.

Human Performance Engineering

MOVES' chroma-keyed augmented training environment will soon be deployed to helicopter squadron 10 (HS-10) for study of its utility in flight navigation training.

Immersive Technologies

MOVES applied techniques from VE and entertainment to improve

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(Above) Associate Professor Don Brutzman demonstrates an agent-based anti-terrorist/force-protection simulation against an immersive video dome.



(Left) Using a head-mounted display, the trainee learns on a simulated M-16 before handling the real weapon. Demo by Capt Claude Hutton, USMC.

FIRST DOCTOR OF PHILOSOPHY AWARDED IN MODELING, VIRTUAL ENVIRONMENTS AND SIMULATION

The first doctoral degree in Modeling, Virtual Environments and Simulation (MOVES) was awarded to Major Joerg Wellbrink of the German Army. Major Wellbrink's dissertation, Modeling Reduced Human Performance as a Complex Adaptive System, studies and realistically simulates the reduction of vigilance, or vigilance decrement, that individuals experience during such operations as airport screening, radar-screen operation, and other vital tasks in which attention easily flags.

After graduating in September 2003, Major Wellbrink will be reassigned to the German Armed Forces Information Technology Agency, where he will be working on integrated modeling and simulation systems with current command, control and communications systems.

MODELING REDUCED HUMAN PERFORMANCE AS A COMPLEX ADAPTIVE SYSTEM

Major Joerg C.G. Wellbrink, German Army

Doctor of Philosophy in Modeling, Virtual Environments and Simulation – September 2003

Dissertation Committee: Professor Mike Zyda, MOVES, Associate Professor Maria Rasmussen, Department of National Security Affairs, Professor Ted Lewis, Associate Professor Rudy Darken, and Research Professor John Hiles, Department of Computer Science, and CDR Lisa Curtin, USN, Dean of Students

Current cognitive models not only lack flexibility and realism, they fail to model individual behavior and reduced performance. This research analyzes current cognitive theories (namely, symbolism, connectionism, and dynamicism). It hypothesizes that reduced human performance can be best modeled as a complex adaptive system.

The resulting multi-agent model "Reduced Human Performance Model (RHPM)" implements reactive agents competing for cognitive resources. Lack of resources is used to trigger the simulation of imperfect perception and imperfect cognition. The simulation system is calibrated with human experimental data in scenarios involving vigilance decrement, wherein vigilance is decreased during the first 30 minutes of a screening task. RHPM is then validated against previous unknown vigilance task scenarios.

RHPM generates realistic reduced human performance with a new cognitive modeling hypothesis. The developed multi-agent system generates adaptive and emergent behavior. Its use for computer generated forces (i.e. radar screen operator) would improve the realism of simulation systems by adding human like reduced performance.

This research's main contribution is the development of a well suited tool to mediate between vigilance theories such as signal detection theory and experimental data. It generates insights creating likely hypotheses to improve the theories.

OPEN HOUSE PROVIDES UPDATE ON MOVES ACTIVITIES, *continued from page 19*

and enhance human ability to comprehend complex tactical information in "live" command and control settings.

MOVES has shown that radio communications, radar, air traffic control tasks, etc, can be improved by use of spatialized auditory cues over headphones.

MOVES faculty filed a patent for our inertial tracker.

MOVES recorded sound with Lucasfilm that was utilized for both an LCAC simulator for Marine Corps training and as a hovercraft in the movie *Minority Report*.

Combat Modeling & Analysis

MOVES assumed management of all future development

of the Navy Simulation System.

MOVES began work with NETWARCOM on designing a virtual FORCENet.

MOVES led an effort to revise all combat modeling courses on campus.

Defense & Entertainment Collaboration

MOVES has transformed Army recruiting by constructing internally a multiple-award-winning PC game—fastest growing online PC game ever—that provides an experience of Army careers in game form, and has researched the possibility of computing aptitude from game play.

NAVAL POSTGRADUATE SCHOOL'S MEYER INSTITUTE LAUNCHES NEW CERTIFICATE PROGRAM FOR NAVY UNRESTRICTED LINE OFFICERS

The Naval Postgraduate School's Meyer Institute of Systems Engineering has implemented a new certificate program in Systems Analysis designed to enhance the quantitative and analytical skills of unrestricted line officers in the Navy. To date, twenty students have enrolled in the certificate program.

The certificate program uses a combination of personal face-to-face instruction, video television conferencing, and web-based instruction to meet the needs of students. Projects are integrated throughout the certificate program, allowing the students to apply their new skills to relevant operational problems. Officers who complete the certificate program

can apply the courses towards a degree at NPS or another graduate school. The courses provide tools that are immediately useful to officers in their current assignments as well.

The Systems Analysis certificate program is a complement to the Information Systems and Operations certificate, the Executive MBA program, and other NPS initiatives to deliver graduate education in the right discipline to the right officer at the right time in the right location.

A second certificate in Systems Engineering will be offered during fall of 2004 for graduates of the Systems Analysis certificate program.

FIRST MASTER OF SCIENCE IN SYSTEMS ENGINEERING VIA DISTANCE LEARNING GRADUATES FROM NPS

The Naval Surface Warfare Center-Port Hueneme Division's (NSWC PHD) partnership with the Naval Postgraduate School (NPS) has yielded the first class of graduates from the NPS' Master of Science in Systems Engineering (MSSE) Program. The two-year program offered students a blended curriculum of on-site and distance learning.

The rigorous NPS program engaged the 26 students, all employees of NSWC PHD and its detachments, in a curriculum focused specifically on Navy systems. The stringent requirements for participation helped NSWC PHD assemble a group of students whose previous experience working on combat systems enabled them to qualify for and gain maximum benefit from the program. Students not only had to meet the challenge of postgraduate coursework, but also had to fulfill the demands of their regular jobs and full travel schedules.

Included in the NPS curriculum were C4I, telecommunications, human systems integration, database management and decision support systems, acquisition and program management, test and evaluation, systems engineering, integration, architecture and analysis, and software engineering. The specifically tailored course of study gave students the background to play an integral role in NSWC PHD's transition to Next Generation In-Service Engineering.

The students were required to put together a Capstone Project instead of a thesis. The class project, developing a layered combat system for a Littoral Combat Ship, exposed students to concepts and information from other disciplines across the command, giving them a broader view of the PHD technical relationships and capabilities.

For additional information on the MSSE Program, contact **Senior Lecturer Wally Owen**, Meyer Institute of Systems Engineering, at wowen@nps.navy.mil.

MEYER INSTITUTE OPENS NEW UNMANNED VEHICLE LAB

The Meyer Institute of Systems Engineering recently opened a new Unmanned Vehicle (UV) Lab. The UV Lab was established to provide faculty and students the opportunity to get involved with S&T and field experimentation, which will provide near-term benefits to the warfighter. In the first two years, the efforts will be directed primarily at Special Operations Forces, with an emphasis on Unmanned Aerial Vehicles (UAVs) and Autonomous Underwater Vehicles (AUVs). Several companies and government facilities are working with NPS to experiment with a surveillance and target acquisition network that links multiple UAVs, ground sensors, and ground troops with two-way voice, data, and streaming video.

AGREEMENTS

THE NAVAL POSTGRADUATE SCHOOL AND THE OFFICE OF NAVAL RESEARCH FORMALIZE THE ESTABLISHMENT OF AN OFFICE OF NAVAL RESEARCH DISTINGUISHED VISITING PROFESSOR OF INNOVATION AT NPS

A recent Memorandum of Understanding between the Naval Postgraduate School (NPS) and the Office of Naval Research (ONR) formalized the establishment and support of the ONR Distinguished Professor of Innovation at NPS.

The topic of innovation has never been more salient for the U.S. Navy. The Navy is moving into an era increasingly dominated by “unknown unknowns.” The Navy’s ability to transform incumbent organizations will be increasingly perceived as being driven by its ability to innovate, and innovation must increasingly be viewed as a key dimension of competition, both in the business world and in military affairs.

This innovation initiative aligns with NPS’ desire to provide a world-class leadership development platform for the defense community, a community that is looking for new methodologies and concepts to turn “getting” innovation to “getting it done.” There are two goals of this cooperative effort: 1) to train a critical mass of Naval (and other) leaders in order to effect a state change in the effectiveness and strategic value of their innovation efforts; and 2) to create an Innovation Initiative located at NPS that will aggregate resources and best practices so that it becomes a hub for innovation “know-how” and “know-what.” This will include the establishment of a lab that will showcase best practices in the field of collaboration.

U.S. NORTHERN COMMAND AND THE NAVAL POSTGRADUATE SCHOOL FOSTER GRADUATE EDUCATION AND RESEARCH IN HOMELAND DEFENSE AND SECURITY

The Naval Postgraduate School (NPS) and the U.S. Northern Command (USNORTHCOM) signed a Memorandum of Agreement (MOA) setting forth the conditions under which NPS will make available its graduate education and research programs in support of USNORTHCOM.

Consistent with the NPS mission, NPS conducts numerous graduate education and research programs related to Homeland Defense and Security (HD/S). NPS conducts an accredited Masters Degree curriculum track in Homeland Defense and Security, jointly sponsored by the Department of Homeland Security’s Office for Domestic Preparedness and the Deputy Chief of Naval Operations for Plans, Policies and Operations. That curriculum is structured to help build the next generation of military and civilian governmental leadership in HD/S. NPS also has other Master of Arts curricula in fields of direct value to HD/S. NPS students and faculty conduct HD/S-related research on both policy and technical subjects, which build case studies and other course materials for use in the curricula, and which also are designed to be of direct benefit to student sponsors.

This MOA provides for NORTHCOM utilization of NPS education and research programs, in accordance with NORTHCOM requirements (to be specified by NORTHCOM to NPS), and consistent with the availability of such programs at NPS and policy guidance concerning them. Consistent with sponsor requirements and NPS policies, NORTHCOM students enrolled in NPS curricula may complete requirements for a fully accredited NPS Masters Degree, graduate credits that could be applied over time to fulfilling Degree requirements at NPS or other institutions, and certificates of completion for non-degree students.

DEFENSE INFORMATION SYSTEMS AGENCY FELLOWS AND CHAIR PROFESSORSHIP ESTABLISHED AT THE NAVAL POSTGRADUATE SCHOOL

The Naval Postgraduate School (NPS) and the Defense Information Systems Agency (DISA) have entered into an agreement defining the relationships and responsibilities for the participation of DISA Fellows and a DISA Chair Professor at NPS.

This MOA between NPS and DISA is to establish a program to allow assignment of DISA personnel to fill the following positions: DISA Chair Professor in Computer Science, DISA Research Fellow in Computer Science, and DISA

Doctoral Fellows in Computer Science or Electrical Engineering.

The intent of this program is to enhance systems engineering excellence at DISA and provide for an exchange in research and academics mutually beneficial to DISA and NPS. This will be achieved through the assignment of DISA civilian professionals to NPS to: a) enhance or develop new capabilities for DISA personnel through advanced graduate

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AGREEMENTS

NAVAL POSTGRADUATE SCHOOL AND AIR FORCE INSTITUTE OF TECHNOLOGY STRENGTHEN GRADUATE EDUCATION PARTNERSHIP

The Naval Postgraduate School, Air Force Institute of Technology, and the Air Force Director of Weather have entered into a memorandum of agreement to elaborate the goals of the Air Force-sponsored graduate programs to expand the knowledge of students and advance air and space power. This agreement delineates the requirements and responsibilities for identifying theses and dissertation topics for Air Force students that will satisfy the aforementioned goals.

STATEMENTS OF INTENT WITH KOREA NATIONAL DEFENSE UNIVERSITY AND COLOMBIAN NAVAL SCHOOL ESTABLISH INTERNATIONAL EDUCATION ALLIANCES

The Naval Postgraduate School (NPS) and the Korea National Defense University (KNDU) intend to establish an international educational alliance to enhance the common education mission of both institutions, and to foster cooperation in research and teaching in national security issues and defense management.

The objective of this Statement of Intent is to discuss the general approach for the sponsorship, funding and administration of an educational partnership between KNDU and NPS that will be established and implemented through binding agreements. Both institutions share common missions and have the requisite faculty expertise to develop cooperative programs in the following complementary subject matter areas: National Security Strategy, International Relations, Civil-Military Relations, Military Strategy, Defense Management, Defense Information Systems, Senior Policy Decision-Making, Defense Resources Management, Defense Administration, Strategic Planning and Implementation, Human Resources Management, Economics, Weapon System Acquisition, Defense Program Management, Contracting Policies and Procedures,

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MEMORANDUM OF UNDERSTANDING IS RENEWED WITH THE INDUSTRIAL COLLEGE OF THE ARMED FORCES, NATIONAL DEFENSE UNIVERSITY TO ENHANCE COMMON JOINT PROFESSIONAL MILITARY EDUCATION MISSION

The memorandum of understanding between the Naval Postgraduate School (NPS) and the Industrial College of the Armed Forces (ICAF), National Defense University (NDU) was recently renewed to continue the relationship to enhance the common Joint Professional Military Education mission of both institutions.

NPS and ICAF have established a strategic alliance within the personnel research and policy arena, with an emphasis on leadership and senior leadership development. Toward this end, faculty from the Graduate School of Business and Public Policy have been assigned to ICAF to conduct research, teach, and serve as thesis advisors.

NAVAL SEA CADETS CORPS SUPPORTED AT THE NAVAL POSTGRADUATE SCHOOL

The Monterey County Division (MCD) of the U.S. Naval Sea Cadets Corps (NSCC) was established in 1972, but since that time has been physically located with frequency detrimental to the coordinated objectives of the Navy and the NSCC. In 2001 the Monterey County Division was relocated to the Naval Postgraduate School. The establishment of this memorandum of understanding makes the Naval Postgraduate School the permanent drill location of the MCD NSCC.

DEFENSE INFORMATION SYSTEMS AGENCY FELLOWS, *continued from page 22*

education, b) foster research in computer science or electrical engineering pertinent to DISA concerns, and c) enrich the faculty at NPS by contributing to the graduate-level education of the students enrolled at NPS.

It is recognized that DISA's strategic goal is to be the provider of choice for information technology (IT) systems and services for DoD and the ability to identify and retain premier systems engineers is integral to that goal. DISA is also interested in: a) enhancing its research programs and employee education, b) involving the NPS faculty in research of interest to the DISA and in which the NPS has expertise, and c) returning DISA Fellows to the DISA with a broadened understanding of the areas of teaching and research expertise at the NPS. It is understood that the exchange would include various engineering disciplines.

AGREEMENTS

STATEMENTS OF INTENT WITH KOREA NATIONAL DEFENSE UNIVERSITY AND COLOMBIAN NAVAL SCHOOL ESTABLISH INTERNATIONAL EDUCATION ALLIANCES, *continued from page 23*

Budgeting and Public Policy, Business and Financial Management, Logistics and Supply Chain Management, Information Resources Management, Operations Research/Systems Analysis, and Computer Systems.

The Universities wish to arrange a strategic alliance within the national security and defense resources management research and policy arena, with an emphasis on educating national security leaders and the development and formulation of national security policies.

The Korea National Defense University serves the Republic of Korea as the premier university educating national security leaders, a national center of national security studies and for development and formulation of national security policies, and a world-class university for education and research on peace and security. KNDU serves the military forces as an academic institution providing the most advanced-level national security education required by senior defense officials, as a think tank for the Ministry of National Defense (MND), and as an education center offering a variety of practical training programs for defense officials. In addition, KNDU is continually working to strengthen its education programs in support of an expanding role as an Asian Pacific regional hub of national security and defense management knowledge and information.

Naval Postgraduate School provides relevant and unique advanced education and research programs in order to increase the combat effectiveness of U.S. and Allied armed forces and enhance the security of the United States. NPS prides itself on the strength and depth of its collaborative relationships with others, particularly its partnerships

with other colleges and universities, business and industry, government, and the international community. Additionally, NPS is working to expand its international leadership role and further develop relationships with foreign universities, other nations, international organizations, and multi-national companies. This expansion and development will enhance the education of NPS students and assure that faculty remain globally competitive in research and teaching.

NPS and the Colombian Naval School (CNS) have entered into a similar relationship. The Colombian Naval School serves the Republic of Colombia as the exclusive university educating naval officers at the undergraduate and graduate levels. Although the school is well known within Colombia for the quality of its graduates, special emphasis is currently devoted to internationalizing the institution; having as an ultimate goal naval officer graduates capable of meeting higher expectations for a more professional military force that can better serve the national security needs of the country. To this end, modernization of the physical infrastructure, an updating of the academic curriculums and academic staff in the CNS is currently a navy priority.

The faculty of CNS and NPS will be encouraged to lend their talent and skills to bring credit to both institutions through research, service and teaching. Specific tasks and projects like Faculty/Student Exchange Program Agreements will be authorized in binding agreements like Foreign Military Sales cases and Personnel Exchange Program Agreements and will be developed within the following areas:

- Faculty/Instructor Exchange in



RADM David R. Ellison, Superintendent of the Naval Postgraduate School, and Rear Admiral Alfonso Diaz, Director of the Colombian Naval School, sign the Statement of Intent for an international education alliance aboard the Colombian training vessel, *Gloria*.

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CHAIR PROFESSORSHIPS

AGREEMENTS WITH THE NAVAL SEA SYSTEMS COMMAND AND PROGRAM EXECUTIVE OFFICE, INTEGRATED WARFARE SYSTEMS COMMIT SPONSORSHIP OF THE CHAIR OF ACQUISITION MANAGEMENT AT THE NAVAL POSTGRADUATE SCHOOL

The Naval Postgraduate School has entered into memoranda of understanding with the Naval Sea Systems Command and the Program Executive Officer for Integrated Warfare Systems to establish a sponsoring relationship for the Chair of Acquisition Management. The Chair Professorship is located within the Graduate School of Business and Public Policy.

The objectives of the Memoranda of Understanding are to provide a direct relationship between the Commander, Naval Sea Systems Command (COMNAVSEA) and the Program Executive Officer for Integrated Warfare Systems (PEO(IWS)) and the NPS to (1) conduct and manage relevant research supportive of COMNAVSEA and PEO(IWS) requirements and (2), provide opportunities for professional development of both faculty and students in Acquisition Management and related curricula at NPS. The specific research objectives are to accomplish current research in topics of immediate concern to the COMNAVSEA and PEO(IWS) partners and to stimulate and supervise research conducted by NPS faculty and students. The specific educational objective is to enhance the capabilities of graduates to assume management and policy-making positions within the Department of Defense acquisition workforce.

The current Chair of Acquisition Management is **RADM Jim Green, USN (Ret.)**.

CHAIR FOR COST ANALYSIS ESTABLISHED WITH MEMORANDUM OF UNDERSTANDING BETWEEN THE DEPUTY DIRECTOR (RESOURCE AND ANALYSIS), PROGRAM ANALYSIS AND EVALUATION, OFFICE OF THE SECRETARY OF DEFENSE, AND THE NAVAL POSTGRADUATE SCHOOL

The purpose of this agreement is to establish the guidelines for a Chair for Cost Analysis in the Department of Operations Research, Graduate School of Operational and Information Sciences, at the Naval Postgraduate School. The principal objectives are: 1) to provide for a liaison between NPS and the Deputy Director (Resource Analysis), Program Analysis and Evaluation, OSD, for cost analysis topics; 2) to enable the Chair to provide assistance to the Deputy Director (Resource Analysis), Program Analysis and Evaluation, OD, in the application of operations research techniques to cost analysis problems; and 3) to enhance the education of the students in the Operations Analysis Curriculum at NPS through the Chair Professor's research and associated responsibilities delineated in the agreement.

The first Cost Analysis Chair Professor is **Associate Professor Robert Koyak**.

STATEMENTS OF INTENT WITH KOREA NATIONAL DEFENSE UNIVERSITY AND COLOMBIAN NAVAL SCHOOL ESTABLISH INTERNATIONAL EDUCATION ALLIANCES, *continued from page 24*

support of resident courses, seminars and workshops at CNS and/or Mobile Education Teams (METs) conducting graduate-level education programs for military and civil officials in the Republic of Colombia, including Ministry of National Defense (MND) and Service officials. Such academic exchanges may include CNS's National Security Courses, Master's Degree Courses, Armed Forces Staff College, Duty Training Center, and Research Institute on National Security Affairs (RINSA).

- Curriculum Development in subject matter areas which either institution feels will improve the overall value and applicability of its curriculum to the various student populations it serves. CNS and NPS will investigate establishing a Student Exchange Program (SEP) for courses and research

collaboration between two institutions.

- Research and Advisory Activities in any of the areas of scholarship noted above, to include NPS faculty exchanges with any of the CNS programs listed above, as well as with public and private universities in the Republic of Colombia. Faculty publications such as manuscripts, reports and presentations produced as a result of such activities should list the joint affiliation(s) of all personnel contributing to each effort.
- Investigate methods of distribution of education in the areas of Distance and Distributed Learning. In this regard, areas of interest may include collaborative programs between CNS and NPS, as well as regional education programs hosted by CNS and offered to ROC organizations, or to similar national security education programs in other countries.

CHAIR PROFESSORSHIPS

CHAIR FOR INFORMATION OPERATIONS ESTABLISHED

A Memorandum of Understanding (MOU) between the Naval Postgraduate School (NPS) and the Joint Information Operations Center (JIOC) established a Chair Professorship at NPS. The MOU establishes a Chair Professorship for Information Operations (IO). The Chair is located in the Information Science Department of the Graduate School of Operational and Information Sciences (GSOIS). The professorship will collaborate among NPS schools and institutes, and between NPS and the JIOC, on research and analysis to develop Joint doctrine, tactics, techniques, procedures and operational concepts. The Chair will serve as a liaison between NPS and JIOC for all research and analysis projects. This cooperative effort will provide valuable opportunities for faculty and student professional development at NPS while enhancing JIOC's ability to foster information operations innovation in support of the Joint war fighter.

Student and faculty research opportunities span the range from technical prototyping of advanced systems to the more general development of innovative doctrine for Information Operations. The liaison will coordinate with JIOC all collaborative research efforts. It is envisioned that this liaison will assist faculty members in establishing independent research arrangements with the JIOC.

The IO Chair will conduct seminars, teach, and support thesis and other research work related to concept and tactical development issues. In addition, the Chair will travel to and from operational, educational, and research activities as necessary to support the research program. Travel will include the Chair's participation at annual meetings and collaborative workshops. The Chair may sponsor other faculty or student travel in support of Joint IO.

The current "Information Operations Chair" is **Associate Professor Raymond R. Buettner Jr.** Professor Buettner is a retired Naval officer with operational tours in submarines, in a land-based aviation squadron and on two aircraft carriers. He earned his Bachelor of Science from the University of the State of New York in 1989, was a graduate of NPS' first class in the Information Warfare Systems Engineering degree program in 1997 and conducted his doctorate work at Stanford University. He has been on the faculty since 1999, when he returned to NPS as a military instructor. Professor Buettner's work with developing influence modeling techniques in support of influence operations has led to his direct support of the PACOM response to the downing of the American P-3 aircraft and the JIOC response to the September 11, 2001 attacks.

As the IO Chair, Professor Buettner has planned an ambitious year. His goals include supporting the OSD lead effort to develop a Joint Integrative Analysis and Planning Capability, demonstrating the feasibility of using text mining technologies to improve the effectiveness of influence campaigns, building a prototype system for tracking process in wars that are primarily of a psychological nature (such as the current war on terror) and developing metrics that can be applied to IO munitions.

SPACE AND NAVAL WARFARE SYSTEMS COMMAND, PROGRAM EXECUTIVE OFFICE FOR COMMAND, CONTROL, COMMUNICATIONS, COMPUTERS, SPACE AND INTELLIGENCE, AND NAVAL POSTGRADUATE SCHOOL RENEW THE RADM GEORGE F. WAGNER CHAIR PROFESSORSHIP

The memorandum of agreement between the Naval Postgraduate School and the Space and Naval Warfare Systems Command establishing the RADM George F. Wagner Chair Professorship at NPS was expanded to include the Program Executive Office for Command, Control, Communications, Computers, Space and Intelligence as a co-sponsor.

The objective in establishing this Chair Professorship is to further develop and enhance the relationship between NPS and COMSPAWARSSYSCOM/PEO C4I and Space in the area of defense C4I and IT systems acquisition and management. The Chair shall act as a coordination mechanism across the NPS faculty and student body to provide research, analytical and other services devoted to addressing and resolving C4I issues, including technical, acquisition, financial and program management issues.

The RADM George F. A. Wagner Chair shall be a Professor in residence at the Naval Postgraduate School and will serve as a focal point for defense C4I systems and acquisition management issues at NPS. The Chair may serve in residence temporarily at COMSPAWARSSYSCOM/PEO C4I and Space or other Navy commands or institutions for periods of time during the fiscal year to further the satisfaction of the duties of the Chair.

The current chair incumbent is **Professor Larry Jones** of the Graduate School of Business and Public Policy.

CONFERENCES

RUSSIAN SECURITY AND THE CONTINUING WAR ON TERROR

On 16-17 September 2003, the Department of National Security Affairs conducted an international conference on Russian Security and the Continuing War on Terror. The conference, hosted by **Associate Professor Mikhail Tsypkin**, brought together experts from Russia, U.S. and France to discuss Russian-U.S. Relations and the Global Counter-terrorist Campaign, Russian Military Reform and the War on Terror,

The Campaign Against the “Oligarchs” and Its Implications for Russian Security, The War in Chechnya and Global Terrorism, The Future of the Russian Strategic Forces and Prospects for Russian-U.S. Cooperation in BMD, and Russian-U.S. Cooperation on WMD Nonproliferation. The conference was sponsored by the Foreign Military Studies Office of the U.S. Army and by the NPS Foundation.

THE NUCLEAR POSTURE REVIEW: IMPLEMENTING THE QUIET REVOLUTION

On 17-19 September 2003, a workshop was conducted in Monterey to explore issues raised by the effort to implement the Nuclear Posture Review (NPR). Organized by the Center for Contemporary Conflict (www.ccc.nps.navy.mil), the workshop attracted about thirty policymakers and schol-

ars who explored the theoretical, historical and practical issues related to the Bush administration’s vision of the American nuclear future, recently articulated in its NPR. Participants from the U.S. Strategic Command, the U.S. State

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Participant discussion during the Nuclear Posture Review Conference held in Monterey.



CONFERENCES

MONTEREY INFORMATION WARFARE WORKSHOP

The 2003 Information Warfare (IW) Workshop was held from 14–16 October. This was the fifth IW workshop hosted by the Naval Postgraduate School (NPS). **Associate Professor Raymond Buettner** (Information Operations Chair in the Department of Information Science) and **Ms. Rita Painter** (NPS/Space and Naval Warfare Systems Center-San Diego Cryptologic Program Manager) coordinated efforts at NPS to make this event another successful experience for the Department of Defense attendees. This year's IW Workshop was designed to bring attendees up to date on changes in the IW community in the years since the 2000 workshop, recent cyber and infrastructure threats and events, and advanced technology. The workshop included a cyber war game to highlight cyber successes and issues and to provide input to the National HUMINT Requirements Tasking Center (NHRTC).

The workshop presented one day of briefings, to include welcoming remarks from NPS Chief of Staff **Colonel David Smarsh, USAF**, and two subsequent days of IW war gaming and discussions. As was the case with the previous IW workshops, this event was conducted at the Top Secret/SCI level. Approximately 80 DoD representatives of various intelligence communities/functions/offices of the federal government, military services, and contractor elements were in attendance. NPS students from the Information Warfare Curriculum actively participated in all activities. Other NPS faculty and students were invited to attend and participate as their schedules permitted.

Workshops such as these help IW community members to collectively examine, further define, and systematically develop new collection strategies for IW exploitation and control. Hosting the IW Workshops at NPS provides the participants a non-attributive venue for the collegial exchange of ideas and concepts and the investigation of required defensive and offensive actions for securing and maintaining information dominance in the 21st century. The next IW Workshop at NPS has been tentatively scheduled for November 2004.

The workshop was sponsored by the Department of Energy, Office of Intelligence (IN-1); the U.S. Naval Postgraduate School (NPS); the Space and Naval Warfare Systems Center-San Diego (SSC-SD); and the Central Intelligence Agency, Information Operations Center (CIA-IOC).

THE NUCLEAR POSTURE REVIEW: IMPLEMENTING THE QUIET REVOLUTION, *continued from page 27*

Department, the Defense Threat Reduction Agency, and Lawrence Livermore and Los Alamos National Laboratories offered their insights into the impediments and problems emerging in the process of implementing the NPR, while scholars traced the logic of its recommendations to understand its impact on international politics and several important military relationships. Participants explored many issues raised by the NPR – offense-defense integration, intelligence, command and control, the new Triad, the global-strike complex and strategy, and missile defense – and identified many unanswered questions that have been raised by the effort to transform the U.S. nuclear forces and doctrine.

The NPR is an effort to restructure the U.S. nuclear deterrent, transforming a Cold-War strategy and force structure into a strategic deterrent better suited to meet today's security challenges. The NPR thus reflects the key concepts of dissuasion, deterrence, defense, and denial

articulated in the Quadrennial Defense Review, which was released in the fall of 2001. The NPR incorporates a new framework for Russian-American strategic relations and a response to the ongoing proliferation of nuclear, chemical, biological weapons and long-range ballistic missiles. The NPR also unveiled a new strategic triad, consisting of nuclear weapons and non-nuclear precision-strike capabilities, passive and active defenses and a revitalized nuclear infrastructure. The Review's authors consider nuclear weapons to be only one element of an array of capabilities designed to address threats posed by the proliferation of chemical, biological and nuclear weapons and long-range ballistic missiles.

The workshop will eventually yield about twenty scholarly papers that will be edited by **Professor James J. Wirtz** of the National Security Affairs Department and published by Palgrave-MacMillan in the fall of 2004.

TECHNOLOGY TRANSFER

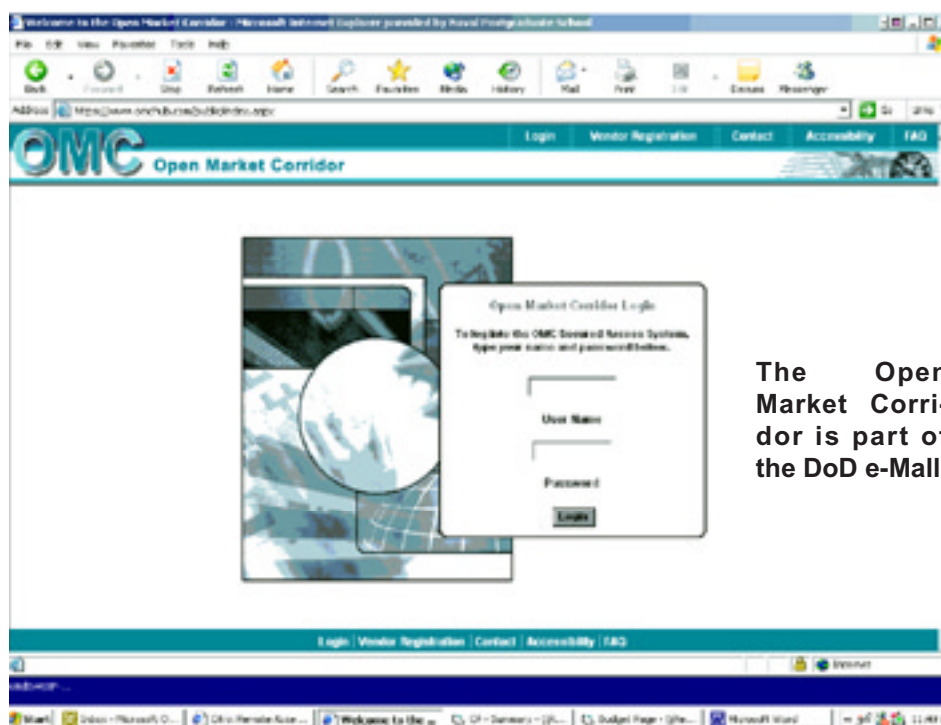
COOPERATIVE RESEARCH AND DEVELOPMENT AGREEMENTS FACILITATE COLLABORATIVE EFFORTS

The Naval Postgraduate School has an active Technology Transfer Program. Technology is transferred to the public sector primarily through the publications of the faculty and students. NPS also interacts with industry, universities, and non-profit agencies on collaborative research efforts through Cooperative Research and Development Agreements (CRADAs). Recent agreements are highlighted here.

NETWORLD EXCHANGE INC.

NPS Program Manager: Lecturer Ron Tudor, Graduate School of Business and Public Policy

The Naval Postgraduate School and Networkworld Exchange Inc. recently entered into a Collaborative Research and Development Agreement to research and test a State-of-the-Art Commercial Internet Ordering and Billing Service. NPS is conducting research on state-of-the-art commercial processes for ordering, delivery and billing of commercial-off-the-shelf supplies and services; and state-of-the-art auction disposal systems for disposal of non-excess Government property. This research will modify these commercial systems for use by the Federal Government to reduce the time it currently takes for processing these transactions and to decrease the cost of current government systems. The successful implementation of these systems will transform the Government purchasing and disposal systems.



ADVANCED CERAMICS RESEARCH, INC.

NPS Program Manager: Distinguished Professor David W. Netzer, Center for Defense Technologies and Education for the Military Services

The Naval Postgraduate School has entered into a Cooperative Research and Development Agreement with Advanced Ceramics Research, Inc. (ACR). ACR is a small corporation that focuses on innovative products for both industrial and military customers. One of their unique capabilities is in the design, rapid prototyping, and manufacturing of small unmanned aerial vehicles (UAVs) with a variety of payloads. This collaborative effort will provide ACR with engineering support on technologies for UAVs and field evaluations of

these technologies and will provide NPS with UAV support for field experiments. The expected result is improvement in warfighter effectiveness of Special Operations Forces (SOF) and other military forces through the use of innovative new UAV technologies and concepts of operations. Initial efforts will focus on autonomous landing of UAVs on ships and field experiments with SOF units. Future tasks will involve control of multiple UAVs, conformal antenna designs, and networked secure communications.

TECHNOLOGY TRANSFER

DIGITALNET GOVERNMENT SOLUTIONS, LLC

NPS Program Manager: Associate Professor Cynthia Irvine, Department of Computer Science and Center for Information Systems Security Studies and Research

The Center for Information Systems Security Studies and Research (CISR) at the Naval Postgraduate School has developed a multilevel secure distributed operating environment, called MYSEA. An early version of MYSEA utilized the DIGITALNET XTS300 security product as its central enforcement mechanism, i.e., its *trusted computing base* (TCB). Since then, CISR has developed a teaching prototype of the OpenBSD operating system, which enforces multilevel security, and has utilized that prototype as the TCB for MYSEA. Meanwhile, DIGITALNET has evolved the XTS300 into the XTS400, which product now has a Linux-compliant interface.

The purpose of the Monterey Security Enhanced Architecture (MYSEA) research project is to develop high assurance security services and integrated operating system

mechanisms that will protect distributed multilevel computing environments from malicious code and other attacks.

The purpose of the MYSEA research project is to develop high assurance security services and integrated operating system mechanisms that will protect distributed multilevel computing environments from malicious code and other attacks.

These security services and mechanisms are intended to extend and interoperate with existing applications and operating systems, providing new capabilities for composing secure distributed systems using commercial-off-the-shelf (COTS) components. The latter objective results from the realization that unless a secure system offers users the same sort of convenient interfaces they use when handling *routine* information, the secure system will fail due to lack of *user acceptability*.

The Monterey Security Enhanced Architecture (MYSEA) project has constructed a prototype demonstration of a potential high assurance distributed operating environment for enforcing

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ADVANCED TECHNOLOGY INSTITUTE

NPS Program Manager: Professor Chuck Calvano, Department of Mechanical Engineering and Meyer Institute of Systems Engineering

NPS and the Advanced Technology Institute have entered into a cooperative relationship to educate American youth about career opportunities in Naval Architecture and Marine Engineering (NA&ME) through a pre-college program for ship design. An integrated education, research and application environment for advanced hull form design is envisioned to develop an integrated education, research and application environment in advanced hull design. This state-of-the-art internet based environment for advanced hull form design will serve as a common toolkit and platform to facilitate the integrated development and close interaction among activities in these three domains. Advanced total ship system engineering and optimization will: (1) enhance the education of future naval officers at MIT and NPS to develop and integrate subsystem technology at the ship system level and to design and evaluate ship system level concepts; and (2) develop tools, methods, decision criteria and processes to enable students and ship designers to make total ship system level trade-off decisions leading to innovative naval vessels in key technology areas such as system level optimization.

NATIONAL UNIVERSITY OF SINGAPORE ACTING THROUGH ITS TEMASEK DEFENSE SYSTEMS INSTITUTE

NPS Program Manager: Professor Leonard Ferrari, Dean of Research

The Naval Postgraduate School (NPS) and the National University of Singapore (NUS) acting through its Temasek Defense Systems Institute previously entered into a Statement of Intent to form a collaboration to establish and operate a Singapore-based institute for graduate education and research in the area of defense technology and systems engineering and analysis. The objective of this CRADA is to provide for collaborative research efforts between NPS and NUS faculty and students. Initial efforts will include: 1) Antenna Design for UAV Application; 2) Analysis and Testing of a 3-5 μ m Thermal Imager, Differential Colour Filter and Polarisation Filter Effects; 3) Multi-IR Band Data Fusion for Target Recognition; 4) Automatic Target Detection; and 5) Development of AUV Technologies.

TECHNOLOGY TRANSFER

GENERAL ELECTRIC COMPANY ACTING THROUGH ITS GE AIRCRAFT ENGINES (GEAE) BUSINESS COMPONENT

NPS Program Manager: Research Associate Professor Chris Brophy, Department of Mechanical and Astronautical Engineering

NPS and GEAE have been participating in a collaborative effort in the development of pulse detonation (PD) technology. NPS has conducted analysis and testing for GEAE specified PD tasks. The collaborative effort has advanced the state of PD technology using liquid fuels. The NPS PD program has benefited from the new technologies provided and from expansion of current programs to include other liquid fuels. This fourth amendment outlines additional work and funding.

DIGITALNET GOVERNMENT SOLUTIONS, LLC, *continued from page 30*

multilevel security policies, composed of a combination of many low-assurance commercial components and relatively few specialized (e.g., high assurance) multi-domain components, based upon a security-enhanced version of the OpenBSD operating system, that supports unmodified COTS productivity applications. The demonstration architecture permits the on-going DoD and U.S. Government investment in commodity PC operating systems and applications to be integrated into a high assurance environment where enforcement of critical security policies is assigned to more trusted elements. The modularity of the architecture permits alternate configurations, for example to include an evaluated high assurance multilevel enforcement component.

The DIGITALNET XTS-400 system is a high assurance system enforcing mandatory access controls. It is derived from earlier systems that received the National Security Agency (NSA) Class B3 evaluation rating. The XTS-400 presents a Linux-compatible interface and supports modern Intel hardware.

This research effort is intended to design and develop enhancements and extensions to the XTS400 "STOP" operating system and MYSEA operating environment such that the XTS400 can be used as the trusted computing base for MYSEA.

As the cooperative effort progresses, activities for subsequent project phases in subsequent years may be defined in amendments.

INTEL CORPORATION

NPS Program Manager: Associate Professor Wei Kang, Department of Applied Mathematics

The goal of the collaborative research is to design CD control methodology based on nonlinear models to regulate the lithography process with multiple parameters in a run-to-run control system in order to achieve the desired CD, to maintain the C stability and uniformity, and to reduce or minimize the influence of unknown disturbances on the performance of the system.

FUEL AND UTILITY SYSTEMS, GOODRICH CORPORATION

NPS Program Manager: Associate Professor Lyn Whitaker, Department of Operations Research

The Goodrich Integrated Mechanical Diagnostics Health and Usage Management System (IMD HUMS) provides aircraft maintainers an extensive set of functions to support rotorcraft health and diagnostics processing. These functions support rotor track and balance operations, gearbox and drive train mechanical diagnostics, operational and structural usage, exceedance detection/processing and engine power assurance checks. The system is comprised of onboard, flight worthy line replaceable units which perform the requisite real time data acquisition, analysis, display and storage. This onboard system is supplemented with networked ground-based workstations which provide maintainer configuration and maintenance management functions along with specialized diagnostics tools. The system is being fielded on a number of helicopter platforms. These programs demonstrate the capabilities of the IMD HUMS as a tool for rotorcraft health management and diagnostics.

NPS and Goodrich will collaborate on the use of IMD HUMS vibration data to be used in analysis of the mechanism of failure of helicopter mechanical parts. This would include modeling failure rates, transition from nominal to failure modes, validation of mechanism of failure and statistical methods of failure detection.

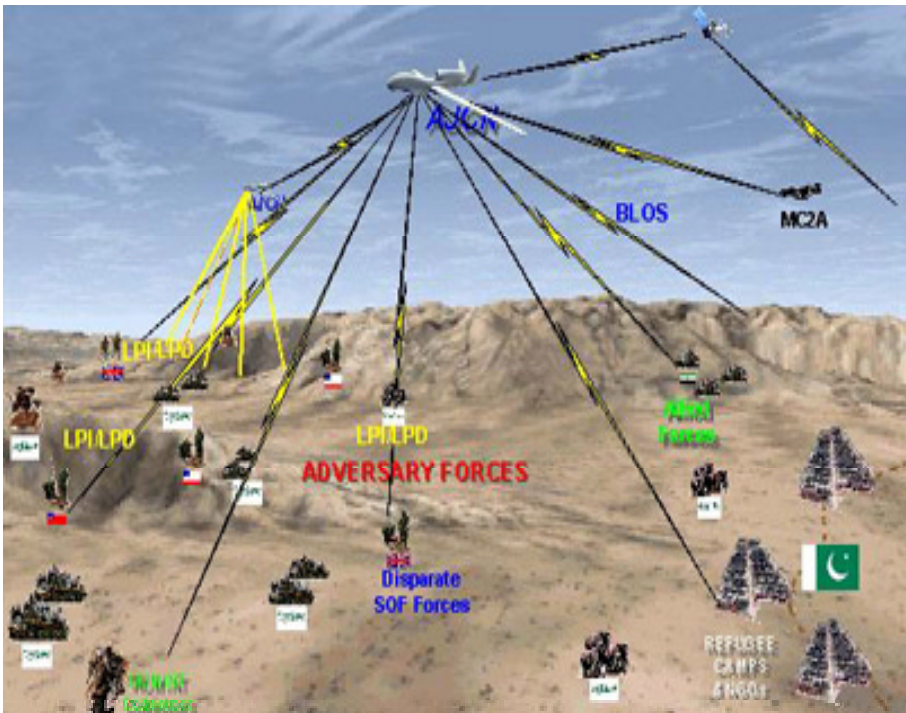
Goodrich will provide data and expertise in mechanical diagnostics. NPS will provide analysis and modeling of failure process. Together the partners will provide analysis and verification of models.

PROJECT NOTES

OPERATIONS RESEARCH FACULTY PARTICIPATE IN ADVANCED CONCEPT TECHNOLOGY DEMONSTRATION PROJECT

During the next two quarters LTC Saverio Manago, USA, and thesis students CPT Russell Rhoads, USA, and CPT Scott Gilman, USA, will be working on a project while partnered with Joint Forces Command (JFCOM), Lawrence Livermore National Laboratories (LLNL), and CUBIC Corporation to assist in the development of the Concept of Operations (CONOPS) for the Adaptive Joint C4ISR Node (AJCN). The Advanced Concept Technology Demonstration (ACTD) is scheduled for January, 2004.

While working the CONOPS for AJCN they also plan to examine what contribution the system might make towards fratricide reduction by itself and in conjunction with other systems specifically designed to enhance situational awareness and prevent fratricide. This effort will involve wargaming, analysis, and combat modeling. The scenario employed will be a futuristic scenario in Asia developed and used by the Operations Research Department Joint Campaign Analysis class and Joint Wargaming Analysis class. The combat modeling effort will involve the use of the Joint Conflict and Tactical Simulation (JCATS) along with other analytical models. The wargaming effort will be integrated into the classroom.



The Adaptive Joint C4ISR Node (AJCN) system is a scaleable, platform independent, multi-function Radio Frequency (RF) system that provides seamless interoperable communications functionality simultaneously with Signals Intelligence (SIGINT), Electronic Warfare (EW) and Information Operations (IO) capabilities.

LIVE-VIRTUAL INTERACTIONS ON HIGH RESOLUTION BATTLEFIELD REPRESENTATIONS

Geometric Pairing utilizes attitude sensors and GPS (global positioning system) position location on weapons platforms to cast virtual bullets in order to determine who shot at whom during operational tests at Ft. Hood, Tx. When fully developed Geometric Pairing systems are expected to replace the current "laser tag" technologies. The requirement for local terrain knowledge to calculate line-of-sight (LOS) and notional trajectories has lead to the development of a tactical terrain server by **Associate Professor Wolfgang Baer**, Department of Information Science, under sponsorship of the U.S. Army. Currently, a tank mounted system is being tested. A cigarette box size unit for infantry applications is in development. One-meter terrain and LOS obscuration algorithms are being adapted from Dr. Baer's ongoing research into live-virtual interactions on high resolution battlefield representations. "Giving the war-fighter detailed knowledge of his surroundings is becoming a reality," says Dr. Baer.

The following conference presentations described the system, algorithms, and initial test results.

- High Resolution Terrain Geometric Pairing System for Operational Tests, WG-25 71st MORSS, 10-12 June 2003, USMC Base Quantico, VA
- Developing a Probabilistic LOS Algorithm, Line-of-Sight Technical Working Group Meeting, 23 September 2003, USA Corps of Engineers' Topographic Engineering Center, Alexandria, VA.

Please contact Dr. Baer (baer@nps.navy.mil) for information.

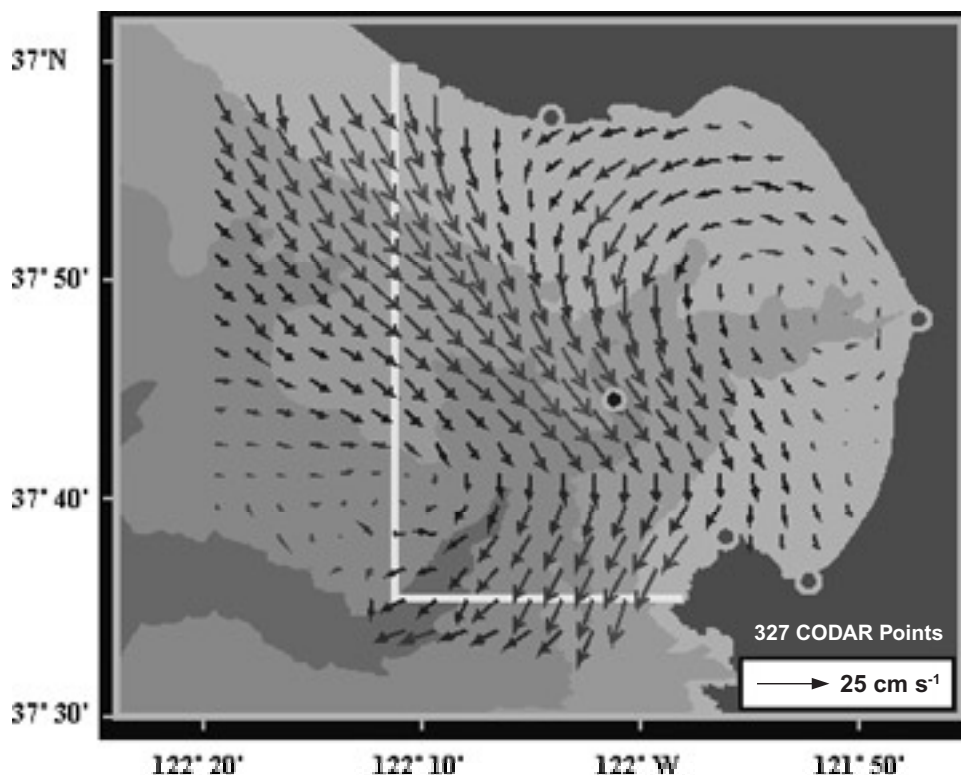
PROJECT NOTES

NAVAL POSTGRADUATE SCHOOL COLLABORATES ON AUTONOMOUS OCEAN SAMPLING NETWORK PROJECT

The Autonomous Ocean Sampling Network or AOSN is a multi-institutional project involving sophisticated new robotic vehicles together with advanced ocean models to observe, predict, and better understand the ocean. A field experiment in Monterey Bay was conducted in August and September.

During the Monterey Bay experiments, oceanographic data was collected using ships, airplanes, satellites, drifters, buoys, and a fleet of autonomous underwater vehicles (AUVs), including gliders. The data collected each day was incorporated into com-

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(Above) Surface ocean current velocity vectors for 13 August 2003 with bottom topography shading. These data were used in real time during AOSN to validate ocean forecast models and to track and recover drifting instruments.

(Left) CIRPAS' twin otter was used during the recent AOSN field experiment over Monterey Bay.

C3F-NPS "DESK" ON THE *USS CORONADO* CONTINUES

In cooperation with the Commander Third Fleet (C3F) the Naval Postgraduate School established a C3F-NPS "Desk" on the *USS CORONADO*, Flagship of the Third Fleet in San Diego. The primary purposes of the desk are to:

1) provide innovative ideas and knowledge of current emerging technologies of value to the Fleet/ Sea Based Battle Lab, and 2) increase faculty awareness of Fleet operations and needs. It is also an opportunity for faculty to obtain data in support of their existing research programs and/or to obtain knowledge and verbal support from the Fleet for future proposals to Navy commands.

NPS actually has a desk with computer in the J9 spaces, a bunk assigned, and the occupant is treated just like staff

— attending staff meetings, etc. The ship goes to sea several times a year, usually for less than two weeks at a time.

NPS has been matching faculty skills and 3F needs. The most expressed 3F needs are in the areas of IT, ASW, IO/IW, visualization, man-machine interaction, networks, computer security, and software engineering.

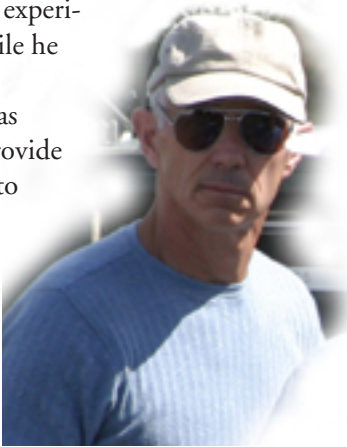
The current C3F desk is **Research Assistant Professor Jeffrey Crowson** of the Department of Operations Research. Dr. Crowson is a research psychologist and professor of human systems integration (human factors). His primary focus while at 3F will be working with the Science Advisor on the CORTEX (Collaborative Operations and Responsive Technology Experimentation) Project.

FACULTY ACHIEVEMENT

THE NAVAL POSTGRADUATE SCHOOL PAYS TRIBUTE TO OUTGOING DEAN OF RESEARCH

Distinguished Professor of Aeronautics and Astronautics David Netzer recently left his position as the Associate Provost and Dean of Research. The Naval Postgraduate School has been the fortunate recipient of his experience and expertise for the past seven years while he served as the Associate Provost and Dean of Research. His performance in this capacity has been exemplary. His positive leadership to provide an environment conducive to academics and to promote research at the institution, and the entire Naval Service, are without parallel. He has lead by example through his superb technical acumen, proactive involvement in relevant, defense-related research and personal achievement.

As Dean of Research, Professor Netzer was a driving force in the establishment of the three research and education institutes at NPS: 1) the Meyers Institute for System Engineering; 2) the Cebrowski Institute for Information Innovation and Superiority; and 3) the Modeling and Simulation Institute. Each institute required a board of advisors, a director, dedicated personnel, facilities, and infrastructure to



David Netzer

be developed and identified. Each institute needed to be integrated and interwoven into the existing academic structure. During the last two years, Netzer has worked tirelessly with the Superintendent, Institute Directors, NPS faculty and staff, and members of DoN/DoD to solidify the purpose and stature of the Institutes. These Institutes leverage the academic skills provided in the NPS Graduate Schools (International Studies; Operational and Information Sciences, Engineering and Applied Sciences, and Business and Public Policy) toward interdisciplinary research that will help the Navy and Marine Corps meet future military challenges.

NPS has sought to increase its contribution toward Naval and Defense Transformation through its interdisciplinary programs. As the Associate Provost and Dean of Research, David Netzer devoted considerable to creating interdisciplinary projects, and coordinating faculty and students in support of those projects. The first project involved five departments, students in three-design classes and two additional thesis stu-

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AUTONOMOUS OCEAN SAMPLING NETWORK PROJECT, *continued from page 33*

puter models to predict changes in circulation, chemistry, and biological processes in and around the bay. Scientists use the output from these models to decide where to focus sampling efforts on the following day (a process called "adaptive sampling"). The daily data also helped refine the models, increasing their ability to represent dynamic ocean processes.

The underlying science goal of this field program is to better understand and perhaps even predict the upwelling of cold, nutrient-rich water that occurs off Monterey Bay during the summer months. Upwelling events create plankton blooms that support the abundant fisheries and other wildlife in and around Monterey Bay. The scientists are interested in both the onset and waning of upwelling events.

The AOSN program and in particular, the Monterey Bay experiment, is a prototype of the integrated ocean observing systems being envisioned for the future. AOSN Partners include:

- California Institute of Technology

- California Polytechnic State University
- Harvard University
- Monterey Bay Aquarium Research Institute
- NASA Jet Propulsion Laboratory
- Naval Postgraduate School
- Naval Research Laboratory, Stennis Space Center
- Naval Research Laboratory, Monterey
- Princeton University
- Scripps Institution of Oceanography
- University of California at Santa Barbara
- University of California at Santa Cruz
- Woods Hole Oceanographic Institution

NPS faculty participants include **Associate Professor Jeffrey Paduan**, **Research Professor Steve Ramp**, and **Research Associate Professor Leslie Rosenfeld**, Department of Oceanography, **Distinguished Professor Anthony Healey**, Department of Mechanical and Astronautical Engineering, and **Research Associate Robert Bluth**, Center for Interdisciplinary Remotely Piloted Aircraft Studies.

FACULTY ACHIEVEMENT

TRIBUTE TO OUTGOING DEAN OF RESEARCH, *continued from page 34*

dents. This collection of faculty and students completed a yearlong assessment of small, fast, surface combatants operating in large groups performing distributed combat operations. The study effort required a level of interdisciplinary and inter-

departmental collaboration not previously attempted at NPS. The final product was a concept called CROSSBOW, and was a strong demonstration of the School's ability to conduct

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Professor Netzer spearheaded creation of the Naval Postgraduate School's Combustion Research Laboratory, which specializes in the study and development of rocket, ramjet, pulse-detonation and gas turbines. He has been the principal investigator on a wide variety of related topics to include: solid propellant combustion, exhaust plume signature, particulate behavior in exhaust nozzles and plumes, solid fuel, liquid fuel and gelled slurry fuel ramjet combustion, dual-mode rocket motors, gas turbine combustor and engine test cell emissions, solid propellant rocket plume afterburning suppression, pulse detonation engines, high-energy fuels for airbreathing missiles and fuel additives for infrared and visible smoke reduction. Professor Netzer is widely published. Forums include 40 articles in journals and books, over 40 papers in proceedings and over 40 technical reports. He is credited with co-editing the American Institute of Aeronautics and Astronautics (AIAA) volume on Tactical Missile Propulsion.

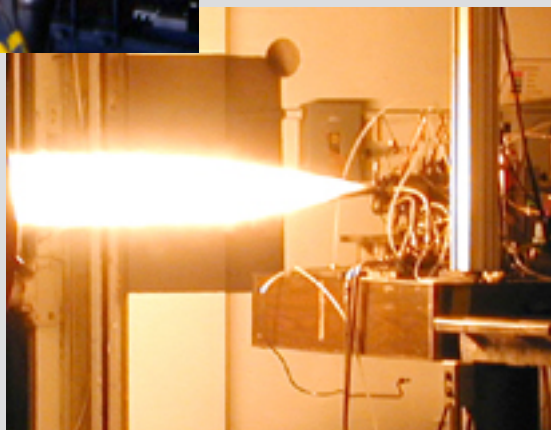
David Netzer's peers and colleagues recognize his stature and stalwart contributions. He is a member of AIAA and the Combustion Institute and serves as an active contributing member in the JANNAF Combustion and Exhaust Plume Technology Subcommittees. During the late 1970s and early 80s, he has served as a member of the Naval Studies Board for the National Academy of Sciences and the Navy Aeroballistics Committee. As an NATO/AGARD consultant, he has completed multiple missions to Germany, Greece, Italy,



Portugal and Turkey. Professor Netzer served as the Working Group Chairman on Ramjet Performance for over 7 years. He has been invited and subsequently presented lectures at the National Cheng Kung University in Taiwan and the Agency for Defense Development in Korea. He served as a member of the Mutual Weapons Development Data Exchange Agreement (DEA) panel between the U.S. and France on Ramjet and Combined Engines Propulsion Technology and is the U.S. leader for Working Group #3, Plume Technologies under the U.S./French exchange MWDDEA-N-F-5660. He has co-authored a NATO Standardized Agreement (STANNAG) on Exhaust Plume Smoke Classification and has authored a proposed new STANNAG on Procedures for the Determination of Ramjet and Ducted Rocket Theoretical and Experimental Performance.

David Netzer is a member of the Sigma Xi

Science and Engineering Honor Society, the Pi Tau Sigma Mechanical Engineering Honor Society, and the Tau Beta Pi Engineering Honor Society. He has received some noteworthy awards during his career - the



Society of Automotive Engineers (SAE) Ralph R. Teetor Education Fund Award for Engineering Educators, the Naval Postgraduate School Admiral J.J. Schiefflin Award and the Allen Griffen Award for excellence in teaching and the Joint Army-Navy-NASA-Air Force (JANNAF) Combustion Subcommittee Annual Award.

FACULTY ACHIEVEMENT

TRIBUTE TO OUTGOING DEAN OF RESEARCH, *continued from page 35*

large-scale investigations of relevant naval issues. He has institutionalized these campus-wide projects and they are expanding - involving more students, more departments - and making even greater contributions today.

David Netzer served as director of the Congressionally-mandated Center for Defense Technology and Education for the Military Services (CDTEMS) while Dean of Research and has now assumed the role on a full-time basis. Under the auspices of CDTEMS and in partnership with the THIRD Fleet, Professor Netzer initiated the Fleet Transit Program. As THIRD Fleet operational ships transit the Monterey coastline, NPS faculty and students have an opportunity to test/experiment/demonstrate some of the latest in Navy Science and Technology (S&T) in an operational environment. The fleet has the opportunity to experience/experiment with these technologies with relatively small investments of time and resources. The program has expanded to include coordination with Naval Research Laboratory (West) and the Fleet Numerical Meteorology and Oceanographic Center (FNMOC). The CDTEMS is also supporting a series of field experiments with Special Operations Forces to examine the performance of new communications systems used with multiple UAVs, ground forces, and ground sensors. This is a highly interdisciplinary effort, involves students and faculty from across the campus as well as active involvement from several companies and government laboratories. Other current efforts include the design and demonstration of autonomous landing of UAVs on ships, swarming UAVs for SIGINT, and human factors in UAV operations.

David Netzer also served as the Executive Director for the Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) from 1999

Dean David Netzer and CW2 Chris Manuel discuss UAV assets to be utilized during operational field experiments at Camp Roberts, CA.

through 2002. CIRPAS operates a variety of manned and unmanned aerial vehicles (including Predator, Altus and Gnat Unmanned Aerial Vehicles, Pelicans, and a Twin Otter) that provide unique flight operation scientific measurement services to the scientific and research, development, test and evaluation communities.

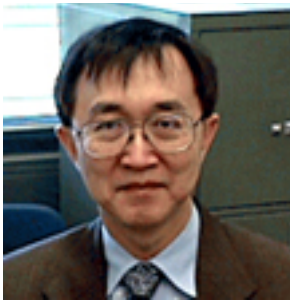
David Netzer's accomplishments as Dean of Research are unparalleled and too numerous to mention. During the last year, the Department of Justice funded an education and research initiative at NPS in Homeland Security. NPS is the first university to offer a Masters degree in Homeland Security. David Netzer has been responsible for coordinating the research arm of this multi-million dollar program. He also established an Institutional Review Board at NPS as research started to incorporate the "human" into specific research projects. He worked with the National University of Singapore to establish the Temasek Institute and has also been the catalyst for establishing new research labs. The MEMS/Nanotechnology Lab within the Mechanical and Astronautical Engineering Department is the most recent. This area of research is gaining momentum and David Netzer spearheaded NPS' foray into this arena. He is also working to maintain a national resource, the SOSUS array located at the former Navy Point Sur Facility.



FACULTY ACHIEVEMENT

THE TITLE OF “DISTINGUISHED PROFESSOR” IS BESTOWED ON THREE NPS FACULTY MEMBERS

A distinguished professor is a “Senior Role Model” among his or her colleagues. A distinguished professor has given continued effective service to the Naval Postgraduate School, and has



C.P. Chang

School that year. Professor Chang is an internationally recognized scholar on monsoons and tropical meteorology. He is a Fellow of the American Meteorological Society. He has published over 80 articles in the open literature and has presented numerous invited presentations. Professor Chang has edited six books in the field of Monsoon Meteorology and Climate of East Asia.

The second recipient is **Professor Anthony Healey** of the Department of Mechanical and Astronautical Engineering. Professor Healey received his Ph.D. in Mechanical Engineering in 1966 from the University of Sheffield in England. In 1967 he became Assistant Professor of Mechanical Engineering at Penn State University. His

conducted work that has had significant impact on national security and on the candidate's field of expertise. NPS recently recognized three professors deserving of this honor.

The first recipient is **Professor C.P. Chang** of the Department of Meteorology. Professor C.-P. Chang received his Ph.D. from University of Washington in 1972 and joined the faculty of the Naval Postgraduate

early teaching and research were in vehicle dynamics and control. He joined the Mechanical Engineering Department at the University of Texas - Austin in 1971 as Associate Professor, and was promoted to Professor in 1974. Healey joined the faculty of the Naval Postgraduate School in 1986. Since joining NPS, Professor Healey has led projects in control and navigation for Autonomous Underwater Vehicles – AUVs - and established the NPS Center for AUVs. With funding from the National Science Founda-



Anthony Healey

tion, Office of Naval Research and Naval Underwater Systems Center, this work has progressed from fundamental studies to construction of an AUV and participation in Fleet Battle Exercises. His students and colleagues alike hold him in the highest regard.

The third recipient is **Professor Guillermo Owen** of the Department of Applied Mathematics. Professor Owen received his doctorate in mathematics from Princeton University in 1962. Prior



Guillermo Owen

to arriving at NPS in 1983, he was a faculty member at Fordham University, Rice University, and the University of the Andes in Bogotá. He is the author or co-author of more than 100 journal articles, but is perhaps best known for his seminal research in cooperative game theory, and for his classic text on that subject (currently in its third edition having been translated into 5 languages). He is recognized internationally by leaders in the field. He has been a visiting faculty member at 28 universities in 10 countries during his career. His collaborations with NPS Professor McCormick utilize his expertise to grapple with topics of great national importance that include terrorist decision making, the dynamics of insurgency and the proliferation of weapons of mass destruction.

OPERATIONS RESEARCH DISTINGUISHED PROFESSOR RECEIVES INFORMS FELLOWS AWARD



Donald P. Gaver

Distinguished Professor Donald P. Gaver of the Department of Operations Research has been inducted as a Fellow of the Institute of Operations Research and the Management Sciences. The plaque presented at the Annual INFORMS Meeting in Atlanta, Georgia, reads, “For years of dedicated leadership and valuable contributions to the profession of operations research and the management sciences.” Professor Gaver joins Operations Research **Distinguished Professor David Schrady** as a recipient of this honor.

FACULTY NEWS

GRADUATE SCHOOL OF BUSINESS AND PUBLIC POLICY

T. Abdel-Hamid, "The Obesity Epidemic: Is a State IN Mind," 21st International System Dynamics Conference, New York, NY, 20-24 July 2003.

Prof. T. Abdel-Hamid chaired the Session on Health Care Dynamics at the 21st International System Dynamics Conference, New York, NY, 20-24 July 2003.

Prof F. Barrett co-authored a paper, "Planning on Spontaneity: Lessons from Jazz for a Democratic Theory of Change," that won the best paper award in the Organizational Development and Change Division of the Academy of Management

D. E. Brinkley, "The Effect of Computer-Mediated Communications on Graduate Student Interactions," World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education, Phoenix, AZ, 7-11 November 2003.

Prof. J. Dillard recently conducted a Project Management Tools Course to 25 Santa Clara Water District employees and mid-level managers, conveying many of the Department of Defense's best practices in areas such as technical performance measurement, earned value management, project scheduling and project cost estimation. Public and private sector organizations continue to benefit from NPS's strategic partnership with University of California at Santa Cruz Extension – Corporate Center, who sponsored these events.

M. Eitelberg, "Spacemen, Scholars, and Sailors: Another Look at the Military's Treatment of Gays," National Confer-

ence of the American Psychological Association, Toronto, Canada, August 2003.

Prof A. Estrada chaired the symposium, "Current Research on Sexual Orientation and Military Service," at the National Conference of the American Psychological Association, Toronto, Canada, August 2003.

K. Euske, "Public, Private, Not-for-Profit: Everybody is Unique?" Annual Performance Measurement Association Symposium, 27-29 July 2003.

Prof. C. Franck chaired the session: Defense Spending and the U.S. Economy, at the Western Economic Association International Annual Conference, Denver, CO, 11-14 July 2003.

C. Franck and **F. Melese**, "Access Deterrence and Access Denial in the Taiwan Strait," Western Economic Association International Annual Conference, Denver, CO, 11-14 July 2003.

K. Gue, "Choosing Picking Strategies in an Order Fulfillment Center," Institute for Industrial Engineers Research Conference, Portland, OR, April 2003.

U. G. Kraus, "Product Line Selection and Pricing under a share-of-surplus choice model," *European Journal of Operational Research*, Vol. 150/3, 2003, pp. 653-671.

I. Lewis and **J. Suchan**, "Structuration Theory: Its Potential Impact on Logistics Research," *International Journal of Physical Distribution and Logistics Management*, 33(4), 2003, pp. 296-315.

S. Mehay, "A Cost-Benefit Analysis of

Drug Prevention Policies," Institute of Economic and Regional Research at the University of Neuchatel, Switzerland, 2 July 2003.

S. Mehay and **B. Hirsh**, "Evaluating the Labor Market Performance of Veterans Using a Matched Comparison Group Design," *Journal of Human Resources*, Vol. 38, No. 3, Summer 2003, pp. 673-700.

S. Mehay, "Graduate Education and Job Performance: Evidence from Federal Government Employees," Global Conference on Business and Economics, Imperial College, London, England, 5 July 2003.

M. Nissen, "Designing Organizations Around Knowledge Flows: Compelling, Crazy or Passé?" Department of Organization and Management Research Seminar, University of Southern Denmark, Odense, Denmark, May 2003.

M. Nissen, **J.S. Edwards**, **M. Handzic**, **S. Carlsson**, "Knowledge Management Research & Practice: Visions and Directions," *Knowledge Management Research & Practice* 1:1 editorial paper, 2003, pp. 49-60.

M. Nissen, **E. Jansen**, **C. Jones**, and **G.F. Thomas**, *Contextual Criticality of Knowledge-Flow Dynamics: The Tragedy of Friendly Fire*, Technical Report NPS-GSBPP-03-002 (September 2003).

B. Ramesh and **T.K. Abdel-Hamid**, "Integrating Genetic Algorithms with System Dynamics to Optimize Quality Assurance Effort Allocation," *Software Engineering with Computational Intelligence*, Taghi M. Khoshgoftaar (editor),

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Kluwer Academic Publishers, Norwell, MA, 2003.

J. San Miguel, "Grand Jean Company, Abrams Company, and Emerson Electric Company Case Studies," R.N. Anthony & V. Govindarajan, *Management Control Systems*, 11th edition, McGraw-Hill/Inwin, 2004.

Prof. J. San Miguel was a judge for the Goldman, Sachs & Co.'s 2003 Executive Leadership Council's MBA Business Case Competition. MBA teams from Wharton, Emory, and Yale were first, second, and third place winners.

Prof. N. Roberts moderated a panel entitled, "Globalization, Internationalization, and Democracy: The Seattle Experience," for the National Academy of Management meeting in Seattle, WA.

Prof. L. Sekerka presented a symposium at this year's Academy of Management Annual Meeting in Seattle, WA. Presentations included papers by **Frank Barrett** (with D. Bright on "Appreciative Inquiry Within the IP Community.") and David Cooperrider (with **L. Sekerka** on new organizational forms through positive approaches to change).

Prof. L. Sekerka was a guest speaker on a Symposium entitled: Role of Emotion in team Effectiveness. The paper she presented, "Appreciative Change Processes in Groups: Impacts on Emotion and Well-being," was a study combining qualitative and quantitative data from a field experiment conducted at the Veterans Administration in Washington, D.C.

Prof C. Simon delivered a two-hour presentation to senior officers and

civilians from the Defense Contracting Management Agency (DCMA San Francisco), "Strategic Planning & Implementation in Defense Contracting," on 25 September 2003.

L. Douglas Smith and **S. M. Sanchez**, "Assessment of Business Potential at Retail Sites: Empirical Findings from a U.S. Supermarket Chain," *The International Review of Retail, Distribution and Consumer Research*, Vol. 13, No. 1, 2003, pp. 37-58.

K.F. Snider and **M.E. Nissen**, "Beyond the Body of Knowledge: A Knowledge-Flow Approach to Project Management Theory and Practice," *Project Management Journal*, 34:2, 2003, pp. 4-12

Prof. G. Thomas, co-led PhD Colloquium at Association for Business Communication Europe, 29-30 May 2003.

Prof G. Fann Thomas was reelected to the Board of Directors for the Association for Business Communications.

Prof. C. Troy's research on accounting irregularities made the news in *The Wall Street Journal*, and *The Wall Street Journal Europe* 3 July 2003. The article, "Study Blames Accounting Fraud on Takeover Fever, Officers' Age," is by Joann S. Lublin.

GRADUATE SCHOOL OF ENGINEERING AND APPLIED SCIENCES

AERONAUTICS AND ASTRONAUTICS

P. Martin, **K. McAlister**, **M.S. Chandrasekhara**, and **W. Geissler**, "Dynamic Stall Measurements and Computations

The 22 August 2003 edition of *Jane's Defense Weekly* highlights a portion of a recent NPS campus interdisciplinary study on expeditionary warfare. The article, "Ship-to-objective lift still a key issues, says U.S. study," clearly shows the impact NPS integrated studies can have outside of NPS. A design of a SeaBase Ship with increased logistics throughput (by NPS Total Ship Systems Engineering (TSSE) students) was part of the systems of systems, as were the heavy lift aircraft designs done by the Aeronautics students. **Professor Chuck Calvano**, Department of Mechanical and Astronautical Engineering, and **Professor E. Robert Wood**, formerly of the NPS Aeronautics and Astronautics Department, were faculty leads in the integrated interdisciplinary project.

for a VR-12 Airfoil with a Variable Droop Leading Edge," American Helicopter Society's 59th Annual Forum and Technology Display, Phoenix, AZ, May 2003. The paper was selected for the 2003 AHS Best Paper Award.

APPLIED MATHEMATICS

D. Givoli, **B. Neta**, 2002: High-Order Non-Reflecting Boundary Conditions for Dispersive Waves, *Wave Motion*, 37, 2003, 257-271.

D. Givoli, **B. Neta**, 2002: High-Order Non-Reflecting Boundary Scheme for Time-Dependent Waves, *Journal of Computational Physics*, 186, 2003, 24-46.

D. Givoli, **B. Neta**, High-Order Non-Reflecting Boundary Conditions

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for the Dispersive Shallow Water Equations, *Journal of Computational Applied Mathematics*, 158, 2003, 49-60.

V. van Joolen, D. Givoli, B. Neta, High-Order Non-Reflecting Boundary Conditions for Dispersive Waves in Cartesian, Cylindrical and Spherical Coordinate Systems, *International Journal of Computational Fluid Dynamics*, 17(4), 2003, 263-274.

V. van Joolen, B. Neta, D. Givoli, "High-Order Non-Reflecting Boundary Conditions for Dispersive Wave Problems in Stratified Media," Sixth International Conference on Computer Modelling and Experimental Measurements of Seas and Coastal Regions, Cadiz, Spain, 23-25 June 2003.

Prof. G. Owen was a guest speaker on "A Century of Game Theory," at the 15th Italian Meeting on Game Theory and Applications, Urbino, Italy, 8-12 July 2003.

G. Owen was a guest speaker on "Consistent Values of Games," at the Stony Brook Festival on Game Theory, 27-29 July 2003.

METEOROLOGY

R. Cantux, C. Wash, T. Murphree, "The Role of Weather in Naval Aviation Mishaps," BACIMO Conference, Monterey, CA, September 2003.

K. Davidson, P. Frederickson, D.R. Kuehn, "Predicting METOC Influences on the Detection of Surface Targets with Small Radar Cross Sections," BACIMO Conference, Monterey, CA, September 2003

P. Durkee, "Passive Visible and Infrared

Observations of Dust Aerosol Properties," 2nd International Workshop on Mineral Dust, Paris, France, 12 September 2003

P. Frederickson, K. Davidson, A. Newton, "Evaluating Model Predictions of Low-Level Microwave Propagation over the Ocean," BACIMO Conference, Monterey, CA, September 2003.

.M. Jordan and P. Durkee, "Marine Boundary Layer Cloud-top Altitude Analysis from Satellite Measurements," BACIMO Conference, Monterey, CA, September 2003.

B.S. Martin, T. Murphree, C. Wash, "Meteorology, Oceanography, and Naval Afloat Operations: Risk Management, Safety, and Readiness," BACIMO Conference, Monterey, CA, September 2003.

D. Miller, D. Walters, G. Jumper, "Mesoscale Model Forecasts of Optical Turbulence: Lessons Learned and New Refinements," BACIMO Conference, Monterey, CA, September 2003.

T. Murphree, B.S. Martin, R. Cantu, C. Wash, J. Hinz, "Systems for Analyzing METOC Impacts on Military Operations," BACIMO Conference, Monterey, CA, September 2003.

Profs. T. Murphree and C. Wash expect to start work on a 3-year METOC metrics research project funded by the Office of Naval Research and the Space and Naval Warfare Systems Command. The project focus will be on developing and applying tools for measuring the impacts of METOC phenomena and products on strike operations during the Iraq War, March-April 2003. These tools will also be applied to other recent conflicts in Afghanistan, the Balkans,

and the Gulf war of 1991. Project collaborators include Systems Analysis and Planning, Commander, Fleet Forces Command (CFFC), CNMOC, and the Center for Naval Analysis.

W. Nuss, D. Miller, C. Garhard, "Boundary Layer Mixing Height Forecasting for Ft Ord, California," BACIMO Conference, Monterey, CA, September 2003.

OCEANOGRAPHY

P.C. Chu, 2003: Multifractal Thermal Characteristics of the Southwestern GIN Sea Upper Layer, *Journal of Chaos, Solitons and Fractals*, 19 (2), 275-284.

P.C. Chu, C.W. Fan, 2003: Hydrostatic Correction for Reducing Horizontal Pressure Gradient Errors in Sigma Coordinate Models. *Journal of Geophysical Research*, 108, C6, 3206, doi: 10.1029/2002JC001668, 2003.

P.C. Chu, R.F. Li, C.W. Fan, 2003: Determination of the Current System on Isopycnal Surface between Mindanao and New Guinea from GDEM, *Chinese Journal of Oceanology and Limnology*, 21 (3) 193-213.

P.C. Chu, L.M. Ivanov, L.H. Kantha, T.M. Margolina, O.M. Melnichenko, Y.A. Poberenzhny, 2003: Lagrangian Predictability of High-Resolution Regional Ocean Models, *Nonlinear Processes in Geophysics*, in press.

P.C. Chu, L.M. Ivanov, and T.M. Margolina, 2003: Rotation Method for Reconstructing Process and Field from Imperfect Data, *International Journal of Bifurcation and Chaos*, in press.

P.C. Chu, C.W. Fan, A. D. Evans, A.

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FACULTY NEWS

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Gilles, 2003: Triple Coordinate Transforms for Prediction of Falling Cylinder through the Water Column, *Journal of Applied Mechanics*, in press.

P.C. Chu, South China Sea Thermohaline Structure and Circulation, the 23st General Assembly of the International Union of Geodesy and Geophysics, Sapporo, Japan, 30 June-1 July 2003 (invited).

P.C. Chu, J.L. Sun, and Q.Y. Liu, High baroclinic equatorial Kelvin waves, central Pacific warming and El Nino onset. The 23st General Assembly of the International Union of Geodesy and Geophysics, Sapporo, Japan, 30 June-1 July 2003 (invited).

P.C. Chu, L.M. Ivanov, T.M. Margolina, O. V. Melnichenko, Flow Decomposition for Velocity Data Assimilation, the 23st General Assembly of the International Union of Geodesy and Geophysics, Sapporo, Japan, 30 June-1 July 2003.

P.C. Chu, Uncertainty in Diagnostic Initialization. International Terrain-Following Ocean Models Workshop, PMEL/NOAA, Seattle WA, 4-6 August 2003.

P.C. Chu, L. M. Ivanov, Prediction-Skill Variability in Regional Ocean Models, International Terrain-Following Ocean Models Workshop, PMEL/NOAA, Seattle WA, 4-6 August 2003.

P.C. Chu, C.W. Fan, Hydrostatic Correction for Terrain-Following Ocean Models, International Terrain-Following Ocean Models Workshop, PMEL/NOAA, Seattle WA, 4-6 August 2003.

P.C. Chu, C.W. Fan, Conservative

Schemes for Terrain-Following Ocean Models, Fifth Conference on Coastal Meteorology and Oceanography, American Meteorological Society, Seattle WA, 7-9 August 2003.

P.C. Chu, Y.Q. Qi, and Y.C. Chen, Validation of Wavewatch-III using TOPEX/POSEIDON Data, SPIE 10th International Symposium on Remote Sensing, Barcelona, Spain, 8-12 September 2003.

P.C. Chu, J. Wang, and Y.Q. Qi, South China Sea Surface Elevation Variability Determined using TOPEX/POSEIDON Data, SPIE 10th International Symposium on Remote Sensing, Barcelona, Spain, 8-12 September 2003.

The cover story of *EOS* featured an article co-authored by **Research Professor Steve Ramp** and **Professor Ching Sang Chiu** of the Department of Oceanography. The article, "Program Fosters Advances in Shallow-water Acoustics in Southeastern Asia," covered their work under the Office of Naval Research ASIAEX Program.

P.C. Chu, C.L. Fang, Observed Rossby Waves in the South China Sea from Satellite Altimetry Data, SPIE 10th International Symposium on Remote Sensing, Barcelona, Spain, 8-12 September 2003.

P.C. Chu, L.M. Ivanov, T. Margolina, Seasonal Variability of the Black Sea Chlorophyll Concentration, Ocean Margin Research Conference Sponsored by the European Commission and UNESCO, Paris, France, 15-17 September 2003.

P.C. Chu, C.W. Fan, A. Evans, A. Gilles, Three dimensional Hydrodynamic Model for Falling Cylinder through the Water Column, OCEANS2003, Marine Technology Society, San Diego, CA, 22-26 September 2003.

P.C. Chu, E. Gottshall, M. Perry, Satellite Remote-Sensed Altimetry Data for Improvement of Naval Undersea Capability, OCEANS2003, Marine Technology Society, San Diego, CA, 22-26 September 2003.

L.N. Ly, P. Luong, F. Aikman, III and M. Batteen, Air-Wave-Sea Interaction and Its Application to Ocean Circulation-Wave Coupling, 14th Conference on Atmospheric and Oceanic Fluid Dynamics, AMS Proceedings, San Antonio, TX, 9-13 June 2003, pp.166-169.

L.N. Ly, R.P. Stumpf, T.F. Gross, F. Aikman III, C. Lewis, T. Powell, A Physical-Biological Model Coupling Study of the West Florida Shelf, Terrain-Following Models Users Workshop, Seattle, WA, 4-6 August 2003.

L.N. Ly, A. Benilov, **M. Batteen**, Breaking Wave Parameterization and Its Use in Ocean Circulation-Wave Coupling, Terrain-Following Models Users Workshop, Seattle, WA, 4-6 August 2003.

PHYSICS

J. Blau et. al., "Multi-mode Simulations of a Short-Rayleigh Length FEL," 25th International Free Electron Laser Conference, Tsukuba, Japan, 8-12 September 2003.

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FACULTY NEWS

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J. Blau et. al., "Multi-mode Simulations of a Short-Rayleigh Length FEL," *Nuclear Instruments and Methods in Physics Research A* (submitted).

D. Book, "The Conception, Gestation, and Birth of FCT," Workshop on High-Resolution schemes for Convection-Dominated Flows: 30 Years of Flux-Corrected Transport, University of Dortmund, Germany, 1-2 October 2003.

W.B. Colson, J. Blau, R.L. Armstead, P.P. Crooker, "Single-mode Simulations of a Short-Rayleigh Length FEL," 25th International Free Electron Laser Conference, Tsukuba, Japan, 8-12 September 2003.

W.B. Colson, E. Adint, "Short Wavelength FELs in 2003," 25th International Free Electron Laser Conference, Tsukuba, Japan, 8-12 September 2003.

W.B. Colson, J. Blau, R.L. Armstead, P.P. Crooker, "Single-mode Simulations of a Short-Rayleigh Length FEL," *Nuclear Instruments and Methods in Physics Research A* (submitted).

W.B. Colson, E. Adint, "Short Wavelength FELs in 2003," *Nuclear Instruments and Methods in Physics Research A* (submitted).

S. Davis, "The LINUS UV Imaging Spectrometer," *Proceedings of the SPIE* (in press).

B. Denardo, G. L. Miller, Quasi-Nonradiating Wave Sources in One Dimension," *American Journal of Physics*, Vol. 71, 2003, pp. 778-782.

N.M. Haegel, S. A. Samperi, A. M.

White, "Electric Field and Responsivity Modeling for Far-Infrared Blocked Impurity Band Detectors," *Journal of Applied Physics*, 93, 2003, pp. 1305-1310.

N. M. Haegel, et. al. "Reduction Algorithms for the Multiband Imaging Photometer for SIRTF," *Publications of the Astronomical Society of the Pacific* (PASP) (submitted).

Prof. N. Haegel is a member of the Scientific Advisory Committee of Research Corporation. This is the committee that makes final recommendations on grant funding for RC. She is entering the last year of a six year term.

M. Heinemann, A. Larraza, K. Smith, "Experimental Studies of Applications of Time-Reversal Acoustics to Non-Coherent Underwater Communications," *Journal of the Acoustical Society of America*, Vol. 113(6), 2003, pp. 3111-3116.

Prof. C. Olsen is working on a project where the commercial remote sensing satellite, Quickbird, was tasked by the vendor, Digital Globe, in a unique imagery collection mode for the first time. The satellite was tasked to take four images in sequence as it flew over the Fresno airport area. They had never taken more than two images in sequence, before. The imagery will be used to study the effects of variations in reflectance with angle from various surfaces, and should enable higher accuracy analysis for terrain classification. Imagery has just been received from these collections.

W. R. Schwartz, N. M. Haegel, "Direct Determination of the Mobility-Lifetime Product from the Transient Response of

Extrinsic Germanium Photoconductors," *Journal of Infrared Physics and Technology* (accepted).

K. Smith, A. Larraza, A.A.M. Abrantes, "Examination of Time-Reversal Acoustics in Shallow Water and Applications to Non-Coherent Underwater Communications," *Journal of the Acoustical Society of America*, Vol. 113(6), 2003, pp. 3095-3110.

K. Smith, L.-S Li, B.-C. Lee, H. Kao, "Sediment Interface and Volume Reverberation Modeling with the Parabolic Approximation," *Proceedings of the Third International Conference on Modeling and Experimental Measurements in Acoustics*, Cadiz, Spain, 16-18 June 2003, pp. 277-296.

K. Smith, F.D. Tappert, "Horizontal Refraction and the Uncoupled Azimuth Approximation," *Proceedings of the Sixth International Conference on Theoretical & Computational Acoustics*, Honolulu, Hawaii, 11-15 August 2003. (Invited paper.)

At the recent Classified Advanced Technology Update conference hosted here at NPS in July, **LT Bry Carter**, USN, and his thesis advisor **Capt Ryan Umstattd** presented an invited talk on a portion of LT Carter's thesis work, an experimental study of the vulnerability of the U.S. water treatment and distribution system to attack from a high power microwave weapon. An executive summary of LT Carter's research was then presented in August at the Science & Technology office of the Department of Homeland Security in Washington, DC, at a meeting with a national panel of water treatment and distribution representatives.

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GRADUATE SCHOOL OF OPERATIONAL AND INFORMATION SCIENCES

COMPUTER SCIENCE

C. Eagle, "Strike/Counter-Strike: Reverse Engineering Shiva," Black Hat Federal 2003, Tyson's Corner, VA, 2 October 2003.

INFORMATION SCIENCE

Prof. N.F. Schneidewind is a member of the IEEE-USA Committee on Transportation and Aerospace Technology Policy (CTATP). The objective of the CTATP is to influence the transportation technology policies of the executive and legislative branches of federal and state governments and to assist in the resolution of technical and system problems in Space, Aviation, and Ground transportation. Under the auspices of this committee, he is leading a study to determine whether the IEEE should recommend legislation to establish a National Software Certification Facility to certify the safety and reliability of safety critical software, such as in aerospace and military applications.

N.F. Schneidewind, "Report on Results of Discriminant Analysis Experiment", Proceedings of the 27th Annual NASA Goddard/IEEE Software Engineering Workshop, Greenbelt, MD, 5-6 December 2002, pp. 9-16.

N.F. Schneidewind, Naval Postgraduate School, Case Study: *Requirements Changes as Predictors of Software Reliability*, Six Sigma for Software Development, 23-24 January 2003, San Jose, CA.

Associate Professor John Arquilla of the Department of Defense Analysis has been named an "E-biz 25 visionary" by *Business Week* magazine. Professor Arquilla is among a select group of executives from Dell, Symantec, Apple, Nokia, IBM, Sony, Intel, Google, United and other companies to receive this honor. Professor Arquilla has been influential through his writing, teaching and consultations with military officials. His ideas are changing the face of the defense industry.

N.F. Schneidewind, "The Role of the Revised IEEE Standard Dictionary of Measures of the Software Aspects of Dependability in Software Acquisition," Conference on the Acquisition of Software-Intensive Systems, 28-30 January 2003 Software Engineering Institute, Arlington, VA, <http://www.acq.osd.mil/sis/acqconference.htm>.

Prof. N.F. Schneidewind is the Working Group Chair of the joint effort between the AIAA and the IEEE Reliability Society to revise American National Standards Institute/American Institute of Aeronautics and Astronautics Recom-

Professor Dorothy Denning of the Department of Defense Analysis has been named by *CSO Magazine* as a COS Compass Award Nominee. Dr. Denning is an expert and visionary in the fields of cybercrime, hacktivism, information warfare and security and encryption. She has published more than 120 articles, four books, and was the first president of the International Association for Cryptologic Research.

mitted Practice for Software Reliability.

N.F. Schneidewind, "Strategy for Achieving Software Dependability with the IEEE Standard Dictionary of Measures of the Software Aspects of Dependability," The Fifteenth Annual Software Technology Conference, Salt Lake City, UT, 28 April-1 May, 2003.

N. F. Schneidewind, "Life Cycle Core Knowledge Requirements for Software Reliability Measurement." Reliability Review, *The R & M Engineering Journal*, American Society for Quality, Vol. 23, No. 2, (ISSN 0277-9633), June 2003, pp. 18-29.

N.F. Schneidewind, "NASA Lessons Learned" and Software Reliability," DoD Fuse Engineering Safety Working Group Software Certification Process Meeting, 9-11 September 2003.

OPERATIONS RESEARCH

G.H. Bradley, "Introduction to Extensible Markup Language (XML) with Operations Research Examples," *INFORMS Computing Society Newsletter*, Vol. 24, No. 1, Spring 2003.

S. Buttrey, I. Kobayashi, "On Strength and Correlation in Random Forests," Section on Statistical Computing, Joint Statistical Meetings, San Francisco, CA, 4 August 2003.

Prof. R. Rosenthal was a keynote speaker at the European Institute of Operations Research conference in Istanbul in July. His topic was "Keys to Success in Optimization Modeling." To illustrate one of his recommended keys to success, he based part of his speech on research done with a masters student, **Major Davi Castro** of the

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FACULTY NEWS

The Defense Information Systems Agency has recognized **Associate Professor Robert Koyak** of the Department of Operations Research for his outstanding technical and programmatic support of the Joint Interoperability Test Command (JITC) for the past four years. The technical reports produced by Professor Koyak and the theses under his direction have received "rave reviews from a variety of organizations including the DoD CIO, Joint Staff J6, JFCOM, the Theater High Altitude Area Defense Program Management Office, the Single Integrated Air Picture Systems Engineer and the Missile Defense Agency (MDA)," according to Denis F. Beaugureau, Acting Commander of JITC. A letter of appreciation to RADM David R. Ellison, Superintendent of the Naval Postgraduate School, goes on to say that, "Professor Koyak has not only established himself as an excellent Operations Research (OR) consultant for JITC, but has rapidly become well-respected in the DoD Theater Air and Missile Defense (TAMD) and MDA communities as a technical expert for various TAMD track quality testing algorithms and as a developer of TAMD OR statistical techniques. Published student theses under his mentorship and guidance have led to the OSD Central Test and Evaluation Investment Program providing additional funding to the NPS."

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Brazilian Air Force. Major Davi's thesis, "Optimization Models for Allocation of Air Strike Assets with Persistence," was sponsored by Prof. Rosenthal's research grant from SPAWAR. A current thesis student, **Maj Paul Weaver**, USMC, is working on operational testing and evaluation of Maj. Davi's optimization model.

D. Rudko, D. Schrady, "Logistical Analysis of the Littoral Combat Ship," International Symposium on Military Operational Research, Oxfordshire, UK, 27 August 2003.

D.A. Schrady, "Reading Logistics," *Joint Force Quarterly*, Autumn 2003, pp.114-115.

A. Washburn, "Diffuse Gaussian Multiple-Shot Pattern," *Military Operations Research*, Vol. 8, No. 3, 2003.

A. Washburn, R. Hohzaki, "An Approximation for a Continuous Datum Search Game with Energy Constraint,"

Journal of the Operations Research Society of Japan, Vol. 46, No. 3, 2003, pp.306-318.

SCHOOL OF INTERNATIONAL GRADUATE STUDIES

NATIONAL SECURITY AFFAIRS

J.W. Knopf, "Recasting the Proliferation Optimism-Pessimism Debate," *Security Studies*, Vol. 12, No. 1, Autumn 2002, pp. 41-96.

J.W. Knopf, "Misapplied Lessons? 9/11 and the Iraq Debate," *The Nonproliferation Review*, Vol. 9, No. 3, Fall-Winter 2002, pp. 47-66.

J.W. Knopf, "Misapplied Lessons? 9/11 and the Iraq Debate," International Studies Association Annual Meeting, Portland, OR, 25 February-1 March 2003.

J.W. Knopf, "The Importance of International Learning," *Review of*

International Studies, Nol. 29, No. 2, April 2003, pp. 187-209.

J.W. Knopf, "Deterrence after September 11," Joint Conference of the Central and East European International Studies Association and the International Studies Association, Budapest, Hungary, 26-28 June 2003.

MODELING, VIRTUAL ENVIRONMENTS AND SIMULATION INSTITUTE

Prof. M. Zyda was invited at the request of Virginia Governor Mark R. Warner and Secretary of Education Belle S. Wheelan to assist Virginia in an important review of the research programs within the Virginia public higher education institutions.

Prof M. Zyda has been invited by the National Research Council to serve as a member of the Committee on FORCENet Implementation Strategy. The Naval Studies Board of the National Academies will conduct a study to assist the Department of the Navy in its approach to implementing FORCENet.

The National Academies of Science has released "An Assessment of NASA's Pioneering Revolutionary Technology (PRT) Program."

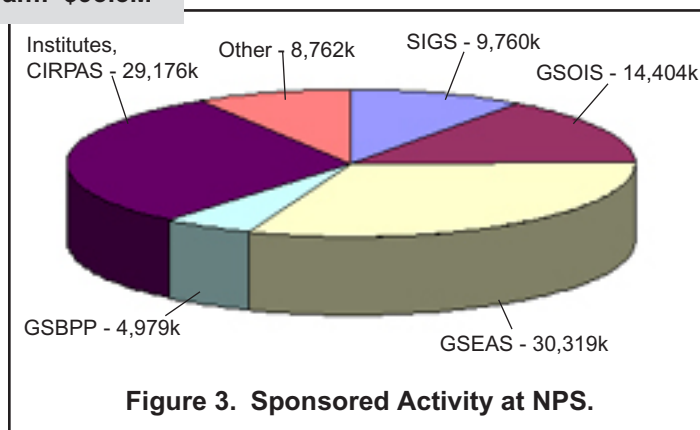
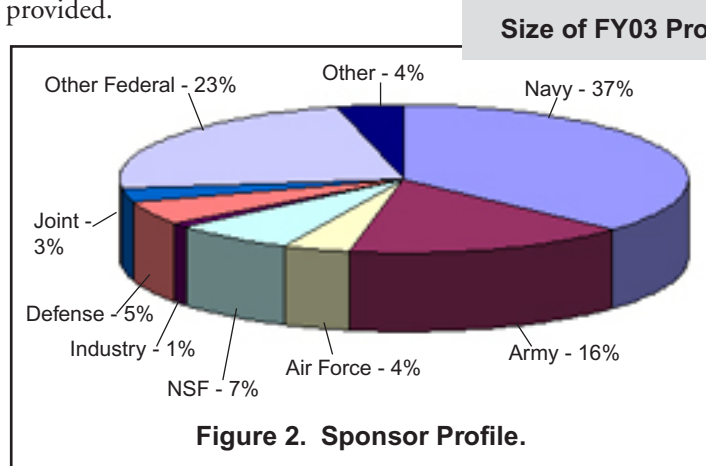
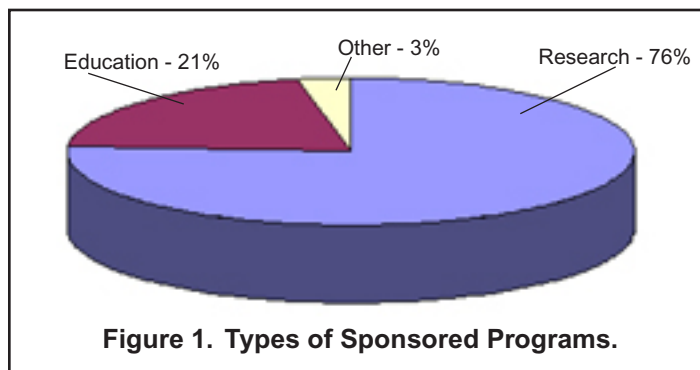
Professor Michael Zyda, Director of MOVES (Modeling, Virtual Environments and Simulation) served as Chair of the Panel on Computing, Information and Communications Technologies, one of three panels working on the assessment of the overall scientific and technical quality of the PRT Program.

SPONSORED PROGRAMS

THE NAVAL POSTGRADUATE SCHOOL'S SPONSORED PROGRAMS ARE A STRONG COMPLEMENT OF GRADUATE EDUCATION

To meet its educational requirements, the Navy developed a unique academic institution at the Naval Postgraduate School (NPS) whose emphasis is on education and research programs that are relevant to the Navy, defense and national and international security interests. Sponsored programs, research, education and service activities, complement the core mission and serve to further meet the requirements of NPS sponsors.

Sponsored activities are conducted in NPS' four graduate schools and research institutes and centers. In 2003, over \$93M in funding was available to support sponsored activities. An overview of the program is provided.



The Graduate School of Business and Public Policy (GSBPP) offers a unique resident defense-focused MBA program plus Masters Degrees in five other DoD-relevant areas. Faculty research is an important component of the school and strives to support military decision making, problem solving, and policy setting, improve administrative processes and organizational effectiveness, contribute knowledge to academic disciplines, and advance the mission of graduate education. The research program is integrated to the greatest possible extent with the educational process. Students are encouraged to participate in faculty projects, and faculty research results are typically incorporated in classroom instruction. Topics and issues can be grouped into five broad functional areas: Acquisition and Contracting, Budgeting and Financial Management, Logistics and Transportation, Manpower Systems Analysis, and Policy Formulation, Analysis, and Management.

The School of International Graduate Studies (SIGS) provides graduate-level education studies and research to U.S. and international students supporting joint and combined objectives. Established in 2001, SIGS mission is to educate the *next* generation of U.S. and international leaders and to equip them with new approaches, new insights, and new problem solving tools that could be immediately applied to their current and/or future jobs in defense/foreign policy areas. Sponsored programs in SIGS represented here are in the Department of National Security Affairs (NSA) and SIGS Centers, Center for Homeland Security and Defense and Center for Contemporary Conflict. Sponsored work is also conducted in the Center for Civil Military Relations which conducts mobile and in-residence courses and long-term national assistance programs that build indigenous capacity within recipient countries, and the Defense Resources Management Institute whose focus is on how best to effectively manage today's limited defense resources.

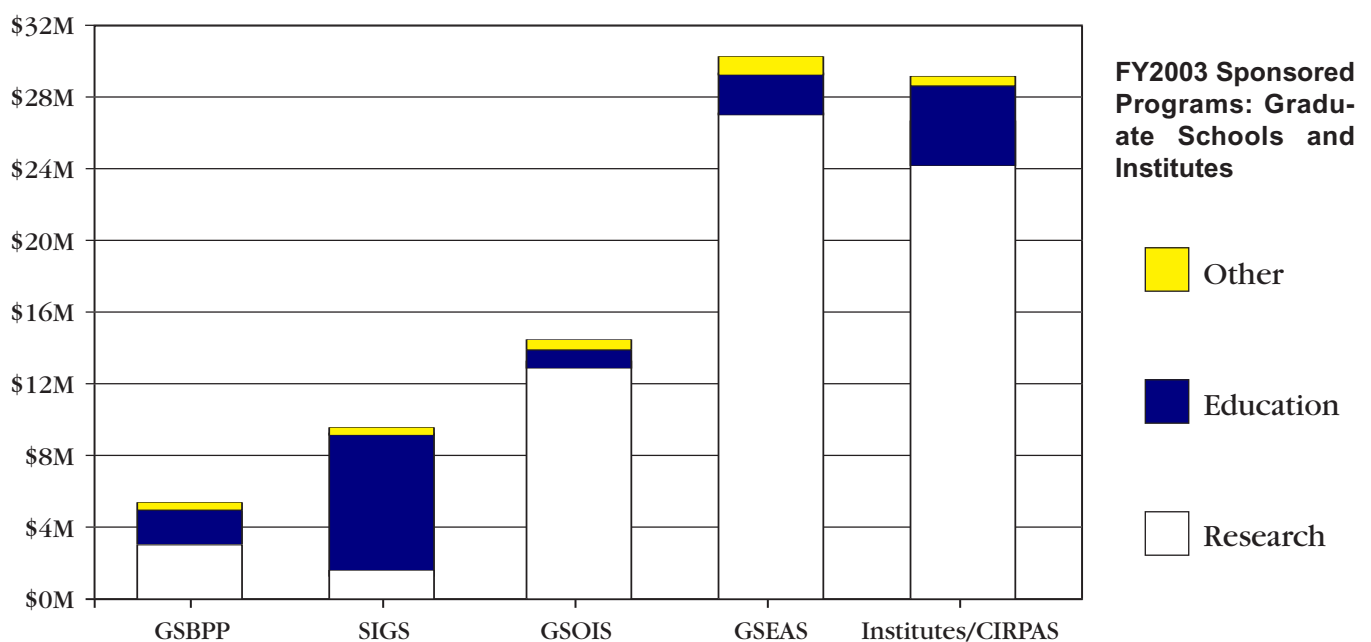
SPONSORED PROGRAMS

SPONSORED PROGRAMS ARE A STRONG COMPLEMENT OF EDUCATION, *continued from page 45*

The Graduate School of Operational and Information Sciences (GSOIS) includes Graduate Resident Programs consisting of 16 technical Curricula and awards Master of Science Degrees and Ph.D. Degrees across four Academic Departments. In response to the needs of naval and military customers, graduate level education and cutting-edge research are focused in four non-traditional knowledge domains: Information Science and Technology, Military Computer Science, Military Operations Analysis and Research, Special Operations and Related Defense Analyses. The emphasis of sponsored activities is on mathematical, scientific, and technical skills to understand the state of the art and foster future improvements in military systems and operations, integration of subject matter contained in classical academic disciplines in militarily relevant ways, and subject matter suited to the corporate university's military customer.

The Graduate School of Engineering and Applied Sciences (GSEAS) provides graduate education leading to the Master of Science, Engineer, Doctor of Philosophy, and Doctor of Engineering degrees. The GSEAS is comprised of seven technical academic departments (Applied Mathematics, Electrical and Computer Engineering, Mechanical and Astronautical Engineering, Meteorology, Physics, Oceanography, Systems Engineering) and one interdisciplinary academic group (Space Systems). These academic entities offer rigorous degree programs tailored to the specific needs of the Navy. At the same time, they provide the technical foundation for interdisciplinary projects undertaken by faculty and students. Research Centers and unique laboratory facilities (Spacecraft Research and Design Lab, Rocket and Combustion Laboratory, Signal Enhancement Laboratory, Ocean Acoustic Observatory, Interactive Digital Environment Analysis (IDEA) Laboratory, Secure Space Systems Research Laboratory, Secure Computer Network Research Laboratory, Directed Energy Lab) provide rigor to the resident academic and sponsored programs.

The three research and education Institutes (Meyer Institute of Systems Engineering, Cebrowski Institute for Information Innovation and Superiority, and the Modeling and Simulation Institute) were established to utilize the knowledge found in the Graduate Schools to provide a focus for interdisciplinary education and research in areas of current and emerging military challenges. The Institutes provide or facilitate degree programs, academic minors, executive education, short courses, workshops, conferences, student interaction with senior Naval leadership, and opportunities for student thesis and faculty research that range from basic to applied and which have significance to the Navy and DoD. The Center for Remotely Piloted Aircraft Studies provides Remotely-Piloted Aircraft (RPA) as well as manned aircraft services to the science, research, test and evaluation communities. CIRPAS conducts payload integration, reviews flight safety and provides logistical planning and support to research and test projects.



RESEARCH DIRECTORIES

NAVAL POSTGRADUATE SCHOOL CHAIR PROFESSORSHIPS

Chair Professorships have been established at the Naval Postgraduate School (NPS) to attract outstanding academicians or practitioners who will contribute significantly to the academic and research programs at NPS. Chair Professors are expected to support NPS curricula and to support Navy/DoD interests.

School of International Graduate Studies

Chair of Strategic Planning
LCDR Greg Gombert, USN
Intelligence Chair
CAPT Steven Ashby, USN
Transportation Security Chair
Dr. James L. Fobes

Graduate School of Operational and Information Sciences

Navy Warfare Development Command Chair for Warfare Innovation
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Chair of Manpower Modeling
Dr. Sam Buttrey
Chair in Applied Systems Analysis
CAPT Starr King, USN
Special Operations Chair
COL Joseph Tyner, USA
Chair of Information Operations
Dr. Ray Buettner
Chair of Cost Analysis
Dr. Robert Koyak
Defense Information Systems Agency Chair Professor in Computer Science
Vacant

Graduate School of Engineering and Applied Sciences

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Navy Tactical Exploitation of National Capabilities (TENCAP) Chair
Dr. Alan Ross
Naval Space Technology Program Chair
RADM Tom Betterton, USN (Ret.)
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Dr. Chirold Epp
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Measurement and Signature Intelligence (MASINT) Chair
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CDR David Kretzman, USN (Ret.)
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Joe Rice
Lockheed Martin Missiles and Space Chair Professorship
Tony Kertesz
NAVSEA Chair of Total Ship Systems Engineering
Charles Calvano
NAVSEA Chair of Total Ship Systems Engineering Chair in Combat Systems
Dr. Robert Harney
Battlespace Environments Chair
Vacant
National Security Agency Cryptologic Research Chair
James Ehlert

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VADM Thomas Hughes, USN (Ret.)
Stanley R. Arthur Chair of Logistics Management
RADM Donald Eaton, USN (Ret.)
Admiral Boorda Chair of Management and Analysis
RADM James B. Hinkle, USN (Ret.)
RADM George F. Wagner Chair in Public Management
Dr. Lawrence Jones
Chair of Acquisition Management
RADM Jim Green, USN (Ret.)

Wayne E. Meyer Institute of Systems Engineering

Chair of Mine Warfare
RADM John Pearson, USN (Ret.)
Chair of Expeditionary Warfare
Dr. Phil Depoy
Chair of Undersea Warfare
VADM Roger F. Bacon, USN (Ret.)

Cebrowski Institute of Information Innovation and Superiority

National Security Agency Cryptologic Innovation Chair
Joanne Kim

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GRADUATE SCHOOLS

School of International Graduate Studies

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- Defense Resource Management Institute
- Center for Civil Military Relations
- Defense Acquisition and Resource Management
- National Security Affairs

Graduate School of Operational and Information Sciences

Senior Lecturer Wayne Hughes, Dean

- Computer Science
- Defense Analysis
- Information Science
- Operations Research

Graduate School of Science and Engineering

Professor James Kay, Dean

- Applied Mathematics
- Electrical and Computer Engineering
- Mechanical and Astronautical Engineering
- Meteorology
- Oceanography
- Physics
- Space Systems
- Systems Engineering

Graduate School of Business and Public Policy

Professor Douglas Brook, Dean

RESEARCH AND EDUCATION INSTITUTES

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Professor Michael Zyda, Director

Cebrowski Institute for Information Innovation and Superiority

Professor Peter Denning, Director

Wayne E. Meyer Institute of Systems Engineering

Distinguished Visiting Professor Phil DePoy, Director

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at NPS can be found at [http://
www.nps.navy.mil/~code09/](http://www.nps.navy.mil/~code09/).**

RESEARCH CENTERS

Aerodynamic Decelerator Systems Center

Associate Professor Isaac Kaminer, NPS Director

Center for Autonomous Underwater Vehicle (AUV) Research

Professor Anthony Healey, Director

Center for Civil Military Relations

Professor Tom Bruneau, Director

Center for Contemporary Conflict

Assistant Professor Peter Lavoy, Director

Center for Defense Technology and Education for the Military Services

Distinguished Professor David W. Netzer, Director

Center for Homeland Security

Associate Professor Paul Stockton, Director

Center for INFOSEC (Information Systems Security) Studies and Research

Associate Professor Cynthia Irvine, Director

Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS)

Research Associate Robert Bluth, Director

Center for Joint Services Electronic Warfare

Professor Phillip Pace, Director

Center for MASINT Research

David Trask, MASINT Chair Professor and Director

Center for Material Sciences

Professor Terry McNelley, Director

Center for Radiation Hardened Electronics

Associate Professor Todd Weatherford, Director

Center for Reconnaissance Research

CDR David Kretzmann, USN (Ret.), Chair Professor and Director

Center for Recruiting Innovation

Professor Mark Eitelberg, Director

Center for the Study of Mobile Devices and Communications

Professor Gurminder Singh, Director

Center for the Study of Potential Outcomes

Professor Ted Lewis, Director

Center on Terrorism and Irregular Warfare

Associate Professors John Arquilla and David Tucker, Co-Directors

Cryptologic Research Center

Professor Herschel Loomis, Acting Director

Software Engineering Center

Professor Luqi, Director

Software Metrics Center

Professor Norman Schneidewind, Director

Spacecraft Research and Design Center

Distinguished Professor Brij Agrawal, Director

Turbo-Propulsion Laboratory

Professor Ray Shreeve, Director

Undersea Warfare Center

VADM Roger F. Bacon, USN (Ret.)