NAVAL POSTGRADUATE SCHOOL

RESEARCH

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MODELING AND PREDICTION OF THE GLOBAL OCEAN AND ARCTIC SEA ICE

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Introduction

Environmental prediction models are important to Naval operations. The faculty members above have worked as a team over the last five years to develop and use basin and global models of ocean and sea ice; however, the focus until recently was on reproducing past decades of ocean-ice behavior driven by observed atmospheric conditions. Results from these models have been analyzed to understand the physics of the ocean and ice as well as to find and correct model deficiencies. Comparisons with vast amount of in-situ ocean and satellite data have been performed in the process. This research contributes to the design of global systems that will predict seasonal to decadal variations in climate. Our previous research along these lines has been supported by the Department of Energy (DOE), National Science Foundation (NSF), National Aeronautics and Space Administration (NASA), and the National Oceanic and Atmospheric Administration (NOAA).

Now, the Office of Naval Research (ONR) is expressing strong interest in using our models as the basis for operational Naval prediction systems on much shorter time scales. We have relatively complete models in terms of hydrodynamics and physical processes, resulting from our prior efforts and from collaborations with two large civilian laboratories: the National Center for Atmospheric Research (NCAR) and Los Alamos National Laboratory (LANL). Our models have also been designed to be very efficient and scalable on high-end computers, including the evolving family of clustered microprocessors that will be at the heart of U.S. prediction centers like Fleet Numerical Meteorology and Oceanography Center (FNMOC) in Monterey. Thus, the models have the promise of providing accurate forecasts in a timely fashion for military operations. In this short article, the earlier development of the models in a climate context is summarized and followed by descriptions of newly funded ONR projects to tailor and evaluate the models for operational global atmosphere-ocean forecasting and Arctic ice-ocean prediction.

Prior Research

Most major ocean currents have quite small widths of a few tenths of a degree of

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FEATURED PROJECT

GLOBAL OCEAN AND ARCTIC SEA ICE, *continued from page 1*

latitude or longitude, and numerical models must have grid spacings of about 1/10 degree (10 km) to fully represent these currents and sharp gradients in temperature, salinity, and sound velocity across them. Other features such as eddies and coastal upwelling zones have the same space scales; therefore, most aspects of ocean prediction, whether in the mid-ocean or in coastal zones, need very fine grid spacing. Also, strong currents as well as coastal and planetary ocean waves have basin-wide to global extents and influences, necessitating global coverage. The time for ocean phenomena to develop and propagate ranges from weeks to decades, so predictive models must be spun up for years with archived atmospheric data and initialized in detail by assimilating the sparse ocean data of prior months.

Because of the above considerations, ocean prediction models require high-end computing resources. Specifically, a global ocean model with 1/10-degree horizontal grid and 40 vertical levels would take a month of FNMOC's entire 16-processor CRAY C-90 to simulate a year of ocean time. The problem would also exceed the C90's memory size many times over. As a result, most studies to date have been conducted with somewhat coarser grids on machines that are set aside for large research efforts. The NPS Ocean Modeling

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About the INVESTIGATORS

Albert J. Semtner

Albert J. Semtner is a Professor in the Department of Oceanography. He received his B.S. from the California Institute of Technology and M.A. from the University of California at Los Angeles. While serving in the NOAA Commissioned Corps, he completed his Ph.D. in geophysical fluid dynamics at Princeton. Before joining NPS in 1986, he worked with the National Center for Atmospheric Research (NCAR) where he still maintains an affiliation.

Professor Semtner's teaching interests include numerical methods of ocean/atmosphere modeling and ocean and sea-ice dynamics. His research interests are in the development of global ocean models, data comparisons, and predictability studies.

Professor Semtner was elected a Fellow of the American Meteorological Society in 1995. He has won numerous awards, including the Smithsonian Leadership Award in Breakthrough Computational Science, and the Cray Research Inc. Gigaflop Performance Award.

Julie McClean is a Research Assistant Professor in the Department of Oceanography. She received her B.S. from Monash University, Australia, and her M.S. from Sydney University. Her Ph.D. in physical oceanography was granted from Old Dominion University where she was also recognized as the Phi Kappa Phi Outstanding Oceanography Ph.D. student. Dr. McClean joined NPS in 1993 as a post-doctoral associate and was later promoted to Research Assistant Professor.

Professor McClean's teaching interests include descriptive physical oceanography and tropical oceanography. Her research interests are in the areas of global ocean modeling, ocean circulation, water masses, property fluxes, satellite altimetry, and intraseasonal to decadal variability. Among other external service activities, she is on the American Geophysical Union Western Pacific Geophysics Meeting 2000 Program Committee.

Julie McClean

Wieslaw Maslowski is a Research Assistant Professor in the Department of Oceanography. He received his M.S. from the University of Gdansk, Poland, and his Ph.D. in Physical Oceanography from the University of Alaska-Fairbanks where he was recognized as the Marine Sciences and Limnology Outstanding Ph.D. student. Dr. Maslowski joined NPS

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FEATURED PROJECT

GLOBAL OCEAN AND ARCTIC SEA ICE, *continued from page 2*

Group has exploited a variety of machines at LANL, NCAR, and the Arctic Region Supercomputing Center to conduct global or Arctic calculations with grids of 1/3- and 1/6-degree. In high latitudes, a dynamic sea-ice model is included at the same grid size as the ocean model. Simulations are sometimes done in collaboration with LANL or NCAR scientists, who provide additional expertise in parallel computing and treatments of sub-gridscale processes. In particular, we have adopted LANL's free-surface ocean formulation, which speeds up the model four-fold and allows better representation of littoral circulations than was possible with earlier global and Arctic models used by the Navy.

The simulations have been carried out using surface boundary conditions from the archived 1979-98 meteorological analyses of the European Center for Medium-range Weather Forecasts (ECMWF). Among weather centers worldwide, ECMWF has the highest model resolution and the most consistent analysis scheme for the last two decades; thus, ECMWF fields are ideal to drive the ocean and ice models. Results of simulations have been compared with observations from a variety of sources, including satellite altimeters and radiometers, temperature and salinity profilers, ocean and ice drifters, and tide gauges. Figure 1 shows Pacific tide-gauge

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About the INVESTIGATORS, *continued from page 2*

Wieslaw Maslowski

in 1994 as a NOAA Climate Change Postdoctoral Fellow and was appointed to his current position in 1995. Prior to joining NPS, he had won a NASA Global Change Fellowship at the University of Alaska.

Professor Maslowski's teaching interests include descriptive physical oceanography, polar oceanography, dynamical oceanography, and numerical modeling. His research interests focus on arctic oceanography, numerical ocean and sea ice modeling, ocean general circulation, and climate change.

Robin Tokmakian

Robin Tokmakian is a Research Assistant Professor in the Department of Oceanography. She received her B.A. from the University of California at Santa Barbara and her M.S. from Oregon State University. Her work experience includes positions at Science Applications, Inc., Martin Marietta Aerospace Inc., Oregon State University, and the Institute of Oceanography Sciences in the United Kingdom. She joined NPS in 1993 as an Oceanographer, received her Ph.D. in Physical Oceanography, and was promoted to Research Assistant Professor.

Her external service includes activities with the International SCOR Working Group on Ocean Bathymetry, the JASON/Topex/Poseidon Extended Mission Science Working Team and the Surface Salinity Integrated Working Group.

Yuxia Zhang

Yuxia Zhang is a Research Assistant Professor in the Department of Oceanography. She received her M.S. from the University of Hawaii and her Ph.D. in Meteorology from Texas A&M University. She joined NPS in 1994 as a NOAA Global Change Postdoctoral Fellow. Prior to coming to NPS, she served as a Postdoctoral Research Scientist at Rice University.

Her research interests include numerical modeling of sea ice and ocean circulations, air-ocean-ice interaction, and climate change.

FEATURED LAB

THE ADVANCED NETWORKING LABORATORY

Assistant Professor John McEachen
Professor Murali Tummala
LCDR Robert Parker, USN
LT Joe Prisella, USN
LT Dave DeMille, USN
LT Doug Powers, USN
Department of Electrical and Computer Engineering

The Advanced Networking Lab was established in 1994 to investigate performance issues associated with high-speed computer communications used in Naval communications systems. The lab is primarily sponsored by the Naval Information Warfare Analysis Center (NIWAC) of the Naval Information Warfare Activity (NIWA) and, consequently, places a high emphasis on vulnerability assessment using performance metrics of computer networks in secure environments. Professor Murali Tummala and Assistant Professor John McEachen of the Department of Electrical and Computer Engineering are co-directors of the lab. The lab supports several research areas in networking and multimedia for both Master's and Doctoral studies. It currently hosts one Ph.D. student and twelve Masters students from three curricula as well as many other students who need hands-on access to advanced networking and multimedia equipment.

The lab is designed to allow easy access to many different cutting-edge technologies and manages two full class C address spaces. The ability to access so many different types of technology integrated into a unique environment gives students a rare look into a future full of ubiquitous global networks serving bandwidth-hungry multimedia applications.

The functionality of the computing hardware contributes directly to the effectiveness of the lab. One of the laboratory's sponsored projects is in IT-21 vulnerability assessment. The IT-21 concept centers on Windows NT workstations connected by high-speed Asynchronous Transfer Mode (ATM)

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About the DIRECTORS

Murali Tummala is a Professor in the Department of Electrical and Computer Engineering and is currently serving as the Associate Chair for Research for the department. Dr. Tummala received his B.S. from the Institution of Engineers, Calcutta, India, and his Masters and Ph.D. in Electrical Engineering from the Indian Institute of Technology, Bombay, India. Before joining the faculty of NPS, Dr. Tummala was a National Research Council Resident Research Associate at NPS. He also worked as a Project Engineer at the Advanced Center for Research in Electronics and the Indian Institute of Technology.

Dr. Tummala currently teaches courses and conducts research in the areas of signal processing, networking, and communications. His was the recipient of the Admiral John J. Scheiffelin Award for Excellence in Teaching at NPS. He is a senior member of the IEEE and a member of Sigma Xi and Eta Kappa Nu.

Murali Tummala

John McEachen is an Assistant Professor in the Department of Electrical and Computer Engineering. He received two M.S. degrees, one from Yale University and the other from the University of Virginia. He received his Ph.D. degree from Yale University. Prior to joining NPS, Dr. McEachen served as a Cryptologic Officer in the U.S. Navy, a consultant for information processing and networking, and a post-doctoral fellow at Yale.

John McEachen

Dr. McEachen's teaching interests include computer networks, communications systems, image and video processing, signals intelligence, and information warfare. His research interests include video bitstream modeling and analysis in asynchronous transfer mode (ATM) environments, image sequence analysis using geometric models and adaptive estimation techniques, and ATM traffic modeling, monitoring and understanding. He is a member of the IEEE and Eta Kappa Nu.

THE ADVANCED NETWORKING LABORATORY, *continued from page 4*

network links. (Fast Ethernet will be used for legacy LAN connections until ATM can be efficiently delivered to the desktop). The Navy's leadership has embraced the IT-21 concept in an effort to standardize afloat and ashore organizations and to minimize cost through purchase of COTS PC equipment. Consequently, the laboratory boasts a fully compliant IT-21 configuration for flexible experimentation and analysis. Currently, there are two Pentium Pro 200 machines running Windows NT Server™ 4.0, two PII-266s, two PII-450s and a Pentium 200 running Windows NT Workstation™ 4.0. This hardware is connected through the ATM and Ethernet networking equipment conveniently collocated in the lab's 8-foot equipment rack.

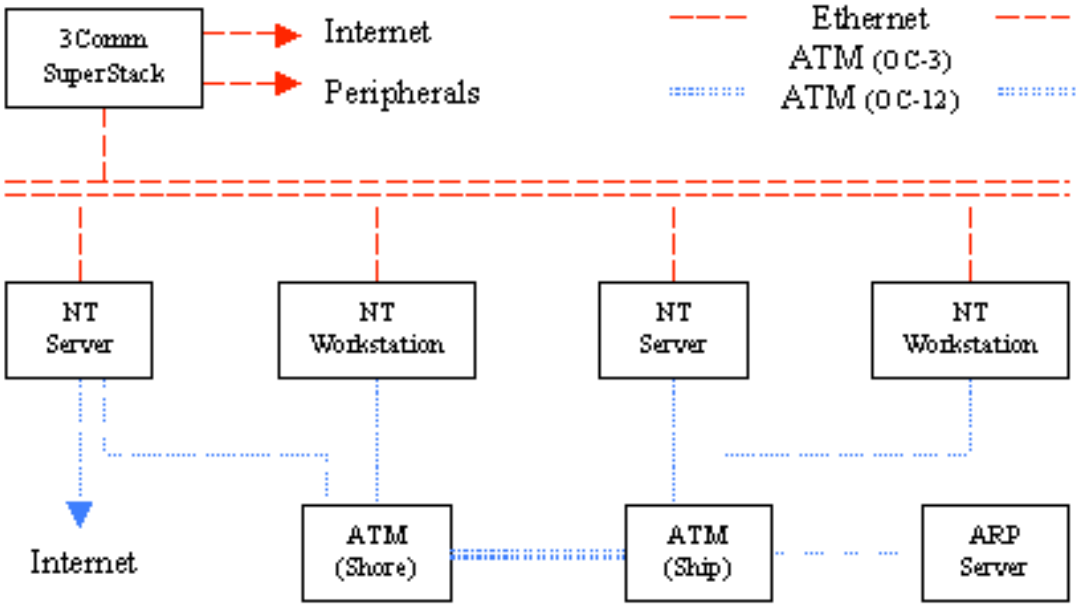

Figure 1. Core ATM and Ethernet Networking Connections

The lab provides fully functional Ethernet (10, 100 and 1000 Mbps) connectivity between workstations using one of the available class C addresses. Each workstation in the lab incorporates either a 3Com Etherlink III or other Novell 2000 compliant NIC for 10/100BaseT connectivity. The heart of the Ethernet network is a 3Com SuperStack II Switch 3000 LAN Emulation Client Edge Device. The SuperStack II accesses the campus-wide ATM backbone through an installed OC-3 module utilizing one of six available multi-mode fiber pairs, leaving five pairs available for future expansion. The switch also facilitates Gigabit Ethernet (1000BaseSX) links. Also available is a FORE POWERHUB 6000 edge device.

The lab also provides a range of network analysis and testing tools. Robust ATM simulation and monitoring capabilities are provided by an ADTECH AX-4000 with two OC-3 (155 Mbps) Generator/Analyzer Modules and a PC interface via a National Instruments general purpose interface bus (GPIB) circuit card. This system allows students to uniquely specify traffic inserted into the network, then analyze how the network responds by examining received packets and recording performance metrics such as throughput, delay and interarrival time. Ethernet analysis is accomplished through the NetBoy suite of software analysis tools. MIL-3's OPNET software is installed on Windows NT™ and Unix workstations for network simulation and modeling.

An ADTECH SX/14 Data Channel Simulator is available for hardware modeling of a variety of networking environments. The data channel simulator is capable of inserting variable propagation delays and bit-error characteristics into a given link, thus allowing students the ability to simulate everything from satellite links to sub-oceanic cables.

Transitioning from legacy Ethernet to the emerging standard of "ATM to the desktop" has provided exciting and robust research topics. As of this writing, one of the Masters students, LT Joe Prisella, USN, has successfully established two LANE networks by splitting one of the labs class C address spaces into an upper (ship) and lower (shore) subnet. The Emulated LANs (ELANS) are configured to model a ship-to-shore ATM Intranet. Each workstation utilizes a single FORE PCA200E (PCI) ATM NIC capable of OC-3 data transfer. These workstations are connected via multi-mode fiber to one of two FORERUNNER ASX-200BX switches providing connectivity between the ship and shore ELANS. The ASX-200s are connected via an OC-12 (622 Mbps) link, which simulates landline connection during an inport period. The ADTECH SX/

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INFORMATION WARFARE AND INFORMATION OPERATIONS (IW/IO)

The Information Warfare (IW) Curriculum leads to the Master of Science in Systems Engineering. This curriculum provides the services with officers knowledgeable in the technical and operational aspects of the roles of information warfare/information operations (IW/IO) as a vital, integral part of modern warfare and is sponsored by the Joint Staff (J39) and the Commander, Naval Security Group. It is designed to provide an interdisciplinary understanding of the principles and technologies underlying the broad fields of Information Warfare. Completion of this curriculum qualifies an officer as an Information Warfare Subspecialist. Typical assignments in this subspecialty include Fleet and Group Staffs, Systems Commands, the Navy Information Warfare Activity, Fleet and other service Information Warfare Centers, Joint and CINC Staffs, Joint Warfare Analysis Center (JWAC), and the Joint Command and Control Warfare Center (JC2WC).

The IW curriculum is interdisciplinary, covering mathematics, physics, computer science, operations analysis, electrical and computer engineering, information systems, and national security affairs. Graduates develop an in-depth understanding of IW and the related disciplines with an understanding of the capabilities, limitations, design, and operations of communications, computers and information networks. They obtain a systems level understanding of information systems and their vulnerabilities as well as capabilities; an understanding of the organizational decision process, as well as the structure and other processes of organizations with an emphasis on their vulnerabilities and capabilities; an understanding of the concepts, principles, methods and capabilities of joint operational intelligence with emphasis on the operational requirements levied upon the intelligence community to support IW; an understanding of the integration of IW as a weapon with application to modern warfare in the integral roles of electronic attack/support/protection, computer network exploitation, attack and defense, psychological operations, military deception, and physical destruction and nodal attack. This includes the study of signal generation, transmission, propagation, reception, processing, as well as suppression of detection and surveillance information; and the ability to conduct independent analysis in IW.

Research at the Naval Postgraduate School is an integral part of the student's graduate education. It provides students with challenges for creative problem solving experiences on DoD relevant issues. It also solves real-time warfare problems. Research is closely integrated with the Information Warfare Curriculum. Faculty and students are actively engaged in a variety of research projects.

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INFORMATION OPERATIONS MODELING AND SIMULATION (IO M&S)

NPS has applied SAIC's SIAM Influence Net Modeling Tool to real-world planning and exercises such as EVIDENT SURPRISE, and developed innovative IO options to address the emergent requirement for Information Operations modeling and simulation. IO M & S has been a top three recommendation from ACOM's EVIDENT SURPRISE IW/IO exercise for the past three years. An influence net model of a targeted country has been constructed with the assistance of SAIC and the ACOM J5, developmental IO options integrated, and the interaction and effects on leadership demonstrated. The result is a first-look simulation of how leadership can be influenced by IO in real-world contingencies. Refinement of intelligence via INTELINK and open sources including the INTERNET is ongoing. NPS student and faculty researchers have demonstrated the results of this analysis to SECNAV, CINCUSACOM, CINCUSNAVEUR, DIRNSA, GEN J.J. Sheehan, USMC, and other high-level decisionmakers to show SIAM's value as an IO influence modeling and decision aid, and modeling and simulation research tool.

INFORMATION WARFARE AND INFORMATION OPERATIONS, *continued from page 6*

Computer and Network Security, Assurance, and Survivability

Today NPS is recognized internationally and stands at the forefront of research and education in Information Assurance and Systems Survivability. The rapid evolution of networking within DoD and DoN has lead to the connection of most computer systems to LANs and the use of WANs for data transport. Architectural issues include system robustness and security: availability for critical operations despite faults and protection from malicious adversaries. Security concerns have lagged efforts at interconnection and now leave systems vulnerable to exploitation. Survivable system architectures are needed for DoD and DoN. Security for systems that must process both classified and unclassified information is an underlying theme of the diverse NPS Center for INFOSEC Studies and Research (CISR) under the leadership of Assistant Professor Cynthia Irvine, (See *NPS RESEARCH, Vol. 8, No. 2*).

Research has included the following information assurance and computer and network security topics: protocols and mechanisms for secure, high speed networking; middleware security services for heterogeneous networked environments; issues associated with security and quality of service; examination of signature identification mechanisms for malicious software, such as viruses; network intrusion detection and response; high assurance techniques for the creation of execution domains; utilization of existing high assurance multilevel products in near-term architectures to achieve robust, operational multilevel secure network solutions; analysis of products which could be used to enhance the protection of sensitive but unclassified information; and the development of DoD-relevant strategies for the analysis of software security products.

A problem for DoD systems includes not only the provision of control of access to and movement of data based on fixed sensitivity levels, but the preservation of compatibility with commercial-off-the-shelf (COTS) application software as well. NPS CISR faculty, staff, and students are constructing a COTS-driven Local Area Network that will provide high assurance multilevel secure (MLS) services to users while permitting them to employ standard office productivity tools on standard workstations executing COTS operating systems. The ongoing development centers on the provision of multilevel mail and messaging to the desktop.

Increasingly, high-speed mechanisms, such as ATM, are being used in DoN networks and techniques to move IP traffic over ATM networks are being explored. Unfortunately, current proposed standards for the transport of IP packets over ATM networks are silent regarding packet security. Computer science faculty and students are examining techniques to provide security for IP traffic in ATM networks. Two areas are being investigated: the design of a network access controller to support IP over ATM seamlessly while preventing the flow of unauthorized information from a secure enclave; and investigation of a security protocol and mechanism for fast IP packet forwarding at the data link layer.

Participating in a project that has as a goal quality of service for end-to-end applications in a highly dynamic environment, NPS CISR faculty, staff, and students are examining techniques to provide security for core services as well as for applications. A layered application architecture has been developed that builds upon notions of least privilege and separation of duty. A second aspect of this work is to treat processing for security as a factor in overall quality of service delivered by the system. This work will help to parameterize security choices.

Lecturer Daniel Warren has worked with IW students to investigate the characteristics of viruses, which continue to be a threat to DoN systems. Their work has been presented at the national level.

DoD has recognized the need for a public key infrastructure (PKI) to support the use of public key cryptography to protect vital information while in transit across networks. Members of the faculty are working with students from several curricula to develop PKI solutions for the services. In one project, under the supervision of Visiting Associate Professor Bret Michael, IW student LT A.P. Hansen, USN, is conducting research on DoN PKI concerns.

NSA Cryptologic Chair Professor Supports IW Curriculum and Research

Vicente C. Garcia, has served as the National Security Agency (NSA) Visiting Chair for Cryptology at NPS since 1994. His duties are to assist NPS on all matters of NSA's mission, enhance support on Cryptologic research and provide a Signals Intelligence (SIGINT) option for the Electrical and Computer Engineering master's degree candidates. In support of the IW curriculum, he developed and teaches two courses, SIGINT Systems I and Information Operations (IO) Systems, which are both mandatory for students majoring in

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INFORMATION WARFARE AND INFORMATION OPERATIONS, *continued from page 7*

IW Systems Engineering.

Professor Garcia sponsors training for NPS students who wish to become authorized Microsoft Certified Systems Engineers (MCSE). This training and certification gives NPS students the tools they need to fully understand Microsoft Windows technologies to include TCP/IP, Windows NT 4.0, and Windows Core Technologies. LT Jonathan Bartel, USN, is the first NPS student to achieve MCSE designation, but several other students are close to getting their certification as well.

Professor Garcia also mentors his students in conducting leading edge IW/IO research dealing with computer and network attack, IO modeling and simulation, directed energy warfare, electronic warfare, and defensive IO/Information Assurance, actively utilizing two recently established NPS research laboratories: the Cryptologic Research Lab and the Computer Network Research Lab.

Cryptologic Research Lab

The Cryptologic Research Lab (CRL) was established at NPS in late 1998 as a resource to develop advances in automated intelligence activities in response to the fast-changing electronic environment in which the U.S. Department of Defense and other government organizations must operate. The CRL is a joint venture between the National Security Agency's Advanced Technology Department and NPS. Professor Garcia acts on behalf of the NSA as the sponsor for the CRL. Professor Tri Ha, Department of Electrical and Computer Engineering, serves as the faculty Technical Director overseeing student research projects. LT Glenn Barker, USN, serves as the Student Technical Director, advising other students and maintaining the laboratory. LCDR Dan Pettit, USNR, provides part-time systems engineering and administration support. The CRL operates as an unclassified lab with the initial primary mission of testing and evaluating software for NSA. The lab will shortly have a network consisting of SUN ULTRA 10 workstations and Pentium II Personal Computers on a fiber optic LAN with UNIX and Windows NT 4.0 servers. Included are printers, a scanner, backup and storage hardware, and assorted software, as well as signal and noise generators and other test equipment for simulation and analysis of live signals. The driving force behind the creation of the CRL is NSA's Project BLEEPER. The goal of Project BLEEPER is to build a software prototype that will achieve non-directed (general) RF search, signal detection and modulation recognition independent of the RF and collection platform. The lab will have all necessary software in order to perform those evaluations and NSA will provide the needed program software for various other projects that they will sponsor. Other evaluation software that will be needed as the capabilities expand will be acquired and installed when and where necessary. As the lab's mission and funding evolve, the research and evaluation conducted will expand in scope. The lab's planned computing power will make it an ideal test-bed for evaluating algorithms in several identification scenarios. Classification of RF emissions, primarily COM-type signals will be the main focus. But, research can be expected to also include identification of emitters from both radar and cellular technology, unclassified cyclostationary work, spread spectrum and jamming techniques. Since the lab is not restricted by security related issues, regular use by the general Electrical Engineering, Cryptology, and Information Warfare students and faculty is expected for research/thesis work on communications related problems.

Computer Network Research Lab

The Computer Network Research Lab (CNRL) is a classified laboratory located in the Secure Compartmented Information Facility (SCIF) at NPS and is jointly sponsored by NSA's Systems and Network Research Center and by the DoD Information Operations Technology Center. The CNRL Technical Director is Research Associate Professor Ray Bernstein, Department of Electrical and Computer Engineering, supported by students LT Wayne Slocum, USN, LT Ray Tortorelli, USN, and LT Jonathan Bartel, USN. LCDR Dan Pettit, USNR, also serves as the part-time systems engineer and administrator for this lab. The CNRL, established in late 1997, is a valuable asset to the study of IW at NPS and provides a viable and robust research platform for NPS students. The lab's primary mission is to provide an open environment where students already adept in computer skills may experiment with various computer network intrusion and counter-intrusion techniques, which could be used by hostiles, with no fear of damage to outside systems. The CNRL is also an educational platform and a place to work for students who want to familiarize themselves with security issues and for students who wish to become more proficient in their computer skills. Students working on IW computer-related topics can investigate network vulnerabilities such as operating systems, software applications, hardware interfaces, protocols, public key encryption, packet filtering,

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INFORMATION WARFARE AND INFORMATION OPERATIONS, *continued from page 8*

firewalls, electronic mail and mail gateways. The first phase of the lab included three desktop Personal Computers running Windows NT Server and Workstation software and two UltraSPARC workstations running Solaris 2.6 software connected by two eight port hubs. With this relatively small system setup, a wide variety of computer security issues can be addressed and multiple intrusion techniques can be demonstrated. The Ultra stations allow for exploration into UNIX operating systems and outgrowths, as well as exploit the massive collection of UNIX hacks developed over the years. The Windows NT operating system can also be critically examined, which is especially important given its growing popularity and the move of the Navy to switch to this operating system. The second phase, just recently implemented, included the addition of several CISCO routers and additional PCs that greatly expanded the capabilities of the lab. Now firewall issues as well as packet filtering and routing can be studied. These are areas of particular interest, since they are especially vulnerable to sophisticated attacks. The most attractive capability allowed by the introduction of the router is real-time offensive and defensive operations. Teams can face off in a series of confrontations where one section actively attempts to penetrate the defenses of another team. These investigations of network vulnerabilities are of tremendous importance to the Navy, DoD organizations, and the nation as a whole. This computer lab is a research tool which helps students formulate workable solutions to ensure network integrity and keep our systems safe from IW/IO attacks.

IW Direct Influence Weapons

New 'psychic' weapons might be used in the future to confuse or incapacitate individuals by introducing "undetected" signals directly into the human body. These weapons could alter the psyche, or attack the various sensory and data processing systems directly, and possibly using cyberspace means. In both cases, the goal is to create a non-equilibrium condition by implanting new signals that prevail over the body's normal equilibrium signals. Potential psychic weapons include direct electronic signals, RF electronic signals, RF electromagnetic signals, photonic input through the eyes and acoustic signals through the ears.

Maj Robert Peterman's, USMC, master's thesis is a foundation for a new area of research at the Naval Postgraduate School in the Human Computer Interface (HCI). Specifically this research explores the potential for exploiting HCI by altering electroencephalograms (EEGs) via photic driving (PD) or photonic input. By using PD, he attempts to alter the brain's functions and elicit a general change in cognitive functioning. To measure the effect of changing the overall EEG of the brain through PD, the experimental procedure measured the changes in performance and alertness. This requires a knowledge base including a thorough study of neocortical cells, EEG physiology, unfiltered wide band EEG spectral analysis, and computerized EEG analysis.

This thesis explores the possible presentation of the computer code through remote computer network insertion. The most obvious method of interfacing with a subject at a computer is to attempt to influence them through video monitor emanations. Due to previous research results in photo-stimulation, Peterman chose to attempt modification of the subjects' EEG through the CRT emanations. The application of a stroboscopic light within a certain frequency range may cause a subject's brain waves to follow or become entrained to the same frequency as the flashing light. This phenomenon is known as photic driving. The objective of this study is to determine if computer monitors can be used as the presentation medium for photic driving, and to investigate whether any measurable cognitive changes can be caused through this photic driving.

In the software design, two Java applets were written which caused the flashing of the screen in both a regular, set frequency and at a random frequency. A webpage was developed as a container for a subset of the Kit of Factor-Referenced Cognitive Tests. An empirical study was performed utilizing a light/sound machine, the Java applets as well as the cognitive tests. Twenty-five subjects were divided into three sample groups and their performance during all phases of the study were recorded and analyzed. Analyses of the results indicate that no direct correlation between photic driving and test score can be proved. Subjects' comments following their participation indicate however that there were some significant effects caused by the photic driving that were not reflected in the test scores. Objective and subjective reports indicate that treatment with light sound machine produced more observable expressions of tenseness and discomfort during the relaxation period, for example.

Direction Finding Antennas

The detection and identification of signals is crucial to the operation of radar and electronic warfare systems. Direction finding (DF) systems are used to detect signals and determine

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SUCCESSFUL PARTICIPATION IN FLEET BATTLE EXPERIMENT ECHO

Research Assistant Professor Alex Callahan, Institute for Joint Warfare Analysis
Research Associate Professor Shelley Gallup, Institute for Joint Warfare Analysis
Associate Professor Bill Kemple, Command, Control and Communications Academic Group
Michael G. Sovereign, Rolands and Associates
LT Michelle Glenn, USN
CDR Ray Holt, USN
Capt Steve Paxton, USAF
Capt Jeff Riley, USMC
Capt Sean Robinson, USAF
Capt Russ Smith, USAF

The Fleet Battle Experiments (FBE) are a CNO-initiated series of operational experiments which examine emerging systems, technologies and concepts. The Maritime Battle Center (MBC) of the Navy Warfare Development Command (NWDC) is the CNO's agent for planning and implementing these experiments in conjunction with the numbered Fleets. FBE-Echo was the fifth in the series and was conducted under the operational sponsorship of Commander Third Fleet (COMTHIRDFLT) in San Diego. The Institute for Joint Warfare Analysis (IJWA) at the Naval Postgraduate School (NPS) observed and conducted the data capture for FBE-Echo during March and April 1999. The modeling and analysis of the experiment will continue for several weeks.

FBE-Echo drew upon experience from four preceding experiments, and most directly from the previous COMTHIRDLT experiments, FBEs Alpha and Bravo. In particular there were follow-ons to the Ring of Fire, Network Centric Land Attack and Theatre Aircraft and Missile Defense (TAMD) from Alpha and the targeting process from Fleet Battle Experiment Bravo. As with FBE Alpha, Echo occurred in conjunction with Marine Corps (USMC) Advanced Warfighting Experiment (AWE). FBE-Echo was conducted in conjunction with the USMC Urban Warrior exercise for Phase 1 in Northern California and with the Extended Littoral Battlespace (ELB) Advanced Concept Technical Demonstration (ACTD) called Littoral Lightning during Phase 2 in Southern California. Limited Objective Experiments (LOE) continued in Phase 2 and 3. Phase 3 was done in conjunction with Kernel Blitz Prime joint amphibious exercise at Camp Pendleton.

The NPS assessment focus on Phase 1 (10-25 March) and to a lesser extent on Phase 2 (10-16 April), was command and control issues, followed by the surface action live fire events in Phase 3 (19-30 April). FBE-Echo highlighted new operational concepts and capabilities for dealing with asymmetric threats in urban environments, network-centric undersea warfare, fusion and reach back for information support of targeting and dynamic weapon-target pairing.

Experiment Concepts and Approach

NPS has performed assessments for several Joint Warrior Interoperability Demonstrations (JWIDs) and routinely for the ONR Adaptive Architecture for Command and Control (A2C2) laboratory experiments. NPS personnel were also involved in the All-Service Combat Identification Evaluation Team field tests in 1995 and 1996. The Modular C2 Evaluation Structure (MCES) is a tool developed at NPS in conjunction with the Military Operations Research Society (MORS) for stepping through quantitative assessments that have applicability for FBE-Echo. NPS followed, in concept, the MCES to help define measures to gauge the success of each of the major areas of FBE-Echo.

Although the FBEs are labeled experiments, they are not laboratory experiments but are operational experiments or better yet, explorations of new concepts, technologies and processes. To date there have seldom been opportunities for experimental replication (several runs under controlled conditions) or control groups that constitute the standard case or experimental designs that systematically vary the very large number of factors in the operations. Usually the base case or standard is simply the "usual process and results." More important are the insights into how they can be made better for the next FBE. The FBE-Echo plan emphasized the experimental process, establishing a baseline and gathering data to assess the concepts.

The concepts explored in FBE-Echo included:

- Asymmetric Threat
- Network-centric ASW with collaborative multi-sensor planning
- Precision Engagement (PE)
- Full Dimension Protection
- Casualty Management/Civil Military Affairs

To provide continuity between experiments, NPS recommended an emerging principle of "model-test-model" for FBEs. Following this principle, simple models of the asymmetric threat scenarios were used to give an indication of the conditions necessary for success. These models were helpful in setting up experiment asymmetric scenarios for FBE-Echo.

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FLEET BATTLE EXPERIMENT ECHO, *continued from page 10*

Comparisons to the results of Echo when available in a few weeks, may be even more useful by indicating directions for the next FBE. This may result in extrapolation of future, improved modeling or indicate the need for Limited Objective Experiments (LOE) before the next FBE. Building a stable of these tools is an important goal for the FBE series.

Assessment Plans for Fleet Battle Experiment Echo

FBE-Echo hypothesized that new processes supported by technology will allow the Navy to enter and remain in the littorals indefinitely with the ability to provide intelligence, naval fires, command and control, and force protection to forces ashore. One key to this capability may be the evolution of Network-Centric Warfare, a concept that multiplies combat power through robust networking of sensors, weapons and command and control grids. FBE-Echo explored new processes for the Navy to provide maritime dominance with a common operational picture including the undersea picture, force protection from air and missile attack as well as asymmetric threats and precision engagement in an urban warfare setting.

Maritime Dominance: Countering Asymmetric Threats: The objective of this area was improved protection of high-value units (HVU) at offshore anchorage or in port from asymmetric threats. Asymmetric implies non-conventional or non-military threat, i.e. terrorists. Such threats range from combat swimmers to jet-skis to civilian aircraft with chemical or biological aerosols. The integration of sensors and networks with existing weapons is the central means for accomplishing

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The Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS), supported by Program 38 Reserve members, actively participated in the Fleet Battle Experiment-Echo. CIRPAS provided a Pelican aircraft to serve as a simulated Unmanned Air Vehicle (UAV) with a Skyball sensor package to provide video and infrared imagery. The sensor package was operated from the Ground Control Station (GCS) at CIRPAS headquarters in Marina, California. The Pelican, although manned due to FAA restrictions on UAV flights over populated areas, functioned as though it were unmanned. The video feed from the Pelican was received via Ku Band on the Slice boat, an ONR sponsored twin hull fast patrol craft upon which a Mobile Inshore Undersea Warfare (MIUW) unit was embarked. The feed was also received on the USS CORONADO (AGF-11) via a TVRO site pierside since the Ka Band GBS system onboard CORONADO was not available.

CIRPAS played a crucial role in the Asymmetric Threat and Precision Engagement missions of FBE-E. An Asymmetric Threat involves a smaller, technologically inferior adversary, which is not necessarily a nation state, using unconventional weapons, forces and tactics against conventional military forces. Asymmetric Threats used or simulated during FBE-E included multiple high speed small boats, jet skis, combat swimmers, anti-ship cruise missiles aboard trucks and low-slow flyers. Precision Engagement examines targeting procedures and advanced technology that may improve the ability to hit targets in an urban environment, employ platforms and weapons against time sensitive land and sea based targets, and rapidly retarget, as needed.

During a tour of the FBE-E spaces on the CORONADO, VADM McGinn (COMTHIRDFLT) had the opportunity to observe the UAV feed in the Joint Air Operations Center (JAOC) and appeared very interested in the technology. He asked several questions about the UAV, including its altitude and the numerical information displayed on the video screen such as the latitude and longitude of UAV and sensor, bearing and range to target, etc.

LCDR Paul Kling (ONR S&T 120) and LCDR Jack Woodward (ONR S&T 822) piloted all of the CIRPAS flights. LCDR Kling piloted 7 sorties and accumulated 26.9 flight hours. LCDR Woodward piloted 8 sorties and accumulated 20.8 flight hours. Sortie completion rate was 100%. Air operations were supported on the ground by AT2 Cesar Gomez and AO2 Robert Hassing (ONR S&T 120). They augmented CIRPAS line maintenance personnel throughout the operations, performing pre- and post-flight inspections and oil/fuel servicing. They provided turn-around capability at Livermore Airport that enabled two tightly scheduled events in the Bay Area to be supported. Between flights, Petty Officers Gomez and Hassing set up unit toolboxes for future use in support of CIRPAS aircraft maintenance. CDR Beth Hubert (ONR S&T HQ 106) provided aviation planning support at CIRPAS headquarters, and later served as a CIRPAS controller embarked on the Slice boat. LCDRs Chuck Kinzer and John Zummo (ONR S&T 120) served as CIRPAS liaison officers and observers onboard the USS CORONADO (AGF-11), and also augmented the MBC Reserve watchstanders in the Exercise Control Center.

LABS IN THE DEPARTMENT OF COMPUTER SCIENCE = COMPUTING POWER

The Department of Computer Science provides graduate education in the major areas of Computer Science. Degrees offered include the Master of Science in Computer Science, Master of Science in Modeling, Virtual Environments and Simulation, and Doctor of Philosophy in Computer Science.

The Department has on-going active research programs in several important areas of interest to the DoD/DoN. Primary research focus areas include:

- Software Engineering
- Programming Languages and Foundations
- Computer Graphics and Visualization
- Artificial Intelligence and Robotics
- Parallel, Distributed, and Networked Computing
- Computer Security
- Databases

To support the rigorous coursework and research, the Department hosts several laboratories; two are general purpose while the rest are highly specialized to focus on specific areas of research. The labs are networked for remote file access and resource sharing. A backbone network provides a gateway to the Internet.

Computer Security Lab

Judged by many to be the best academic computer security laboratory in the country, the Computer Security Laboratory focuses on the design and implementation of systems that will meet functional goals, and information assurance objectives of security policy enforcement and survivability. In support of classes, the laboratory hosts a variety of trusted systems ranging from typical commercial systems that are only weakly resistant to penetrators, malicious software, and subversion, to highly trusted systems as providing much greater confidence of correctness and policy enforcement. Used in a variety of configurations, and for both tutorials and projects, these systems support all six of the computer security courses offered through the NPS Center for INFOSEC Studies and Research (CISR) effort.

Ongoing research includes the development of a high assurance mail server to support clients on a multilevel LAN. March graduates participating in this project include LT Scott Heller, USN, winner of the Navy League Award, and LT Susan Bryer-Joyner, USN, who together developed the server networking software required to permit trusted path and session-level services at multiple sensitivity levels. Maj Brad Eads, USMC, also a March graduate, ported an IMAP mail server to the high assurance platform and modified it to provide true multilevel capabilities to clients. LT Steven Balmer, USN, LTJG Cihan Agackek (Turkish Navy), and LTJG Bora Turan (Turkish Navy) are developing a hardware component intended to provide a "trusted path" between client PCs and the high assurance server.

LTJG Scott Robin, USAF, is studying the security properties of virtual machine monitors. He is examining the virtualizability of the Intel Pentium processor and is conducting an analysis of a forthcoming commercial product to determine the faithfulness of its virtualization and the security properties of the result.

Other recent or ongoing student research has involved firewalls, by LT W. Lee Joyner, USN; the Navy and USMC public key infrastructure, by CPT Dan Morris, USA, CPT David Rowe, USN, and LT Anthony Hansen, USN; security issues for wireless computing, LT James Fowler, USN; and multilevel security features for the Linux operating system, Paul C. Clark.

Research Associate Timothy Levin and Assistant Professor Cynthia Irvine are developing a security service taxonomy and costing framework that can be used by a resource management system scheduler to optimize quality of security service (QoSS). This effort is part of the MSHN project sponsored by the Defense Advanced Projects Research Agency (DARPA) Quorum program.

Visiting Associate Professor J. Bret Michael is conducting research on security policy expression and management and is exploring ways to provide users with reusable components for reasoning about composed policies.

The Computer Security Laboratory also supports the CISR's academic outreach efforts. Web pages and multimedia materials are produced and made available to academic institutions starting computer security education efforts.

The NPS CISR Computer Security Laboratory has been sponsored by the National Security Agency, Naval Security Group, Defense Information Systems Agency (DISA), DARPA, N6, Space and Naval Warfare Systems Command and Systems Center-San Diego, and others. Cooperative Research and Development Agreements (CRADAs) permit collaborations with industry partners.

Network and Multimedia Lab

The Network and Multimedia Laboratory focuses on experimental work aiming to enhance the performance, security, and integrated service capabilities of the Internet.The lab

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COMPUTER SCIENCE LABS, *continued from page 12*

currently supports several exciting and cutting-edge network and multimedia research projects.

The development of a novel server-and-agent-based network management (SAAM) architecture for the next-generation Internet is funded primarily by the Defense Advanced Research Projects Agency (DARPA) with additional support from NASA. The project team consists of four faculty members, Assistant Professor Geoffrey Xie, Associate Professor Debra Hensgen, Associate Professor Taylor Kidd, and Associate Professor Bert Lundy. Ten students have been involved in this project.

The LLPA (Link Layer Packet Authentication) and STARGATE projects, funded by DARPA and the Naval Security Group Command, study network security, with a focus on developing very high speed authentication protocols for both IP and ATM networks. The project team consists of Assistant Professors Geoffrey Xie and Cynthia Irvine. Two of the four students involved have already graduated.

The TIS project investigates the feasibility of using a Computer Based Training (CBT) system to improve the quality of the Army's threat identification training for pilots. The Lab contains advanced computer and network equipment including an experimental Gigabit ATM switch, a dozen high-end PCs and UNIX workstations, and audio/video devices.

Mobile Computing Lab

The Mobile Computing Lab was organized in 1998 by Professor Ted Lewis and Associate Professor Dennis Volpano of the Department of Computer Science and Associate Professor Xiaoping Yun of the Department of Electrical and Computer Engineering. Its primary goal is to expose students to technology and issues in wireless data networking and mobile computing. The lab is equipped with a variety of COTS wireless LAN equipment, mini computers, pen tablets and wearable computing devices.

There are several ongoing projects in the lab, attracting students from a wide variety of curricula. Students currently working on projects within the lab are Capt Wayne Collins, USMC, LT Mark Matthews, USN, LT David Odom, USN, LT Mark Roemhildt, USN, LT Kurt Rothenhaus, USN, and Capt Joe Wronkowski, USMC. Assessments of COTS FHSS and DSSS wireless networking performance have been completed onboard a submarine and a ship. A study onboard the carrier USS TRUMAN was completed in March 1999. New applications of the technology are also being developed. LT Kurt Rothenhaus developed client and server-side software

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The Computer Science Academic UNIX Laboratory provides a general-purpose time-sharing environment for a variety of programming languages and software tools. The lab has several Sun Ultra 5 and 10 workstations and a Sun Ultra Enterprise server. The UNIX Lab is used for advanced coursework and thesis research.

The Computer Science Academic PC Lab is used for teaching and research on programming languages, computer architectures, networking and distributed systems. It is used for classes and by individuals for coursework and thesis research. The lab is part of the campus-wide NT domain that allows students from other areas of the campus to utilize the resource. There are 24 Pentium II 450 MHz class PCs in the lab that are served by two Dell applications and file servers.

The Computer Graphics and Video Laboratory has Silicon Graphics IRIS workstations providing support for virtual-world and visual-simulation system construction, plus a variety of video and multimedia support hardware. Research currently focuses on NPSNET, a low-cost, workstation-based, 3D visual simulator that utilizes SIMNET databases and networking formats. This laboratory also supports research for the Modeling, Virtual Environments and Simulation (MOVES) curriculum which is rapidly growing.

The Artificial Intelligence and Robotics Laboratory has Unix-based workstations with LISP, Prolog and various knowledge-based software tools. An IRIS workstation manages an autonomous mobile robot "Yamabico" with a color TV camera. This laboratory also supports research on planning, navigation, dynamics, and control of the autonomous underwater vehicles, a joint project with the Departments of Mechanical Engineering, Electrical and Computer Engineering, and Undersea Warfare Academic Group. Recent work has focused on automatic recognition of changes in aerial photographs and on intelligent multimedia retrieval systems.

The Visual Database and Interface Laboratory supports research in human-computer interfaces for data retrieval systems, and visual query-languages in particular.

PROJECT NOTES

THE UTILITY OF ELECTRO-OPTICAL DEVICES TO ENHANCE NIGHT DRIVING

Assistant Professor William K. Krebs
Department of Operations Research

Infrared (IR) and image-intensified (II) sensors are commonly used in military operations, and IR sensors will soon be commercially available on automobiles. Work in the Operations Research Human Factors Laboratory by Assistant Professor Kip Krebs and his associates is investigating the use of night vision sensors for military and civilian applications. The information provided by night-vision sensors is degraded in many ways compared to unaided daytime vision. Dr. Krebs and his students are studying how this degradation affects visual performance, and how night vision imagery might be improved.

The laboratory has recently collected infrared and image-intensified videotaped footage from sensors mounted to the roof of a moving sport utility vehicle. Psychophysical tests have begun to examine how these different sensor types support various perceptual abilities integral to safe night driving—the ability to detect obstructions, the ability to see through the glare of oncoming headlights, and the ability to estimate the time until an approaching vehicle passes.

Footage has been collected after dark several evenings since mid-November from various locales around the Monterey area. After several hours of driving around without headlights, and being pulled over by suspicious police, Krebs and company have gathered footage of several mission scenarios for use in a planned series of experiments.

An initial study has assessed the ability to detect a pedestrian against the glare of an approaching car's headlights. Images for this experiment were collected with the sensors facing down a stretch of straight road, and into the headlights of a parked car. Later, in the laboratory, observers were asked to view these images and to determine whether a pedestrian was visible in each one. Response times for detecting pedestrians were faster with IR than with II imagery. More notably, performance with II imagery declined substantially as targets were located at greater distances from the sensor, and as targets were located nearer the oncoming vehicle's headlights, while performance with IR imagery showed little effect of target distance or of interference from glare. This suggests that IR sensors might be effective night driving aids, and could be especially helpful in overcoming difficulties imposed by glare.

Subsequent research will be conducted with Drs. Frank Werblin and Tibor Kozek from the Department of Molecular Cell Biology at UC Berkeley that will use similar psychophysical tests to assess the utility of sensor-fusion. Sensor fusion combines images from multiple sensors into a single display, and provides a promising enhancement of night-vision for military and civilian use. Fusion might allow IR and II information to be presented simultaneously as a single image—almost as if a transparency of one image is being laid over the other—so that a night driver could use information from both sources simultaneously, and without making eye-movements between different displays.

Image Sensor Fusion system mounted on a sport utility vehicle. The owner, LT James Elias, USN, is enrolled in the Test Pilot Student program within the Aeronautics Curriculum at the Naval Postgraduate School.

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ELECTRO-OPTICAL DEVICES TO ENHANCE NIGHT DRIVING, *continued from page 14*

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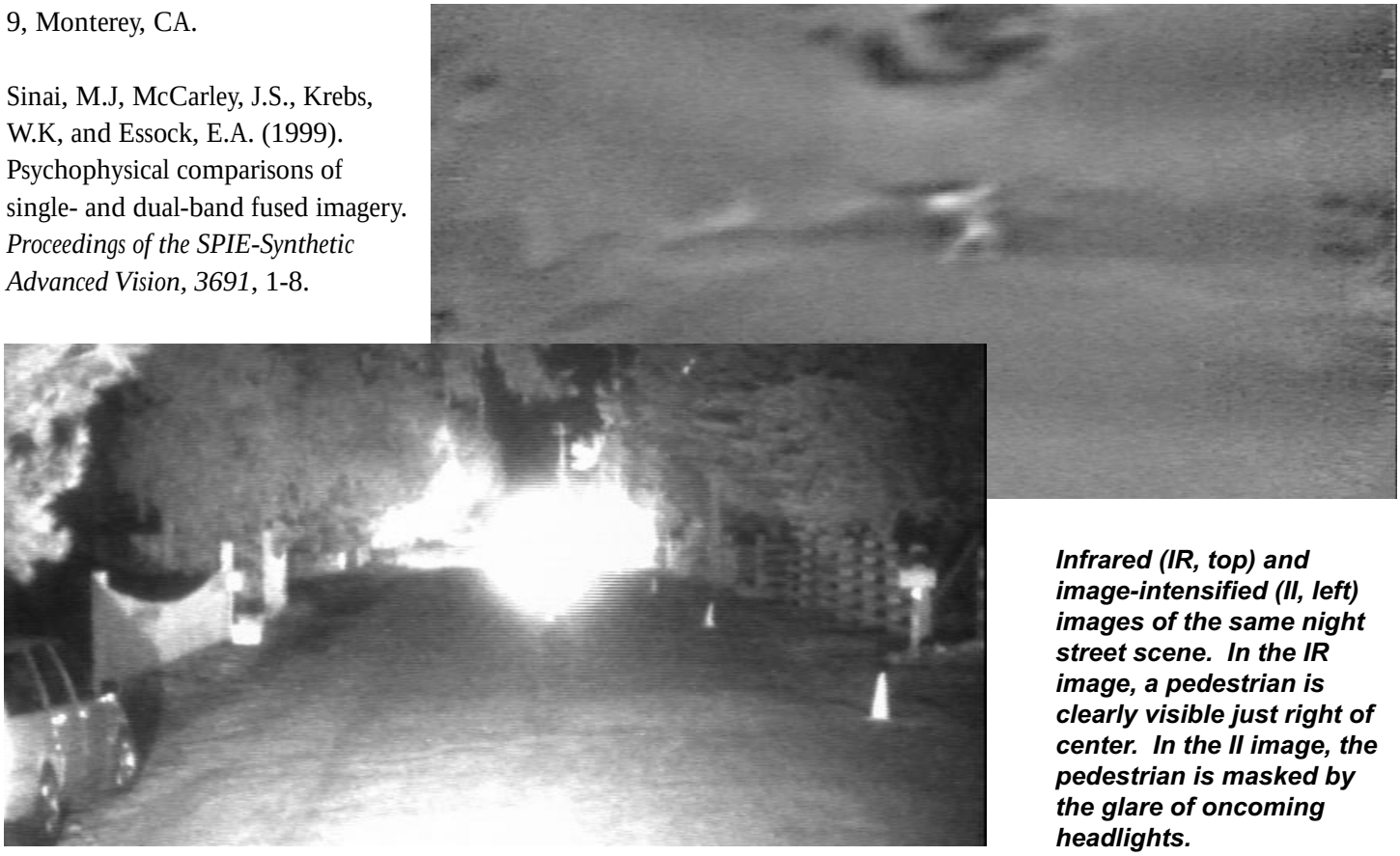
Assistant Professor Kip Krebs, Human Factors Specialist within the Department of Operations Research, has recently added postdoctoral students Michael Sinai and Jason McCarley to his laboratory. Both Drs. Sinai and McCarley are trained as experimental psychologists, and in the study of visual perception and human performance.

Dr. Mike Sinai completed undergraduate and graduate study at the University of Louisville, where his research examined topics as diverse as the mechanisms of visual light adaptation, the ability of human observers to accurately estimate distances, and the early effects of glaucoma on visual perception.

Dr. Jason McCarley conducted undergraduate study at Purdue University and graduate work at the University of Louisville, studying basic and applied aspects of perceptual organization and visual cognition. He has previously worked as a Graduate Research Associate at Armstrong Labs at Brooks AFB, and as Visiting Professor within the Department of Psychological Sciences at Purdue University.

Dr. Sinai and Dr. McCarley are at NPS under the Office of Naval Research-American Society for Engineering Education Post-Doctoral Associateship Program.



Infrared (IR, top) and image-intensified (II, left) images of the same night street scene. In the IR image, a pedestrian is clearly visible just right of center. In the II image, the pedestrian is masked by the glare of oncoming headlights.

FIRST PROPOSALS AWARDED UNDER DAU EXTERNAL ACQUISITION RESEARCH PROGRAM

NPS serves as Executive Agent for the Defense Acquisition University's External Acquisition Research Program (EARP). Assistant Professor Mark Nissen, Department of Systems Management, is the program manager. The primary objective of the EARP is to catalyze an increase in the quality and quantity of acquisition research. Pursuing this goal, a broad agency announcement was issued for research proposals in January 1999. This coincided with an EARP marketing plan which involved sending letters to Deans of the top 40 U.S. business schools, the top 55 schools of public administration, and 50 top researchers in the field. Information was also disseminated through multiple internet listservers which ultimately reached about 2,000 people. In response, over thirty researchers from various U.S. universities, and several from overseas, expressed interest in the program. Seven proposals were received by the BAA deadline of 1 March. To date, awards have been made to:

- University of Maryland at Baltimore County: Beyond CESA (COTR Expert System Advisor): An Intelligent Agent for Helping COTRs in U.S. Government Defense Research Contracting
- Wright State University: Current Status of Procurement Strategy and Outsourcing in U.S. Industrial Firms
- University of California at Irvine: Design of an Infrastructure to Support Research in Software Systems Acquisition
- Purdue University: Synthetic Environments for Defense Acquisition Simulations
- University of California at Berkeley: Assessment of Electronic Catalog Strategies to Support Acquisition Processes

Proposals for the second EARP fiscal year (FY00) are scheduled for solicitation against a similar BAA late this summer. Even greater interest and participation is expected next year, for several scholars indicated they were unable to meet the FY99 deadline. NPS faculty have also expressed interest in the program, but they are encouraged to team with colleagues at leading "external" universities beyond the DoD "sphere of influence." NPS faculty, like researchers at the Defense Systems Management College, Air Force Institute of Technology, and other schools within the DoD sphere can greatly facilitate research being conducted by scholars who are unfamiliar with the DoD and government. Such interaction and exchange between scholars within and beyond the DoD represent important aspects of the program strategy. And toward this end, the inaugural Acquisition Research Workshop is scheduled to be conducted at NPS this May.

FORMATION AND COORDINATION OF COMPLEX SYSTEMS

Assistant Professor Wei Kang
Department of Mathematics

Automatic control of a single air or space vehicle has been studied for decades. However, many military and civilian applications involve coordination of multiple vehicles. An example of such applications is a satellite constellation for interferometric imaging. Traditional earth-imaging missions have used single aperture telescopes to survey the planet. To improve the angular resolution at a given wavelength, one must increase the aperture diameter of the telescope. Currently, the diameter of optical and radio space-based telescopes is limited by the size of the launch vehicle payload. To overcome this limitation and to improve the angular resolution, interferometry technique can be used. The technique requires multiple separated collectors placed in space with a given distance apart to form a synthetic aperture with an angular resolution equivalent to that of a single aperture telescope with a diameter equal to the baseline between collectors.

During an operation, the formationkeeping of satellites in the presence of disturbances is a challenging problem. Furthermore, the coordination among the space vehicles requires highly automatic on-line controllers. To improve the overall reliability, formation reconfiguration to replace a satellite with malfunction is necessary. Formation reconfiguration is also an important feature for multi-mission applications. Answers to all these questions of control applications do not exist in the literature. Research development in the area of multi-vehicle coordination involves several topics such as modeling of multi-vehicle systems and their formations, theoretical analysis and design algorithms, controller architecture design, simulations, and experiments. The goal of the joint project of NPS and the Air Force Research Lab on formation and coordination of complex systems is to develop control theory and design tools for the formationkeeping and coordination of multi-satellite systems.

RELATIVE CRITICAL VALUE DEVIATION (RCVD) FOR CLASSIFYING AND PREDICTING SOFTWARE QUALITY

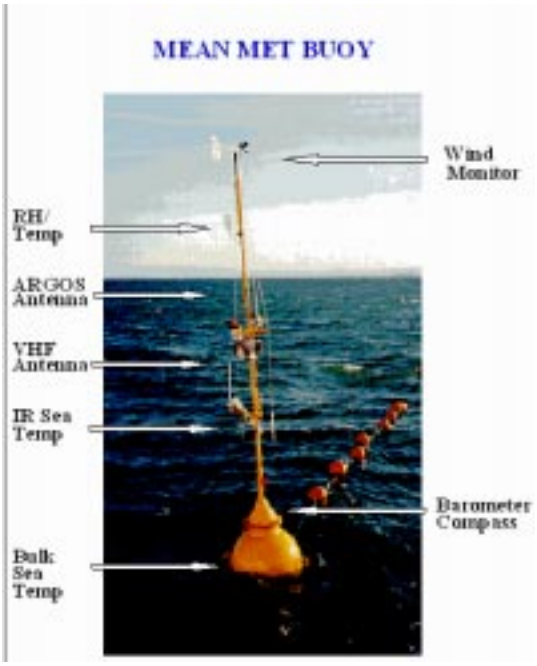
Professor Norman F. Schneidewind
Information Systems Academic Group

A new software quality metric, the Relative Critical Value Deviation (RCVD), has been developed for classifying and predicting software quality. The RCVD is based on the concept that the extent to which a metric's value deviates from its critical value, normalized by the scale of the metric, is an indicator of the degree to which the entity being measured does not conform to a specified norm. For example, the extent to which body temperature exceeds 98.6 degrees Fahrenheit (i.e., critical value) is an indicator of the deviation from an established norm of human health. An interesting aspect of measurement is that it involves using surrogates: the deviation in temperature above 98.6 degrees is a surrogate for fever. Similarly, the RCVD is a surrogate for the extent that the quality of software deviates from acceptable norms (e.g., zero trouble reports written against the software). An important aspect of software measurement is that surrogate metrics are needed to make predictions of quality early in development before quality data are available. The RCVD can be computed for a single metric or multiple metrics. Its application is in making a quality assessment of newly developed modules in the absence of quality data. In order to initiate this process, one build of the *Space Shuttle* flight software was used to validate the metrics and several additional builds to apply the metrics. During validation, critical values are estimated by an inverse Kolmogorov-Smirnov distance criterion. The validated critical values are used in subsequent builds and can be updated, if necessary, once the quality data (e.g., software trouble reports) become available. The RCVD is a part of a larger framework of measurement models that include the use of Boolean Discriminant Functions for classifying software quality.

In their master's thesis, "Software Evaluation for Developing Software Reliability Engineering and Metrics Models," March 1999, CDR Dennis J. Brophy, USN, and LCDR James D. O'Leary, USN, developed software tools using spreadsheet and database management techniques for supporting this research. This approach allows the technology to be more easily transferred to practitioners because many practitioners use and are familiar with these tools, whereas this was not the case for statistical and software reliability tools that were previously used in this research.

METEOROLOGY FACULTY PARTICIPATE IN MULTI-GROUP EXPERIMENT

Faculty and Staff in the Department of Meteorology participated in a multi-group experiment in the North Carolina coastal zone that was designed to describe aerosol generation and transport within the surf zone. The experiment was performed during February and March at the Duck, NC, U.S. Corps of Engineers Field Research Facility. This was the fifth field experiment within an Office of Naval Research-sponsored multi-year effort titled, "Electro-Optical Properties in the Coastal Environment (EOPACE)." This was the first field experiment conducted on the U.S. East Coast and the third that focused on surface zone optical properties as influenced primarily by surface zone wave breaking produced aerosol. Department of Meteorology faculty participants included Professors Kenneth L. Davidson and Carlyle Wash; staff participants were Paul Frederickson, Keith Jones, and Mary Jordan. NPS participation included both on-site acquisition of near-surface data from moored buoys and acquisition and interpretation of data obtained by satellite-borne sensors. In addition to collaboration with scientists who collected information on surf zone bubble properties and concentration and aerosol data, NPS investigations were coupled with aircraft measurements.



Buoys instrumented to measure surface waves as well as airflow properties were used during EOPACE

AUTOMATED COMMUNICATIONS INTERCEPT, DIRECTION FINDING, AND ANALYSIS SYSTEM (ACIDS)

LT George Greenway, USN
Associate Professor Man-Tak Shing
Department of Computer Science

Introduction

We are designing and building a signals collection, direction finding, and analysis system that is built completely from commercially available components. Our design is centered around a standard desktop computer (x86) architecture to keep costs low and to study the feasibility of building a fully functional signals processing system with this standard architecture.

Further, we are defining a new way to display and manipulate signals intercept data for the user to enhance tactical awareness of the surrounding signals environment. It is our hope that some of the design work that we have done can be used to enhance current systems and in the development of new systems.

The Office of Naval Research Naval Science Assistance Program (NSAP) provides on-the-spot technical assistance to the Joint and Naval operational commands by facilitating the identification of operations readiness deficiencies in order to influence longer term science and technology investments. NSAP solves real operational problems in a rapid and inexpensive manner through the evaluation and insertion of mature technologies. NPS has established a relationship with NSAP to couple Fleet/Force issues into NPS thesis research. Several students at NPS are working on problems of Fleet/Force interest as part of their thesis research. LT George Greenway, USN, and LT David Varnes, USN, have received NSAP funding to support their thesis research.

Objectives

We have a variety of performance, design, and technical objectives for the project. The larger objectives include:

- Provide design information and source code to interested organizations such as SPAWAR for development of new signals intercept systems based on the x86 architecture and windows NT.
- Evaluate the capability and effectiveness of this design against real world signals in an operational environment.
- Develop code and interfaces that allow ACIDS to work directly with direction finding antenna arrays and processing systems (T-RDF, for example) that are already in the Fleet.
- Provide copies of our prototype to Fleet and field units desiring the capability offered by ACIDS.

Objectives for the initial prototype include:

- *Keep the hardware cost low:* So far, our hardware cost is below $40K; with nearly half of that figure represented by the direction finding antennas and processor. For a system that would interface with T-RDF, the cost would only be about $20K.
- *Automatically calculate bearings to all signals stopped on by a sweeping receiver:* The sweeping receiver will pause for at least 500 milliseconds on active signals to allow calculation of an accurate bearing. This is a tough problem. We are still working out some of the timing and accuracy details for this performance requirement. A 5 second pause will give bearings accurate within 3 to 5 degrees. A 2 second pause begins to approach system performance limits very closely. Bearing accuracy degrades to around 10 degrees and signals are sometimes (about 15% of the time) missed altogether.

This places our performance short of our goal by a factor of 10 (5 second pause vice a 500 millisecond pause) for bearing calculation time. The actual bearing calculation (integration) time required is only about 300 milliseconds. The largest time use comes from RS-232 port I/O and DF Receiver switching time of over 800 milliseconds. The time is required for switching the receiver to a new frequency, requesting the new direction finding (DF) data be placed on the output port of the DF Receiver/Processor, and then actually reading the data. At the same time, there are a variety of other I/O operations executing including reading navigational and time data from a GPS receiver that uses up more of our 500 millisecond time budget.

The best solution to this problem is to put the DF processor on a card, place it in the ISA or PCI bus, and feed RF to it directly from the sweeping receiver that could be connected to the DF antennas. This, in fact, was our original design. The DF processing card that we currently have installed in an ISA slot (the only one, as far as we know, that can be installed in an ISA or PCI slot), however, did not come with a special device driver that will make it work with Windows NT. We are working with the vendor to put one together before September.

- *Provide an informative tactical display of intercepted data*:

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DEVELOPMENT OF A HELICOPTER VORTEX RING STATE WARNING SYSTEM THROUGH A MOVING MAP DISPLAY COMPUTER

LT David J. Varnes, USN
Associate Professor Russ Duren and Professor E. Roberts Wood, Department of Aeronautics and Astronautics

The development of personal computer-based moving map displays and other similar commercial systems and software have made possible the implementation of numerous pilot aid features without the complexity of Operational Flight Program (OFP) changes or avionics structural changes. Some of these features include flight planning aids such as fuel consumption calculation, navigational aid (NAVAID) identification, emergency landing field and airspace identification, route construction, and flight time calculation. This research investigates the use of one such system as a mechanism for providing warning to helicopter pilots on a not well recognized aerodynamic phenomena known as vortex ring state.

Vortex ring state (VRS), also known as power settling or settling with power, is an unsteady flight condition characterized by severe thrust fluctuations, vibrations, rapid rates of descent, sluggishness and vibrations of the controls. This condition typically occurs in a helicopter during flight conditions that combine low horizontal airspeed and a rate of descent that is equal to approximately twenty three to one hundred and twenty five percent (23%-125%) of hover induced velocity. It usually results in substantially increased vertical vibrations, and, at its worst, can result in temporary loss of helicopter control. Vortex Ring State is an aerodynamic phenomena whose analysis proves to be extremely difficult. The breakdown of the rotor wake leads to the inability of momentum theory to adequately predict behavior inside the vortex ring state boundaries. It does, however, serve to predict the instability that leads to vortex ring state. Analysis of safety data from the Federal Aviation Agency (FAA), Navy, and Marine Corps shows entry into vortex ring state between thirty and forty times over the past fifteen to twenty years resulting in accidents. Incorrect pilot identification of vortex ring state led to control inputs that further exacerbated the situation. Significant numbers of these accidents were the result of accepting slight tailwinds or downwind approaches as well as steep descents from high hovers. Given the expanding nature of helicopter operations in all conditions and terrains the likelihood of a helicopter encountering vortex ring state is certain to increase. It is imperative that rapid and correct identification be made in order to recover the aircraft in sufficient time to avoid ground contact.

The GADGHT (Ground/Air Display for Geographical/ Hydrographic Tracking) system is a series of PC-based moving map information/displays that are small, lightweight, inexpensive, flexible and supportable. The GADGHT system was originally conceived to allow older aircraft to incorporate newer technology within the constraints of budgets and time. The GADGHT system is based on commercial-off-the-shelf (COTS) technology and is completely customer configurable for mission and aircraft installation. Additionally, the GADGHT system will support the development of additional pilot aid features, again, configurable to the aircraft and mission needs of the users. The system currently contains three different prototype units. "Proto E" consists of a hand held Fujitsu Stylist 1200 computer operated by a touch screen and containing its own internal commercial GPS receiver with external antenna. This system is completely self-contained and has been installed in 20 aircraft. GADGHT "Proto 1" consists of a main unit and a kneeboard display. The main unit contains a PC-104 form factor personal computer and the user hard drive. GADGHT "Proto 2" system is a functional design that is more H-60 cockpit friendly. It provides two displays that are mounted left and right of the forward console replacing map holders. It allows pilot interface through a keypad/joystick that is connected to a computer unit containing two processors. This particular prototype receives navigational data from the aircraft avionics system through the MIL-STD-1553 data bus rather than relying on a stand alone internal GPS receiver. The 1553 data bus connection is available without modifying the H-60 avionics system.

The GADGHT system developed by NAVAIR is based on the FalconView Flight Planning Station Software. FalconView was originally developed by the U.S. Air Force Reserve, Air National Guard, and the Georgia Tech Research Institute for the U.S. Air Force to permit its pilots and aircrews to flight plan through the use of a laptop anywhere in the world. It is currently used by over 13,000 aircrew members worldwide, including the 89th Airlift Wing at Andrews AFB, Maryland, which provides airlift and logistical support for the president, vice president, cabinet and other government officials. FalconView, along with other commercially available flight planning software is a Windows 95/NT based system which allows the user to follow the aircraft's position overlaid on a digitally presented map. It also includes overlay tools that allow the pilot to mark no-fly zones

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DETERMINING ENTRAINMENT RATE AND THE ROLE OF ENTRAINMENT IN STRATOCUMULUS CLOUDS

LT David W. McDowell, USN
Master of Science in Meteorology and Physical Oceanography-June 1999
Advisor: Assistant Professor Qing Wang, Department of Meteorology

The structure and evolution of the cloud-topped boundary layer are of significant meteorological interest and of tactical importance to the United States Navy. In contrast to a cloudless boundary layer, a boundary layer topped with extensive clouds, such as stratocumulus, adds a level of complexity and uncertainty in the ability to assess or even predict boundary layer structure. As a result, weather forecasts and the effectiveness of tactical decisions may be degraded. The presence of stratocumulus, for example, significantly alters the boundary layer inversion strength, which plays a role in Electromagnetic and Electro Optical (EMEO) propagation and the tactical use of elevated ducts. The change in inversion stability and corresponding changes in cloud evolution also modifies aerosol-cloud interaction. The resulting changes to cloud structure therefore impact Navy remote sensing and surveillance capability, such as in the satellite analysis of ship tracks. In addition, the presence of stratocumulus adds difficulty to short-period and mesoscale forecasting, pollution transport and its chemical evolution, and radiative feedback processes in climate studies. Consequently, an improved understanding of the evolution of a stratocumulus-topped boundary layer will significantly enhance the Navy's tactical use of the environment.

One important process in predicting the evolution of a stratocumulus-topped boundary layer is entrainment, which describes the exchange process between the relatively quiescent free atmosphere and the turbulent boundary layer. Entrainment, or even more importantly the rate of entrainment, transports free tropospheric air into the cloud-topped boundary layer. The resulting mixing then alters cloud structure and consequently influences the boundary layer dynamics. A quantitative measure of an entrainment velocity is therefore an essential tool in determining low-level cloud evolution. The objective of this study is to therefore evaluate a reliable means of quantifying entrainment.

The disparity between the numerous conceptual models describing entrainment and the mechanisms that drive entrainment mixing reflects a general inadequate representation of the entrainment process. In the past, several attempts have been made to parameterize the entrainment rate, but with some receiving no verification of the calculations using observed data. Consequently, there have been few validated studies of entrainment and its effects. Observation of the entrainment rate, or entrainment velocity, on the other hand, introduces an additional level of uncertainty, which stems from the determination of the cloud-top jump conditions. In this study, a new gradient method for estimating entrainment velocity is proposed. Calculations are performed using aircraft measurements obtained off the coast of California during the First International Satellite Cloud and Climatology Project (ISCCP) Regional Experiment (FIRE) in 1987. The sensitivity of this method to variations in inversion layer jump conditions is assessed and compared to results from a previously accepted method for determining entrainment velocity. The overall goal of this analysis is to develop an optimal method for determining entrainment velocity and to validate entrainment rate parameterization for numerical modeling.

ASSESSING THE EFFECTIVENESS OF THE BATTLEFIELD COMBAT IDENTIFICATION SYSTEM

CPT Mark V. Grabski, USA
Master of Science in Operations Research-June 1999
Advisors: Associate Professor Arnold Buss, Department of Operations Research, and MAJ Gerald M. Pearman, USA, TRADOC Analysis Center – Monterey

The Battlefield Combat Identification System (BCIS) was developed at the direction of the Joint Chiefs of Staff following the Gulf War to address the problem of direct fire fratricide. The system improves target identification and increases situational awareness for ground combat forces. The purpose of this thesis is to determine if BCIS improves combat effectiveness. The experiment includes an M1A1 tank platoon executing two doctrinal missions (defense and movement to contact) for target identification only, and with BCIS equipped with a Digital Data link. The research will assess measures of performance to determine whether BCIS increases platoon combat effectiveness. This thesis draws conclusions about the effectiveness of BCIS, recommendations for improving the system, and recommendations on changing how we train to best utilize the capabilities of BCIS.

DEFENSE OF NAVAL TASK FORCES FROM ANTI-SHIP MISSILE ATTACK

LCDR James R. Townsend, USN
Master of Science in Operations Research-March 1999
Advisors: Professor James G. Taylor and Associate Professor Arnold H. Buss, Department of Operations Research

The quantity, capability, and availability of Anti-Ship Missiles (ASMs) pose a significant threat to the safe operation of United States Naval Forces in the waters off of potentially hostile shores. Potential adversaries continue to improve their ability to attack our ships, requiring that we constantly analyze our defenses against such attacks. Existing computer models and simulations do not provide force commanders or naval analysts with an adequate tool to properly evaluate the threat and the best ways to minimize it. This thesis has developed such an analysis tool, called the Anti-Ship Missile Defense (ASMD) model. It allows for analysis to be performed from an entire task force perspective, modeling the entire process by which ASMs select their targets and the methods by which the defending escorts assign defensive fire. Effective Screen Design and Defensive Firing Policy is a large and complex problem, but exploratory analysis using ASMD has yielded useful insights. In ASMD, moving objects are more fully rendered, featuring smooth acceleration, turning and altitude change features. In support of these complicated moving entities, a highly capable mathematical library was created to solve the resulting equations of motion. The software components and architecture developed for ASMD provide significant flexibility and reuse potential for future analysts.

A CASE STUDY OF THE ADVANCED AMPHIBIOUS ASSAULT VEHICLE (AAAV) PROGRAM FROM A PROGRAM MANAGEMENT PERSPECTIVE

LtCol Scott R. Adams, USMC
Masters of Science in Management-March 1999
Advisors: Professor David V. Lamm and Senior Lecturer Michael W. Boudreau, Department of Systems Management

This research effort focused on the program management issues of the U.S. Marine Corps' Advanced Amphibious Assault Vehicle (AAAV) Program. The research answered the primary question of what were the critical program management decisions during the early phases of the program and how would an analysis of these decisions affect the future of the AAAV program. Interviews were conducted with key personnel from the AAAV Office and General Dynamics Land Systems. Additionally, program documents and other relevant literature were reviewed. The key findings of the research effort concluded that: reducing technical risk early in the program is critical; Program Managers (PMs) must influence system design as early as possible; physical collocation of Government and contractor personnel facilitates the implementation of Integrated Product and Process Development (IPPD) and Integrated Product Teams (IPTs); the use of IPPD and IPTs has helped the AAAV program but personnel need to be trained before implementation; adopting an evolutionary acquisition strategy will help prevent component obsolescence prior to fielding; and PMs should use special contracting provisions to incentives contractors to reduce total ownership costs.

MAPPING COASTAL SURFACE WINDS IN MONTEREY BAY USING HIGH FREQUENCY RADAR

LT Raymond R. Delgado III, USN
Master of Science in Meteorology and Master of Science in Physical Oceanography-March 1999
Advisor: Associate Professor Jeffrey D. Paduan, Department of Oceanography, and Professor Carlyle H. Wash, Department of Meteorology

Over-water wind directions derived from high frequency (HF) radar - the new Multi-frequency Coastal Radar (MCR) - are compared to in situ observations to determine the skill of the radar measurements. Conventional beam processing of data collected from two MCR sites located around Monterey Bay during summer 1997 was used to create wind directions based on the relative strength of the positive and negative Bragg-resonant peaks, which correspond to the wind-driven waves approaching and receding from the radar, respectively. Based on a selected functional relationship that converts the radar signal to wind direction, radar-derived wind directions were created using a new wind-retrieval algorithm and are compared to mooring observations under a variety of wind conditions. Analysis indicates that the signal not only follows wind direction, but also strongly correlates to the wind speed measured at the mooring. Results show that many of the Bragg peaks are close to the noise level, and consequently, low signal-to-noise ratios restrict the statistical confidence of the measurements. Nonetheless, maps of radar-derived wind directions show good agreement with in situ observations, especially when the wind speed is relatively strong and is sustained for a long duration.

STUDENT FELLOWSHIPS AWARDED BY SPACE AND NAVAL WARFARE SYSTEMS CENTER-SAN DIEGO

The Space and Naval Warfare Systems Center-San Diego (SPAWARSYSCEN-SD) sponsors a Research Fellowship Program. The program was instituted to promote SPAWARSYSCEN-SD's partnership with NPS, address SPAWARSYSCEN-SD research focus areas, lay the groundwork for future technical and project management assignments, and foster long-term professional associations with SPAWARSYSCEN-SD technical personnel and management.

Six NPS students were recently awarded fellowships. The award includes $10,000 to support the student's thesis research. The most recent awardees (listed with their research topic) are:

· Capt Kevan D. Katuin, USMC: Space-Based Imagery Intelligence (IMINT): Using Information Operations (IO) to Maintain Information Superiority

· Capt Leslie M. Prior, USMC: Wireless Area Network (WLAN) Applications in the Common Aviation Command and Control System (CAC2S)

· LT Robert B. Moss, USN: Low Probability of Detection Communications for Special Operations Forces Deployed Using Commercial-Off-The-Shelf (COTS) Wireless Networking Equipment

· LT James M. Novak, USN: Detection of Undersea Objects with Spectral Imagery

· LT Douglas A. Powers, USN: Vulnerability Analysis of the Border Gateway Protocol (BGP)

· LT Stephen J. Tripp, USN: High Data Rate, Low Probability of Detection Communications for Navy P-3 Aircraft High Resolution Optic and Other Sensor Information Using Commercial-Off-The-Shelf (COTS) Wireless Networking Equipment

DEVELOPMENT OF A HELICOPTER VORTEX RING, *continued from page 19*

and restricted or prohibited flight areas as well as to download the latest updates on the ever-growing number of towers and antennas that could pose flight hazards. FalconView utilizes National Imaging and Mapping Agency (NIMA), Compressed Arc Digitized Raster Graphics (CADRG) maps, Digital Aeronautical Flight Information File (DAFIF), Digital Terrain Evaluation Data (DTED), and Electronic Chart Upgrades (E-CHUM) information sources.

The current thesis development is targeting application to the CH-60 series helicopter. Initial research has been aimed at identification of the boundaries of the vortex ring state. The methodology adopted for detecting vortex ring state is to obtain airspeed, rate of descent, and torque data over the avionics 1553 data bus. The data will be sensed by a combination of existing sensors including inertial navigation sensors and GPS sources. This data will be fed into the GADGHT computer and plotted against theoretical vortex ring state boundary regions. The supplied data's current position will be compared to that theoretically computed for various thrust and descent angles. Any approach within a predefined tolerance will trigger an alarm to the pilot that he/she is approaching vortex ring state conditions. As mentioned previously, vortex ring state has also been characterized by a significant increase in vertical vibration levels on the order of two to three times (.6-.8 g's). The researchers are also investigating the use of acceleration data as a means of detecting the presence of vortex ring state. This data could be obtained from an accelerometer contained within the GADGHT computer. It is thought that the dual indication will serve to prevent possible false alarms and to enhance validation confidence.

The result of this effort will be to enhance aircrew situational awareness and safety by providing pilots adequate warning of the approach of or existence in vortex ring state. This warning will ensure correct identification and permit subsequent recovery procedures to be made with confidence and without delay preventing mishaps and accidents.

NPS FACULTY APPOINTED AS LEAD SCIENTIST FOR U.S. WEATHER RESEARCH PROGRAM

Distinguished Professor Russell L. Elsberry of the Department of Meteorology has been appointed Lead Scientist for the Hurricane Landfall portion of the U.S. Weather Research Program. The five year initiative to improve weather prediction over the U.S. is sponsored jointly by the National Science Foundation, National Oceanic and Atmospheric Administration, National Aeronautics and Space Administration, and the Office of Naval Research. The Hurricane Landfall portion will address science and technology opportunities that can improve understanding and prediction of hurricane landfall.

NPS FACULTY ELECTED IEEE FELLOW

Professor Luqi of the Department of Computer Science was recently elected as an Institute of Electrical and Electronic Engineers (IEEE) Fellow. Professor Luqi was recognized for her contributions to software technology for computer-aided development of embedded real-time systems.

IEEE Fellowship is a prestigious honor, bestowed upon a very limited number of Senior Members to recognize their worldwide achievements in electro and information technology. In 1999, only 230 new Fellows were elected from a global IEEE membership of well over 300,000.

NPS STUDENT RECEIVES OUTSTANDING STUDENT PAPER AWARD AT AGU

The American Geophysical Union's (AGU) Ocean Sciences Section at the 1998 Fall Meeting in San Francisco honored LT Steve Murley, USN, with an Outstanding Student Paper Award. LT Murley presented a poster titled, "Variability of Fresh Water Export through Fram and Davis Straits from a High Resolution Model."

Working with advisors, Professor Robert Bourke and Research Assistant Professor Wieslaw Maslowski of the Department of Oceanography, LT Murley has had the opportunity to pursue his diverse research interests, which range from the impact of the Arctic Ocean on the global climate to the potential use of ocean processes for power generation. LT Murley is currently attending the Surface Warfare Officer School in Newport, RI, and will report to the USS WINSTON CHURCHILL this fall as the weapons officer.

AMERICAN HELICOPTER SOCIETY RECOGNIZES NPS INSTRUCTOR

The Lichten Award is given by the American Helicopter Society (AHS) every year for the best technical paper presented by a new author at a local meeting during the preceding year. LCDR Robert L. King, USN, a lecturer in the Department of Aeronautics and Astronautics, is the most recent recipient. His paper, "Nonlinear In-Plane Flexbeam Stiffness Provides Rotor System Stabilty Without Lag Dampers," reports on the effectiveness of employing Duffing type nonlinear stiffness in limiting rotor blade lead/lag motion and reducing susceptibility to ground and air resonance.

The Lichten Award was established in 1975 to honor the memory of Robert L. Lichten, an outstanding rotary wing aeronautical engineer, who many call the "Pioneer of Tilt Rotor Technology." This is the most prestigious award given by AHS to a young researcher. In 1990, Associate Professor Joshua Gordis of the Department of Mechanical Engineering, then a doctoral student at Rensselaer Polytechnic Institute,

During a recent visit to NPS, Dr. Hans-Georg Schultz-Gerstein, President of the University of the Federal Armed Forces in Hamburg, Germany, and RADM Detlef B. Kammolz, German Navy, presented Professor Rudolf Panholzer, Dean of Science and Engineering, with a commemorative coin signifying the establishment of the German university. Dr. Panholzer was recognized for his contributions towards the collaborative program established between the two schools that began in 1973.

NPS FACULTY RECOGNIZED FOR OUTSTANDING RESEARCH ACHIEVEMENTS IN 1998

DIVISION OF COMPUTER AND INFORMATION SCIENCES AND OPERATIONS

Assistant Professor Cynthia Irvine was recognized for outstanding research achievement in the Department of Computer Science. Professor Irvine has done significant work on the key issues in secure software and secure networks. She has been Director of the NPS Center for INFOSEC (Information Security) Studies and Research (CISR) for the last three years and has built an impressive program in this area. She has done important research on software design for security enforcement in computer networks and for computer systems containing both classified and unclassified information. This includes design of safe electronic mail systems and analysis of potential places of attack in computer programs.

Professor Norman Schneidewind was recognized for outstanding research achievement in the Information Systems Academic Group. Professor Schneidewind has done significant work on a major issue in software engineering: the relationship between (1) product quality and (2) process capability and maturity. His integration of product and process measurement and evaluation serves the dual purpose of (1) using metrics to assess and predict reliability and risk and (2) concurrently using these metrics for process stability evaluation. He has used the NASA Space Shuttle flight software to illustrate his approach, and his work has been widely cited in the literature.

CAPT James Powell, USN, was recognized for outstanding research achievement in the Information Warfare Academic Group. Captain Powell has done significant work on high power microwave applications to military problems. He was instrumental in constructing and completing a project on High Power Microwave effects on anti-ship missiles which included static ground tests and two airborne dynamic tests. He also assisted a classified program office in the development through test completion of a High Power Microwave Advanced Concepts Technology Demonstration, the results of which were a national first in transitioning such a capability to a successful field test. In a parallel effort, CAPT Powell also was the principal investigator in a series of Information Operations modeling and simulation efforts that have received attention at the highest levels in the Navy and Joint Staff.

The Annual Research Recognition Evening held in April honors the recipient of the Carl E. and Jesse W. Menneken Faculty Award for Excellence in Scientific Research. This year's recipient was Associate Professor *Hemant Bhargava* of the Information Systems Academic Group (see *RESEARCH, Volume 9, Number 1*). The event also provides the opportunity to recognize faculty at NPS for outstanding research achievement in the previous year. The faculty listed here were recognized for outstanding research achievements in 1998.

Assistant Professor Todd Weatherford of the Department of Electrical and Computer Engineering was recognized for outstanding research achievement in the Space Systems Academic Group for his collective achievements in the field of radiation hardening of solid state devices and microelectronic circuits. The research conducted by Professor Weatherford and his faculty/student research team has lead to significant improvements in both the theoretical understanding of and practical solutions to radiation hardening of space electronics. His most recent work rescued a National Security Agency program when it was discovered that a new chip that was under development did not meet radiation susceptibility specifications. The work of Professor Weatherford resulted in a six order of magnitude, or one million times, decrease in the radiation susceptibility of the new chip, allowing the behind-schedule project to be immediately transferred to production. The work of Professor Weatherford and his faculty/student team is a prime example of the military-relevant research conducted at the Naval Postgraduate School.

DIVISION OF SCIENCE AND ENGINEERING

Distinguished Professor Max Platzer was recognized for outstanding research achievement in the Department of Aeronautics and Astronautics. Professor Platzer has a record of productive research extending back to before the time of his arrival at NPS in 1970. His work has focused on a variety of prob-

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OUTSTANDING RESEARCH ACHIEVEMENTS, *continued from page 24*

lems in both internal and external aerodynamics and in the interdisciplinary field of aeroelasticity. For many years, he has led an illustrious group of scholars in a multi-faceted reimbursable research program for all branches of the military service, including the Naval Air Systems Command, the Office of Naval Research, the Army Research Office, and the Air Force Office of Scientific Research. In that process, dozens of students have worked on thesis research under his direction and have had the opportunity to directly contribute to solutions of relevant Naval aviation problems. To broaden this effort, Professor Platzer was instrumental in forming a Joint Institute between NPS and the NASA Ames Research Center in 1986 to enable cooperative research, with student involvement, on aerodynamic problems related to both rotary wing and fixed wing aircraft. Professor Platzer has served as director of the institute for thirteen years.

Pictured with the NPS Superintendent, RADM R.C. Chaplin, are the faculty honored at the Annual Research Recognition Evening. From left to right are Associate Professor Jim Luscombe, Associate Professor Peter Chu, Professor Norman Schneidewind, Distinguished Professor Max Platzer, Assistant Professor Pierre Poulain, Assistant Professor Cynthia Irvine, Professor Richard Franke, Assistant Professor Todd Weatherford, Assistant Professor James Felli, Assistant Professor Qing Wang, Associate Professor Arnold Buss, Assistant Professor Xiaoping Yun, and Associate Professor Ashok Gopinath.

Associate Professor Xiaoping Yun was recognized for outstanding research achievement in the Department of Electrical and Computer Engineering. Professor Yun works in the area of controls and robotics. He has one reimbursable research project funded by the National Science Foundation and this past year initiated another long-term project with the Naval Sea Systems Command to investigate the use of wireless networks for submarine damage control. During 1998, Professor Yun supervised six MSEE theses, delivered three conference presentations with published papers and published two journal articles related to his research. In addition, he served as a Technical Program Committee member for five international conferences and submitted a successful proposal to bring the 1999 IEEE International Symposium on Computational Intelligence in Robotics and Automation to Monterey. He will serve as Co-Chair for that conference this year.

Professor Richard Franke was recognized for outstanding research achievement in the Department of Mathematics. Professor Franke is honored for his valuable research on statistical interpolation and correlation, especially as applied to the correlation of temperature and relative humidity errors. Plans for increasing the vertical resolution of the Navy Operational Global Atmospheric Prediction System (NOGAPS) used by Fleet Numerical Meteorological and Oceanographic Center required that the covariance structure for temperature and relative humidity errors be modeled more accurately. Professor Franke has carried out an investigation into the statistical properties of the data for these quantities. Using historical data, he found that his methods give a substantially better fit than methods previously used.

Assistant Professor Ashok Gopinath was recognized for outstanding research achievement in the Department of Mechanical Engineering. Professor Gopinath has been involved in a variety of interdisciplinary research efforts, as well as a participant in the Space Systems program at NPS. His expertise

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OUTSTANDING RESEARCH ACHIEVEMENTS, *continued from page 25*

lies in the areas of acoustics and the thermo-fluids sciences. With NASA sponsorship he has applied his expertise to thermoacoustic refrigeration. Based on related work he has initiated a patent for a novel, acoustic-based laboratory technique, which he has developed with his students, to measure the oscillatory wave loading on large-scale marine and offshore structures. In another interdisciplinary effort he has collaborated with Professor Alan Fox on the studies of heat transfer in underwater welding with the sponsorship of NAVSEA. This work has application to in situ ship repair, which can lead to reduced need for expensive dry-docking.

Assistant Professor Qing Wang was recognized in the Department of Meteorology for her outstanding research accomplishments in understanding the physical properties of the marine atmospheric boundary layer. This new understanding was achieved by a combination of insightful analysis of atmospheric measurements taken from aircraft following freely drifting balloons, and by theoretical modeling. She has developed a diverse and increasing base of reimbursable research funding sources, including NASA, ONR and NSF, and she documented her results in five journal articles published last year.

Assistant Professor Pierre Poulain was recognized for outstanding research achievement in the Department of Oceanography. In collaboration with the Naval Oceanographic Office and European oceanographic institutes, Professor Poulain is using low-cost satellite-tracked drifters to study the spatial structure and temporal variability of the surface currents, from the mesoscale (10km, days) to seasonal scales (1000 km, months) in semi-enclosed basins, such as the Adriatic and Ionian Seas. The data are augmented with passive satellite data for sea surface temperature and chlorophyll concentration. The most important, and Navy relevant, results emerging from the research are quantitative maps of the sea surface currents, temperature and chlorophyll (turbidity) in sea areas where classical ship-based measurements are not possible due to political and military reasons.

DIVISION OF OPERATIONAL AND POLICY SCIENCES

Professor David Yost was recognized for outstanding research achievement in the Department of National Security Affairs. Professor Yost received the Department's research award for his ongoing work on issues related to European security, information warfare, and the Revolution in Military Affairs. In 1998 his efforts produced a major article on NATO and Collective Security, a topic of immediate importance, in the prestigious journal *Survival* and a monograph entitled *NATO Transformed: The Alliance's New Roles in International Security* published by the U. S. Institute of Peace. Professor Yost also has been highly successful in securing sponsorship of his work by the Under Secretary of Defense for Policy, the Naval Information Warfare Activity, the Defense Threat Reduction Agency, and the U. S. Institute of Peace.

Associate Professor Arnold Buss was recognized for outstanding research achievement in the Department of Operations Research. Professor Buss is recognized for his contributions in the area of modeling, simulation and analysis. With multi-year funding from the Air Force Office of Scientific Research, the Army TRADOC Analysis Center, and the U. S. Special Operations Command, Professor Buss is pioneering the component-based approach to simulation. His best known achievement is *SimKit*, a public-domain Java-based package of reusable simulation components. *SimKit* has been applied by thesis students, as well as analysts in other organizations, to improve our understanding of important defense issues, such as ship missile defense, search and detection, integrated air defense, radar detection, and operations other than war. According to the U. S. Marine Corps' Principal Analyst for Modeling and Simulation, "Professor Buss's work is thriving because the simulation community is consolidating on a standard set of basic components, which notable includes *SimKit*. Dr. Buss is one of a handful of people setting the course for academic simulation in the next century."

Associate Professor James Luscombe was recognized for outstanding research achievement in the Department of Physics. Professor Luscombe's highly productive research provides innovative and diverse thesis topics for our students. His research is ultimately concerned with miniaturization of practical technologies. These days this kind of work falls under the heading of Nanotechnology, i.e., technologies pertaining to nanometer length scales, where quantum effects become important. As a theoretical physicist Professor Luscombe has made significant contributions in this field by developing theoretical models of the electronic, magnetic and structural properties of materials and systems at the nanometer scale. Professor Luscombe's excellence in research and established national reputation is evidenced by the fact that

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OUTSTANDING RESEARCH ACHIEVEMENTS, *continued from page 26*

as part of the 100th year celebration of the American Physical Society, the editor of the American Journal of Physics solicited him to write a review article on fundamental developments in Statistical Physics.

Assistant Professor Mark Nissen was recognized for outstanding research achievement in the Department of Systems Management. Professor Nissen engages in research focused on process innovation, as it applies to military, government and business enterprises. His research has led to development and demonstration of a prototype knowledge system that was successfully employed in the field to redesign the procurement processes of a major Navy aviation command. The systematic innovation method and knowledge systems are also used for instruction and thesis direction in both the acquisition and information systems curricula. Mark's research led to acceptance of nine published papers, seven conference presentations and two book chapters in 1998. Professor Nissen also secured a major new research sponsor in 1998, which brought an additional half-million dollars of funding and considerable recognition to the Naval Postgraduate School.

Associate Professor Peter C. Chu was recognized for outstanding research achievement in the Institute for Joint Warfare Analysis. Professor Chu's research on the environmental effects on joint warfare simulations at various scales (e.g., theater level, technical level, …) such as incorporating the Navy's Meteorological and Oceanographic (METOC) date and models effectively into the Navy Research Evaluation Systems Analysis (RESA) model and the mine warfare countermeasure models, is noteworthy. Professor Chu is contributing to operational effectiveness by insuring that ocean environmental models in use by the Navy are state-of-the-art. In this way he is merging traditional academic research with operational applications.

DEFENSE RESOURCES MANAGEMENT INSTITUTE

Assistant Professor James C. Felli was recognized for his significant research contributions in the areas of health economics and in the Department of Defense's management of foreign currency operations. In one paper published this past year, he and his co-author examined the use of sensitivity analysis in the health literature. In another paper accepted for publication this past year, Professor Felli and another co-author examined the Department of Defense's foreign exchange rate exposure in light of the government's prohibition against foreign currency hedging. Using data from the United States Air Force and Monte Carlo simulation, they examined whether the use of forward foreign exchange contracts or currency options might reduce the financial impact of currency fluctuation. Their results strongly indicated that these alternatives outperformed the DoD's current method for dealing with foreign currency exposure.

SYMPOSIUM HONORS OPERATIONS RESEARCH PROFESSOR

On 26 March 1999, the Department of Operations Research at the Naval Postgraduate School hosted an International Symposium in Honor of Distinguished Professor Peter A.W. Lewis on the occasion of his retirement. Leading scholars gathered from around the world to present papers highlighting Professor Lewis' contributions to: Nonlinear Time Series, Simulation Methodology, Statistical Computation and Stochastic Point Processes. The scholars came from a broad spectrum of disciplines, attesting to the wide range of interest and applicability of Lewis' work. The symposium concluded with a banquet attended by 88 people, some of whom had traveled from as far away as New Zealand, Hong Kong, Paris and Scotland just to participate in this event.

In a tribute typical of the gathering, Professor Manny Parzen of Texas A&M University and the Hebrew University of Jerusalem said: "Peter Lewis is distinguished both in job title and in his career. He has achieved excellence at the highest levels in teaching, dissemination of knowledge, mentoring colleagues, consulting on difficult problems, and service to the professional community."

Peter Adrian Walter Lewis was born in South Africa in 1932 and emigrated to the U.S. in 1950. He received two bachelor's degrees from Columbia University in 1954 and 1955, the first liberal arts and the other in electrical engineering. He worked for IBM from 1955 to 1971 with breaks for taking a Ph.D. with Sir David Cox at the University of London, and for a visit with the U.S. Army. He joined the Naval Postgraduate School in 1971 as Professor of Operations Research

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CONFERENCES/WORKSHOPS

MARINE AND COASTAL WEATHER FORECASTER WORKSHOP

Over 30 forecasters from the National Weather Service (NWS) and the U.S. Navy attended the Marine Forecaster Training Workshop from 24-28 May 1999 that was sponsored by the NWS and developed by the Naval Postgraduate School (NPS). Associate Professor Wendell A. Nuss, Department of Meteorology, conducted the workshop along with 17 guest speakers from NWS, National Oceanic and Atmospheric Administration (NOAA), Fleet Numerical Meteorology and Oceanograpy Center (FNMOC), and the National Center for Environmental Prediction. Topics included summer- and winter-time coastal meteorology (Professor Nuss and Dr. F. Martin Ralph, NOAA), satellite meteorology (Professor Chuck Wash, Department of Meteorology, NPS), coastal oceanography observations and modeling (Associate Professor Jeff Paduan, Department of Oceanography, and Professor Robert Haney, Department of Meteorology, NPS), and ocean wave modeling and forecasting (Dr. Hendrik Tolman, NOAA, and Dr. Steve Lyons, the Weather Channel). This is the second time this training course has been conducted by NPS. The course is a crucial outreach activity of the Department of Meteorology to NWS and the operational Navy METOC community.

WORKSHOP TO "BENCHMARK" THE EFFECTS OF SHALLOW WATER ENVIRONMENTAL VARIABILITY

Assistant Professor Kevin B. Smith, Department of Physics, and Dr. Alex Tolstoy, Scientific Solutions, Inc., are co-organizers of a workshop to "benchmark" the effects of shallow water environmental variability, to be held at NPS on 8-10 September 1999. This workshop will investigate the effects of environmental variability, i.e., range, depth, and azimuthal variability, on acoustic signal propagation, the accuracy of the applied propagation models, and will consider some limited signal processing of the modeled acoustic fields. The long-term objective is the development of efficient propagation models that can accurately estimate acoustic signal behavior in all kinds of shallow water environments. These shallow water environments include but are not limited to: continental shelves, canyons, seamount neighborhoods, highly sedimented and/or lightly sedimented bottoms, highly attenuated bottoms, rough sea surfaces and bottoms, elastic bottoms, the presence of internal waves, and bubbles. Such advance future models will also be capable of predicting full 3-D acoustic fields as necessary. Additional information can be found at http://web.nps.navy.mil/~kbsmith/main.html.

HARDENED ELECTRONICS AND RADIATION TECHNOLOGY CONFERENCE

The Hardened Electronics and Radiation Technology (HEART) Conference, along with the Government Microcircuit Applications Conference (GOMAC), were held at the Naval Postgraduate School (NPS) on 8-12 March 1999. The conferences are a forum for government agencies and the private technical community to exchange current information on classified and International Traffic-In-Arms (ITAR) research in the areas of radiation effects, electronics vulnerability, nuclear hardness technology, microcircuits and pulse power systems development. The Defense Special Weapons Agency (DSWA), Sandia National Laboratories, Air Force Research Laboratory, U.S. Army Space and Missile Defense Command, and the Navy Strategic Systems Program Office jointly sponsor this annual conference. Assistant Professor Todd Weatherford, Department of Electrical and Computer Engineering, was the local arrangement chairman. Approximately 400 attendees represented the Services, government laboratories and agencies, and a broad cross-section of contractors from the electronics industry.

Dr. Frank Fernandez, Director of the Defense Advanced Research Project Agency (DARPA), Dr. William Spencer Chairman of the Board of SEMATECH, and RADM Robert Chaplin, NPS Superintendent, gave keynote addresses. Dr. Fernandez discussed the future role of semiconductor electronics needs for government applications in the next century. Dr. Spencer presented SEMATECH's roadmap for silicon electronics. RADM Chaplin discussed how these national needs are driving education and how NPS contributes to the community.

NPS student LCDR Jeffery P. Link, USN, presented a paper at the GOMAC conference titled, "A Bus Interface for Tactile Communications." NPS students attended several sessions to understand the issues between the special needs of the military and the increasing consumer focus of the semiconductor industry.

The joint conference committees look forward to returning to Monterey in the future. NPS and the Hyatt Hotel provide one of the few locations where unclassified and classified conferences can occur within walking distance for attendees.

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SHORT COURSE ON RECENT RESULTS IN WARFIGHTING TECHNOLOGIES PRESENTED TO SWEDES

Through video-teleconferencing, RADM R. C. Chaplin, the Superintendent of the Naval Postgraduate School, VADM Arthur Cebrowski, U.S. Naval War College, and the delegation from the Swedish National Defence College were able to share their views at the recent Results in Warfighting Technologie's short course.

The Naval Postgraduate School's Center of Joint Services Electronic Warfare conducted the third three-week short course to officers from the Swedish National Defence College. This year's course was titled "Recent Results in Warfighting Technologies." Organized by Associate Professor Phillip E. Pace of the Department of Electrical and Computer Engineering, the course was well received by the 33 attendees. Sessions presented by NPS faculty included: Unmanned Aerial Vehicle (UAV) Technology; Electronic Warfare (EW) Modeling and Simulation; Advanced Receiver Technology I and II: Weapons Effects I and II; Estimation of Atmospheric Effects; Impulse and Ultra Wideband Scattering; ATM Technologies I and II; Laser/Radar Cross Section I and II; Infrared and Electro-Optical Systems; and Countermeasures. The course also included field trips to the Silicon Valley (Condor Systems and Lockheed Martin). The special features of this short course were: the focus on interoperability of forces in littoral warfare and a special 2-day session titled "C2W for the Next Millenium: A Flag Review."

The success of the three-week course has made it an integral part of the 2-year Military Technology curriculum at the Swedish National Defence College and has opened up discussions concerning other collaborative efforts. These include professor exchanges, joint research projects, FOA (Swedish Defence Research Establishment) translation of literatures, televideo-courses, and additional students for the NPS' degree granting programs. The next course is scheduled for 20 March through 7 April 2000.

NPS students and faculty joined members of the Swedish National Defence College during the three-week course. NPS faculty and students can attend any of the conferences, courses or workshops at NPS (within security classification requirements) free of charge.

SHORT COURSES, *continued from page 27*

FIRST ANNUAL CLASSIFIED ADVANCED TECHNOLOGY UPDATE

The Naval Postgraduate School offered the First Annual Classified Advanced Technology Update (CATU) Short Course, 8-12 March 1999. The week-long course, held at the TOP SECRET/SCI clearance level, was facilitated by Professor Herschel Loomis, Department of Electrical and Computer Engineering, and Mr. Vicente Garcia, the National Security Agency Cryptologic Chair at NPS. Approximately 100 representatives from the intelligence community attended the classified course. NPS students and staff, with the requisite security clearance, were also present for various presentations that were of particular interest to them. Twenty-one guest lecturers, selected for their renowned work and recognized subject matter knowledge, provided technical presentations on their area of expertise. Technical topics presented included Cryptology, Information Operations, Overhead Reconnaissance, Digital Signal Processing, Navigation, Communications, Low Probability of Intercept, and Geolocation. Department of Defense forums such as these allow military and civilian technical personnel to stay current on the technological trends in these areas. NPS also provides an unbiased, unrestrained environment for all participants to freely discuss the research and development at their organizations and applications of those technologies in support of their missions. On the last afternoon of the CATU, attendees were provided tours of several NPS research laboratories. Because of the overwhelming success of this year's first CATU, as evinced by the positive feedback noted on participant course critiques, NPS plans to continue offering this course on an annual basis. The next CATU has been tentatively scheduled for March 2000.

NPS TO OFFER SOFTWARE TECHNOLOGY REVIEW AND UPDATE SHORT COURSE

NPS will offer the first Software Technology Review and Update Short Course from 30 August –3 September 1999. The course is modeled after the Technology Review and Update Course that has been successfully conducted at NPS for the past 16 years. The course is intended for military and civilian technical personnel who are interested in refreshing and updating their knowledge in the areas that are listed in the course outline below. This course provides an excellent overview and stresses the more practical aspects of the topics listed.

- Economics of the Information Age
- Risk Assessment and Management
- Requirements Engineering
- Maintenance of Large Software Systems
- Software Engineering and Management
- Network-Centric Computing
- Software Productivity and Quality
- Decision Support Systems
- Computer-Aided Prototyping

For further information about the course, please e-mail se@cs.nps.navy.mil.

TECHNOLOGY REVIEW AND UPDATE

The sixteenth annual Technology Review and Update for Technical Personnel was conducted at NPS in April. The five-day course, organized by Professor Rudolf Panholzer, Dean of Science and Engineering and Chair of the Space Systems Academic Group, was attended by over 30 representatives from government and industry. Presenters and topics included:

- Vicente Garcia, National Security Agency Cryptologic Chair at NPS, and CAPT Jim Powell, Information Warfare Academic Group: Information Warfare and Information Operations
- Professor John Powers, Department of Electrical and Computer Engineering: Electro-Optical and Infrared Systems
- Dr. Richard White, University of California-Berkeley: Micro Electro-Mechanical Systems
- James Lenz, Honeywell, Inc.: Optical Sensing Technology.
- Jeff Jenkins, Xilinx, Inc.: Integrated Circuits
- Austin Boyd, Science Applications International Corporation: Military Satellite Communications Technologies
- Dr. James Stuart, Kitcomm: Satellite Communication Technologies and Trends
- Dr. Hamid Berenji, Intelligent Inference Systems Corporation: Computational Intelligence.

In addition to the presentations, the participants were provided tours of selected NPS research labs. Feedback from technically oriented participants and those wishing to get back into these technical fields was excellent. Future courses will continue to respond to the changes rapidly occurring in technology today.

RELATIONSHIPS

MEASUREMENT AND SIGNAL INTELLIGENCE (MASINT) CHAIR ESTABLISHED AT NPS

A recently executed Letter of Intent between the Naval Postgraduate School and the Central MASINT Organization established a MASINT Chair Professorship and a Research Center at the Naval Postgraduate School. The objective of establishing the Chair Professor is to nurture a closer relationship between the two organizations. The MASINT Chair will serve as a liaison between NPS and CMO and direct the operations of the MASINT Research Center. The Chair will conduct and direct mutually beneficial research, chair joint conferences/workshops or symposia, serve as a thesis and research advisor to NPS students, and present seminars or teach classes as appropriate.

Lyle Ashton Cox, Jr. will be the first chair incumbent. Mr. Cox will occupy the Chair under an Intergovernmental Personnel Act Agreement with Riverside Research Institute. Mr. Cox has over 30 years experience in complex systems engineering and high performance information technology and is expected to be a valuable resource to NPS faculty and students.

MEMORANDUM OF UNDERSTANDING ESTABLISHES USMC SPONSORSHIP OF NEW CURRICULA

A Memorandum of Understanding has been executed between the Assistant Chief of Staff, Command, Control, Communications, Computers, and Intelligence (C4I), U.S. Marines Corps USMC), and the Naval Postgraduate School (NPS). The purpose of the agreement is to establish an USMC sponsor for Information Technology (IT) related curricula at the Naval Postgraduate School. The IT curricula under this MOU are Information Sciences, Systems, and Operations (ISSO) and Information Sciences and Operations (ISO). The ISSO curriculum is a technical curriculum with specialties in computer science, joint C4I systems, information technology management, information warfare, modeling, virtual environments, and simulations (MOVES), and space systems operations. The ISO curriculum is an operational focused curriculum for warfighters.

MEMORANDUM OF UNDERSTANDING WITH DON CIO

Under a Memorandum of Understanding recently signed between the Department of the Navy's Chief Information Officer (DON CIO) and the Naval Postgraduate School (NPS), Dr. Maxine Reneker, NPS' Library Director, will rotate to the DON CIO to assist with new Enterprise Integration area projects including those within the scope of the Librarian of the Navy. The rotation will also provide the opportunity for Dr. Reneker to participate in the development of new strategies and approaches for these projects.

CONFERENCES, *continued from page 28*

NATO RTO SCI-23 WORKING GROUP MEETING

The biannual meeting of the NATO Research Technology Organization (RTO) SCI-23 Working Group was held at the Naval Postgraduate School on 22-26 March 1999. The group consists of over 20 members from NATO countries. Associate Professor Isaac Kaminer, Department of Aeronautics and Astronautics, hosted the meeting. The purpose of the group is to produce a document detailing future key technology areas that need to be developed to produce completely autonomous Unmanned Combat Air Vehicles (UCAVs). As a member of the group, Professor Kaminer had the opportunity to provide input to the document that will be used by the NATO military planners as an aid in making decisions on allocation of research and development funds for UCAVs well into the 21st century. The meeting was highly relevant to NPS' mission in general and in particular to our emphasis on UAVs.

ONR WORKSHOP ON SPATIAL KNOWLEDGE ACQUISITION IN LARGE-SCALE VIRTUAL ENVIRONMENTS

Experts in psychology, engineering, computer science, and geography from Stanford University, Vanderbilt University, MIT, Harvard University, University of South Carolina, University of Virginia, University of Houston and representatives of the ONR funded programs, Spatial Orientation and Navigation (SPATNAV) and Virtual Environment Training Technology (VETT), participated in a NPS workshop organized by Assistant Professor Rudolph P. Darken, Department of Computer Science. The attendees brought together their expertise from related areas to the theme of the meeting to define a strategic plan for future ONR programmatic investments. Discussion began on topics related to basic research in human spatial cognition ranging from the phenomenon of mental rotation to

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AERONAUTICS AND ASTRONAUTICS

Prof. S.K. Hebbar has prepared a concise study guide specifically for refresher students, entitled, "Self-Study Instructions for AA-R261—Solid Mechanics Refresher."

I.H. Tuncer, S. Weber, and W. Sanz, "Investigation of Periodic Boundary Conditions in Multipassage Cascade Flows Using Overset Grids," *Journal of Turbomachinery,* Vol. 121, pp. 341-347, April 1999.

COMPUTER SCIENCE

S. Balmer, S. Bryner-Joyner, B. Eads, S.D. Heller, C.E. Irvine, "High Assurance Multilevel Secure Mail Service, Session Server and IMAP Server," IEEE Symposium on Security and Privacy, Oakland, CA, May 1999.

M. Harn, V. Berzins, and Luqi, "A Dependency Computing Model for Software Evolution," *Proceedings of the Eleventh International Conference on Software Engineering and Knowledge Engineering,* 17-19 June 1999, Kaeserslautern, Germany.

C.E. Irvine and T. Levin, "Security Approach for a Resource Management System," IEEE Symposium on Security and Privacy, Oakland, CA May 1999.

C.E. Irvine served on the Program Committee of the Twentieth Anniversary IEEE Symposium on Security and Privacy, Oakland, CA, May 1999.

C.E. Irvine, "Student Research in INFOSEC Education," Third National Colloquium on Information Systems Security Education, Palisades, NY, May 1999.

C.E. Irvine, "The Reference Monitor Concept as a Unifying Principle in Computer Security Education," *Proceedings of the First World Conference on Information Security Education,* Stockholm, Sweden, June 1999.

C.E. Irvine, "Amplifying Security Education in the Laboratory," Keynote address at the First World Conference on Information Security Education, Stockholm, Sweden, June 1999.

C.E. Irvine, "The Reference Monitor Concept as a Unifying Principle in Computer Security Education," *Proceedings of the First World Conference on Information Security Education,* Stockholm, Sweden, June 1999.

Prof. N. Rowe has been appointed General Chair of the Fourth ACM Conference on Digital Libraries, Berkeley, CA, 11-14 August 1999.

M. Shing, Luqi, V. Berzins, M. Saluto, and J. Williams, "Architectural Re-Engineering of Janus Using Object Modeling and Rapid Prototyping," *Proceedings of the 10th IEEE International Workshop on Rapid System Prototyping,* Clearwater, FL, 16-18 June 1999.

W.R. Shockley, C.E. Irvine, and H.R. Isa, "A Multi-Threading Architecture for Multilevel Secure Transaction Processing," *Proceedings of the IEEE Symposium on Security and Privacy,* Oakland, CA, May 1999.

ELECTRICAL AND COMPUTER ENGINEERING

J. Butler, P.E. Pace, and J.P. Powers, "Experimental Results of a Low-Power Sigma Mode-Locked Fiber Laser for Applications in Mobile Sampling of Wideband Antenna Signals," Ninth Annual DARPA Symposium on Photonic Systems for Antenna Applications, Naval Postgraduate School, 18 February 1999.

Prof. R. Janaswamy was appointed for a two-year term as an Associate Editor of *Radio Science Journal of the American Geophysical Union.*

R. Janaswamy was listed in *Baron's Who's Who of the World,* 1999-2000 Edition.

P.E. Pace, J.P. Powers, J.M. Butler, and S. Bewley, "NPS Research in Digital Antennas," DARPA/ETO 1999 Photonic A/D Converter Technology Meeting, MIT Lincoln Labs, 20 April 1999.

Prof. P. Pace served on the Navy's Blue Ribbon Panel for the NULKA Opeval Test, 11-15 January 1999.

Prof. P. Pace chaired the N9 Threat Simulator Validation Working Group, Monterey, CA, 13-15 April 1999. This group discusses the validation of threat missile simulators (RF, IR digital computer models) for use by COMOPTEVFOR.

P.E. Pace, S.A. Bewley, and J.P. Powers, "Fiber Lattice Accumulator Design Considerations for Optical Sigma-Delta Antennas," Ninth Annual DARPA Symposium on Photonic Systems for Antenna Applications, Naval Postgraduate School, 19 February 1999.

R. Pieper and S. Michael, "A Robust Algorithm for Predicting Freezeout and Exhaustion Under Equilibrium Conditions," *Proceedings of the Second International Conference on Modeling and Simulation of Microsystems,* pp. 87-90, 19-21 April 1999, San Juan, Puerto Rico.

J. P. Powers presented a three-day short course on Fiber-Optic Systems Engineering at the Naval Surface Warfare Center-Dahlgren Division (NSWC-DD), March 1999.

J.P. Powers and P.E. Pace, "NPS Research in Digital Antennas," DARPA's Photonic Analog-to-Digital Converter Technology (PACT) Program, MIT-Lincoln Laboratory, April 1999.

C. Robertson served as General Chairman of the IEEE Communications Theory Workshop, Aptos, CA, 23-26 May 1999.

S. Roquette, O. Atlata, M. Najim, and C.W. Therrien, "2-D High Resolution Spectral Estimation Based on Multiple Regions of Support," *Proceedings ICASSP Conference,* Phoenix, AZ, March 1999.

C.W. Therrien, W.K. Jenkins, and X. Li, "Optimizing the Performance of Polynomial Adaptive Filters: Making Quadratic Filters Converge Like Linear Filters," *IEEE Transactions on Signal Processing,* Vol. 47 No. 4, April 1999.

M. Sedogan, R.D. Hippenstiel, and T.T. Ha, "Performance Analysis of NonCoherent DPSK with Various Diversity Combining Techniques in a Ricean Fading Channel," Second Annual UCSD Conference on Wireless Communications, San Diego, CA, 1-2 March 1999.

INFORMATION SYSTEMS

M.N. Kamel, "Knowledge Acquisition," John G. Webster, ed., *Wiley Encyclopedia of Electrical and Electronics Engineering,*

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February 1999.

N.F. Schneidewind, "Software Validation for Reliability," *Encyclopedia of Electrical and Electronics Engineering*, John G. Webster, ed., John Wiley & Sons, Inc., March 1999.

N.F. Schneidewind, "Software Maintenance," *Encyclopedia of Electrical and Electronics Engineering*, John G. Webster, ed., John Wiley & Sons, Inc., March 1999.

N.F. Schneidewind, "Call for Participation: Standard Dictionary of Measures of the Software Aspects of Dependability," *IEEE Software*, Vol. 16, No. 1, p. 57, January-February 1999.

Prof. Schneidewind was recognized by the IEEE Standards Board in the "Awards Spotlight" of the IEEE Standards Bearer, Vol. 13, No., p. 6, February 1999.

N.F. Schneidewind, "IEEE Standard for a Software Quality Metrics Methodology: Revision," Celia Modell, ed., *IEEE Standards Office*, December 1998.

N.F. Schneidewind, "Development and Maintenance Process Assessment Using Reliability, Risk, and Test Metrics," Quality Week, Software Research, Inc., San Jose, CA, 24 May 1999.

N.F. Schneidewind and A.P. Nikora, "Issues and Methods for Assessing COTS Reliability, Maintainability, and Availability," *Proceedings of the Workshop on Ensuring Successful COTS Development*, 21st International Conference on Software Engineering, Los Angeles, CA, 22 May 1999.

N.F. Schneidewind, "Case Study of Evaluating the Maintenance Process of a Legacy System," *Proceedings of the Eleventh Annual Software Technology Conference*, (CD/ROM), Salt Lake City, UT, 6 May 1999.

N.F. Schneidewind, "Applying Software Reliability Engineering in the 1990s," *IEEE Reliability Society 50th Anniversary Special Publication*,William Everett, et al, pp. 374-SP & 376-SP, September 1998.

INFORMATION WARFARE

J. Arquilla and T. Karasik, "Chechnya: A Glimpse of Future Conflict?" *Conflict and Terrorism*, Fall 1999.

J. Arquilla, "The Two Faces of Cyberwar," *SHINCHOSA* ("Foresight"), May 1999.

MATHEMATICS

C. Borges, "On the Estimation of Markov Random Field Parameters," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, Vol. 21, No. 3, pp. 216-224, March 1999.

R. Franke and H. Hagen, "Least Squares Surface Approximation Using Multiquadrics and Parametric Domain Distortion," *Computer Aided Geometric Design*, 16, pp. 177-196, 1999.

MECHANICAL ENGINEERING

A.G. Fox, "Modern Trends in Transmission Electron Microscopy and Diffraction," National Center for Electron Microscopy, Lawrence Berkeley Laboratory, University of California, Berkeley, CA, 25 March 1999.

A.G. Fox and G.M. Evans, "An Analytical Transmission Electron Microscope Study of the Inclusions Responsible for the Nucleation of Acicular Ferrite in C-Mn Steel Weld Metals Containing Titanium and Aluminum," 80th Annual American Welding Society Convention, St. Louis, MO, 12-15 April 1999.

E.S.K. Menon, A.G. Fox, and R. Mahapatra, "Phase Transformations in Ti-44A1-11Nb," Solid-Solid Phase Transformations 99, Kyoto, Japan, 24-28 May 1999.

E.S.K. Menon, M. Saunders, J. Walters, A.G. Fox, and G.M. Evans, "An Analytical Microscope Study of Inclusions in C-Mn Steel Weld Metals," Solid-Solid Phase Transformations 99, Kyoto, Japan, 24-28 May 1999.

M. Saunders, A.G. Fox, and P.A. Midgley, "Structure Factor Measurement by ZAPMATCH," *Acta Crystallographica*, A 55, 471, 1999.

M. Saunders, A.G. Fox, and P.A. Midgley, "Debye-Waller Factor Measurement by ZAPMATCH," *Acta Crystallographica*, A55, 480, 1999.

T. Sarpkaya, "Mechanisms of Spray Generation in Space-Scales of Microns and Time-Scales of Nano-Seconds," ONR Meeting, University of California, San Diego, CA, 20-22 February 1999.

METEOROLOGY

R. Elsberry, "Forecasters Learning to Read a Hurricane's Mind," *Science Magazine*, Vol. 284, pp. 563-565, 23 April 1999.

T. Murphree, "North Pacific-North American Climate Anomalies: East Asian Wave Trains and the Northern Oscillation Index," NOAA Climate Prediction Center, Washington, D.C., 8 April 1999.

P. Sirayanone will be working on the ocean modeling at global and North Atlantic Scales for about 4 months from mid-March with Prof. J. McClean of the Department of Oceanography. At one point, the hope is to introduce the multiquadric approximation scheme into the interpolation of Naval Operational Global Atmospheric Prediction System (NOGAPS) and European Center for Medium-Range Weather Forecasts (ECMWF) wind field and wind stress. These fields are important in ocean modeling.

NATIONAL SECURITY AFFAIRS

R. Looney, "Rail and Road Transport in Pakistan: Competitive or Complementary?" *Government College Economic Journal*, Vol. XXX, No. 1& 2, pp. 1-18, 1998.

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Orin Marvel, Research Associate Professor and C3 Chair, residing in the Command, Control, Communication, Computers, and Intelligence (C4I) Academic Group, recently published an article titled, "C4ISR—The Big Picture," in the United Nations Magazine, *EEZ Technology*. *EEZ Technology* provides a review of advanced technologies for the integrated management of EEZs (Extended Enterprise Zones) and coastal zones worldwide. C4ISR plays a crucial part in integrated EEZ management.

Dr. Marvel's article will form part of a series to be featured both in future editions and on the magazine website (www.eeztech.com).

FACULTY NEWS

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R. Looney, "The Growth and Decline of Pakistan's Rail System," *The International Journal of Transport Economics*, Vol. XXV, No. 3, October 1998.

R. Looney and P. Frederiksen, "Rail Track Expansion in Developing Countries in the 1980s," *Transportation Research-E, Logistics and Transportation Review*, Vol. 34, No. 2, 1998.

R. Looney, "Foreign Capital Flows and Defense Expenditures; Patterns of Causation and Constraint in Pakistan," *Canadian Journal of Development Studies*, Vol. XIX, No. 1, pp. 117-132, 1998.

R. Looney, "Insurance in an Islamic Setting: The Case of Pakistan," *Journal of Developing Societies*, Vol. XIV, No. 2, pp. 255-270, September 1998.

D.S. Yost, *NATO Transformed: The Alliance's New Roles in International Security*, United States Institute of Peace Press, Washington, D.C., 1998.

D.S. Yost, "The New NATO Strategic Concept: Likely Outcomes and Impact," NATO at 50: The Alliance's Role at the Turn of the Century, West Sussex, United Kingdom, 19 January 1999.

D.S. Yost, "The New NATO and Kosovo," United States Institute of Peace Roundtable on NATO'S New Roles: The Kosovo Challenge, Washington, D.C., 30 March 1999.

D.S. Yost, *The U.S. and Nuclear Deterrence in Europe*, Adelphi Paper, No. 326, London: Oxford University Press for the International Institute for Strategic Studies, March 1999.

OCEANOGRAPHY

M.L. Batteen and P.W. Vance, "Modeling Studies of the Effects of Wind Forcing and Thermohaline Gradients on the California Current System," *Deep-Sea Research II*, Vol. 45, pp. 1507-1556, 1998.

P.C. Chu and C.W. Fan, "A Non-Uniform Three-point Combined Compact Difference Scheme," *Journal of Computational Physics*, 148, pp. 663-674.

P.C. Chu, "Two Kinds of Predictabilty in Lorenz System," *Journal of the Atmospheric Sciences*, 56, pp. 1427-1432, 1999.

P.C. Chu, Q.Q. Wang, and R.H. Bourke, "A Geometric Model for Beaufort/Chukchi Sea Thermohaline Structure," *Journal of Atmospheric and Oceanic Technology*, 16, pp. 613-632, 1999.

P.C. Chu, "Fundamental Problems in Coastal Ocean Prediction," Oceanology International 99, Singapore, 27-29 April 1999.

D.M. Fernandez, K.E. Laws, and J. D. Paduan, "High-Frequency Radar Simulations," *Proceedings of the IEEE Sixth Working Conference on Current Measurement*, pp. 9-13, 1999.

A.L. Gordon and J.L. McClean, "Thermohaline Stratification of the Indonesian Seas: Model and Observations," *Journal of Physical Oceanography*, 29, pp. 198-216, 1999.

T.H.C. Herbers, S. Elgar, and R.T. Guza, "Directional Spreading of Waves in the Nearshore," *Journal of Geophysical Research*, 104(C4), pp. 7683-7694, 1999.

S. Lentz, R.T. Guza, S. Elgar, F. Feddersen, and T.H.C. Herbers, "Momentum Balances on the North Carolina Inner Shelf," *Journal of Geophysical Research* (in press).

T.C. Lippman, T.H.C. Herbers, and E.B. Thornton, "Gravity and Shear Wave Contributions to Nearshore Infragravity Motions," *Journal of Physical Oceanography*, 29(2), pp. 231-239, 1999.

L.N. Ly and L. Jiang, "Horizontal Pressure Gradient Errors of the Monterey Bay Sigma Coordinate Ocean Model with Various Grids," *Journal of Oceanography*, 55, pp. 87-97, 1999.

L.N. Ly and P. Luong, "Numerical Grids Used in a Coastal Ocean Model with Breaking Wave Effects," *Computational and Applied Mathematics*, 103, pp. 125-137, 1999.

L.N. Ly and R.W. Garwood, Jr., "On Breaking Wave-Enhanced Turbulence in the Oceanic Surface Boundary Layer," *Proceedings of the Thirteenth International Symposium on Boundary Layers and Turbulence*, pp. 359-361, 1999.

L.N. Ly and P. Luong, "Numerical Multi-Block Grids in Coastal Ocean Circulation Modeling," *Applied Mathematical Modeling*, 1999 (in press).

L.N. Ly, "A Numerical Model for Circulation of the Monterey Bay Region Using Numerical Grid Techniques," Workshop on California Current Modeling, Scripps Institute of Oceanography, San Diego, CA, February 1999.

L.N. Ly and R.W. Garwood, Jr., "On Breaking Wave-Enhanced Turbulence in the Oceanic Surface Boundary Layer," Thirteenth International Symposium on Boundary Layers and Turbulence, American Meteorological Society, Dallas, TX, January

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Professor David Yost of the Department of National Security Affairs has recently published a book and a monograph. The book, *NATO Transformed: The Alliance's New Roles in International Security* (Washington, D.C.: United States Institute of Peace Press, 1998), deals with NATO's attempts to develop cooperative security structures involving Russia and the rest of the Euro-Atlantic region and NATO's conduct of crisis management and peace operations in the Balkans. Professor Yost concludes that NATO remains the single most effective institution for combining the political-military assets of the major Western powers, and that its effectiveness must be preserved for collective defense, above all, but also to enable it to conduct selected operations in support of collective security. Professor Yost's monograph is entitled *The US and Nuclear Deterrence in Europe*, Adelphi Paper no. 326 (London: Oxford University Press for the International Institute for Strategic Studies, March 1999). In this work Professor Yost examines why the Allies continue to regard U.S. nuclear forces and commitments as essential elements of NATO's security posture, even in the profoundly changed post-Cold War world. The main explanations include persistent uncertainties about Russia's future, potential threats in Europe's vicinity (including the proliferation of weapons of mass destruction), and the continuing dependence of Germany and other non-nuclear Allies on U.S. nuclear protection.

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J.D. Paduan, R. Delgado, J.F. Vesecky, Y. Fernandez, J. Diada, and C.C. Teague, "Mapping Coastal Winds with HF Radar," *Proceedings of the IEEE Sixth Working Conference on Current Measurement*, pp. 28-32, 1999.

J.D. Paduan, "HF Radars for Coastal Oceanography," IEEE Sixth Working Conference on Current Measurement, San Diego, CA, 11-13 March 1999.

Prof. J.D. Paduan was an invited program review panel member at the "Pacific Northwest Coastal Ecosystems Regional Study (PNCERS)," sponsored by the NOAA Coastal Ocean Program, 17 May 1999.

J.D. Paduan, J.F. Vesecky, D.M. Fernandez, I. Shulman, F.P. Chavez, R.A. Maffione, and J.C. Kindle, "An Innovative Coastal-Ocean Observing Network (ICON)," American Society of Limnology and Oceanography, Santa Fe, NM, 1-5 February 1999.

J.D. Paduan, "Monterey Bay Modeling and Nesting," First Surfside Climate Workshop, Scripps Institution of Oceanography, La Jolla, CA 8-10 February 1999.

L.K. Rosenfeld, J.D. Paduan, E.T. Petruncio, and J.E. Goncalves, "Numerical Simulations and Observations of the Internal Tide in a Submarine Canyon," *Proceedings of the 'Aha Huliko'a Hawaiian Winter Workshop*, University of Hawaii at Manoa, 19-22 January 1999.

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OPERATIONS RESEARCH

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DEFENSE RESOURCE MANAGEMENT INSTITUTE

P.C. Frederiksen met with the Chief Justice and spoke at the Intellectual Property and International Trade Court in Bangkok, Thailand, 27 April. This court is the first court established worldwide with jurisdiction over both intellectual property rights and international trade issues. Associate Judge Jagkrit is a DRMI graduate (SIDMC), a second Associate Judge will attend the 1999 DRMI Senior International class.

INSTITUTE FOR DEFENSE EDUCATION AND ANALYSIS

Pat-Anthony Federico was pleased to accept the invitation to join the consulting board of editors for the peer-reviewed journal, *Computers in Human Behavior.* This scholarly journal examines the use of computers in psychology and related disciplines, their impact on individuals, groups, and society, and human interactions with these machines and associated technologies.

COMPUTER SCIENCE LABS*, continued from page 13*

for wireless data entry of damage reports from a pen tablet.

A new multi-disciplinary project is getting underway. It is the mobile IP initiative, based on RFC 2002. It involves the Departments of Computer Science, Electrical and Computer Engineering and Operations Research. Each of these departments will operate a wireless bridge to a local subnet. The bridges will be running mobile IP under Linux. The Computer Science Department is initially making up to 14 mini notebooks with Ethernet radios available to students. Each mini notebook is a Libretto 110CT running Linux and the transceiver is a Lucent 2Mbps DSSS 802.11 PC card. When finished, the project will allow a student to mount filesystems local to their department or academic group and then roam anywhere on campus (even outside) and access these filesystems transparently. No network administration will be required on the mobile device even if it falls within range of a wireless bridge on a foreign subnet.

Computer Aided Prototyping Lab

The Computer Aided Prototyping Laboratory (CAPS) Lab is the premier site for the study of computer aided prototyping technology for large system development and acquisition. It is one of the best software engineering labs in the country for distributed real-time software. The lab has been developed through support from many sponsors who are committed to its success, including the National Science Foundation, Office of Naval Research, Army Research Office, Army Research Lab, Defense Information Security Agency, and the Space and Naval Warfare Systems Command and Systems Center-San Diego. The facilities include a network of workstations and multiprocessor servers, connected via a high performance fiber-optic network.

The laboratory contains a large collection of public domain reusable component libraries, including thousands of lines of reusable code on missile navigation and C3I systems developed locally. The CAPS tools help users build requirements models for proposed systems rapidly, perform feasibility and risk assessment via simulation, reduce human error, reduce development cost, perform incremental integration, check software quality incrementally, and prevent surprise project failure. It has been used to support both teaching and research on computer-aided software engineering, in a program which has been ranked the best among all academic institutions and third overall in the nation by the *Journal of Systems and Software*.

GLOBAL OCEAN AND ARCTIC SEA ICE, *continued from page 3*

comparisons over a multi-year period that includes El-Nino events. The astronomical tides have been filtered out of the records to leave only the environmental responses. The close agreement between simulated and observed fields indicates that the model is reproducing both the locally and the remotely forced events along coastlines, as would be required of any short-term Navy prediction model. Figure 2 shows a comparison of simulated ice drift and observed trajectories of drifting ice buoys; and parallel tracking over many months indicates that shorter-term forecasts will be able to predict divergence events and open water of importance to Surface-Navy and submarine operations. Figure 3 shows the time-mean simulated currents that connect the Arctic and North Atlantic Oceans via the Nordic Seas. The flows are properly positioned because the bottom topography is correctly included in the model; and current strengths are close to those observed because of the 1/6-degree grid size. Predictive models can initialize observed eddy structures in these currents through satellite data assimilation and then project the currents and acoustic fronts forward in time for weeks to months.

Figure 2: Trajectories of drifting buoys deployed on Arctic sea ice during the period 1990-1994, compared with simulated tracks from a sea-ice model. The model was driven by observed atmospheric data of the same time period and by simulated ocean currents.

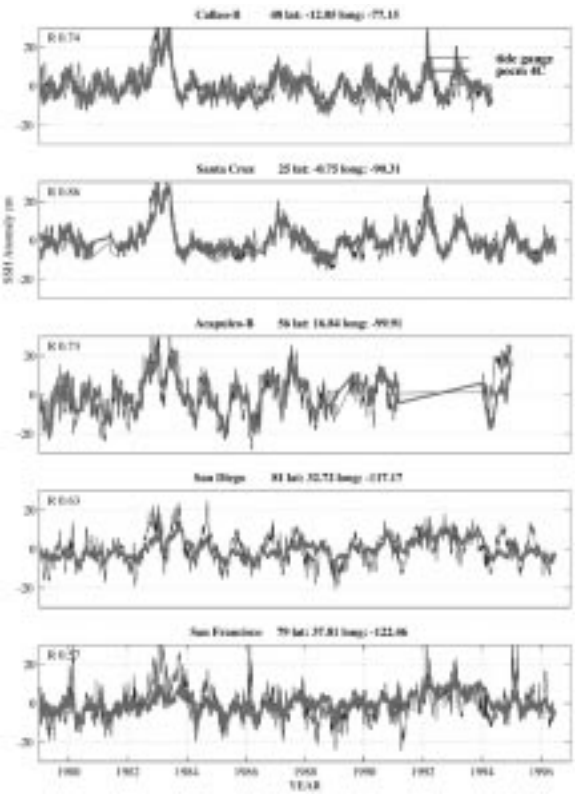

Figure 1. Time series of Eastern Pacific sea-surface heights (cm) from ocean gauges and a high-resolution model. The model captures major events in 1982, 1986, and the 1990s that propagated from the Western Pacific, as well as numerous other events that were locally forced.

Toward Global Ocean-Atmosphere Prediction

A new grant to NPS from ONR supports the testing and transitioning of global ocean models to operational status for short-term predictions when coupled to the Navy Operational Global Atmospheric Prediction System (NOGAPS). NOGAPS is a fully operational atmospheric model, for which there is no ocean counterpart other than a mixed layer model without currents or fronts. The present Thermal Ocean Prediction System (TOPS) only produces localized changes in surface temperature that result from variations in mixed-layer depth and vertical fluxes of heat and moisture. To improve on TOPS, the NPS project will use a circulation model similar to what we used in earlier studies, the LANL Parallel Ocean Program (POP); and POP will include a widely accepted method of treating localized vertical mixing via a K-profile-parameterization (KPP) of small-scale turbulence.

To ensure fully global ocean coverage without employing a separate Arctic grid to bypass problems of a singularity at the North Pole, we have adopted a new version of POP in which the north pole of the orthogonal coordinate system has been displaced into Canada. The resulting grid structure has the added advantage of giving higher spatial resolution near the U.S. East and West Coasts and in the Arctic. The grid structure of a prototype version of the model with 1/3-degree grid spacing is shown in Figure 4; and comparisons of mixed layer depths as simulated with KPP at 1/3 degree and as observed are shown in Figure 5.

This model will be regridded at 1/6-degree, spun up for twenty years

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GLOBAL OCEAN AND ARCTIC SEA ICE, *continued from page 37*

with climatological atmospheric forcing, and tested with NOGAPS forcing fields to determine how much improvement over TOPS surface temperatures can be expected by adding ocean circulation. In addition, the subsurface fields will be evaluated against the observed ocean data of the 1991-1997 World Ocean Circulation Experiment, additional datasets from Navy sources, and our own simulated fields obtained with higher-resolution ECMWF forcing. The 1/6-degree POP model will be fully coupled to NOGAPS for quasi-operational 5-day forecasts and compared with uncoupled NOGAPS and TOPS forecasts. As a result of ongoing collaboration with an NCAR DOE project, the NPS project has coupling software available to move easily between the displaced-pole grid of POP and the spherical grid of NOGAPS. Any deficiencies in the forecasting ability of the fully coupled model will be examined to find possible remedies that can be easily implemented. The coupled global model will also be able to provide open boundary conditions

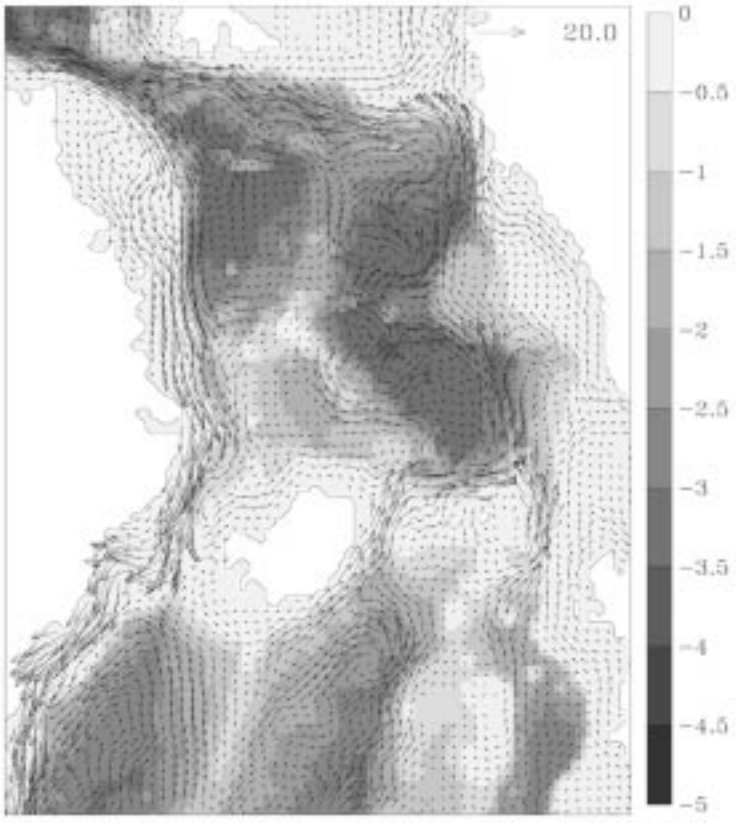

Figure 3. Time-averaged ocean currents (cm/s) below the mixed layer in the Nordic Seas. Ocean depths (km) strongly influence flows, e.g. along the Greenland-Iceland-Scotland Ridge just below center.

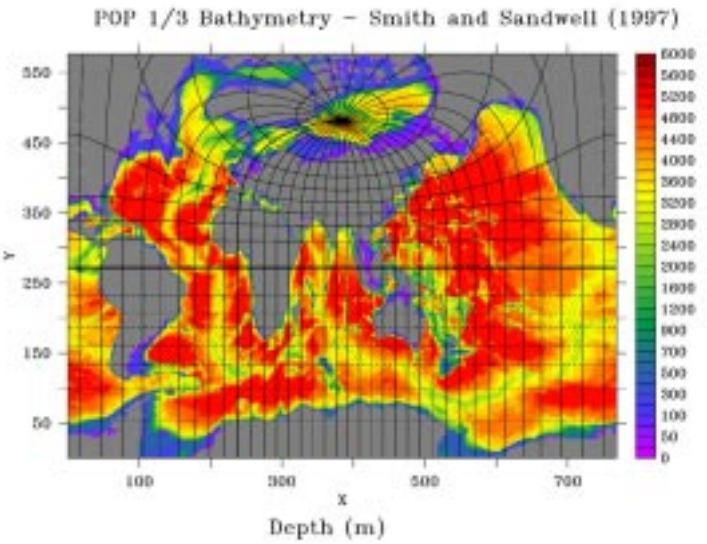

Figure 4. Ocean model geometry at 1/3-degree grid spacing, with lines of true latitude and longitude and ocean depths (m). Displacing the North Pole removes a coordinate singularity and puts many of the 768 x 576 grid points near US coasts and in the Arctic.

for the Navy's Coupled Ocean Atmosphere Mesoscale Prediction System (COAMPS).

The full promise of ocean-atmosphere forecasting cannot be realized without adding ocean data assimilation and going to even finer than 1/6-degree grid spacing. Since ocean data assimilation is computationally more expensive than predictive modeling alone, we will test some promising methods from the Naval Research Laboratory (NRL) in our existing 1/3-degree POP model. Regarding higher resolution, we have access to output from a 1/10-degree North Atlantic calculation that was run by LANL and NCAR investigators, and we are evaluating that output against measures of Naval importance in order to assess the model's performance in littoral regions and near strong currents and ocean fronts. Analysis to date suggests that a large number of diverse features can be simulated with quantitative accuracy by going to 1/10 degree. Although computer power is not yet available to conduct global simulations at this resolution, the POP model is being continually upgraded at LANL to run on rapidly improving U.S. clustered microprocessor machines. Thus, enhanced computer power can be exploited as soon as it becomes available, which may be sometime in the year 2000.

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GLOBAL OCEAN AND ARCTIC SEA ICE, *continued from page 38*

Toward Arctic Sea-Ice Prediction

The Navy has for a number of years employed an operational Arctic ice-ocean model, called the Polar Ice Prediction System (PIPS). Ice forecasts are generated at FNMOC and disseminated to the Fleet by the National Ice Center in Maryland. The ice portion of PIPS uses a 1979 viscous plastic constitutive law, and the ocean part is an earlier version of the POP-type model with less advanced numerical and physical algorithms. PIPS 1.0 and PIPS 2.0 had grid spacing of 110 km and 27 km, respectively. The NPS modeling group has been tasked by ONR to develop and test a 9-km version of PIPS 3.0, which will then be made operational by scientists at NRL South in Mississippi.

The model domain to be used for PIPS 3.0 is shown in Figure 6. Essentially all of the ice-covered seas of the Northern Hemisphere are included. The ocean part of the model is a double-resolution extended version of our Arctic POP model. Along the artificial southern boundaries of the domain, open ocean boundary conditions can be specified as necessary from the global simulations described above. The ocean and ice circulation will be spun up for 15 years and then used as initial states for simulations to test and evaluate improved formulations of sea ice.

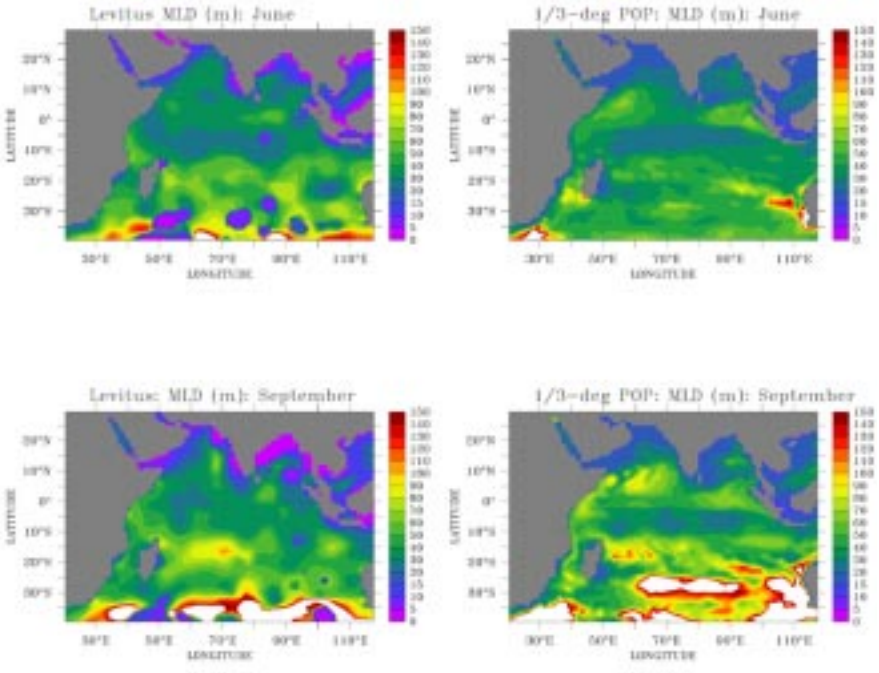

Figure 5. Mixed-layer depths (m) in the Indian Ocean from climatology (left) and as simulated (right). Judging from the months of June and September, the model better depicts Monsoon-induced depth changes than a climatology derived from sparse data.

The improvements in the sea-ice model will build upon our own parallel version of the basic ice dynamical model. This will ensure that the ice model is efficient on microprocessors and scalable to very many processors and nodes. A number of previously supported ONR investigators have new algorithms for ice dynamics and thermodynamics that can be installed and tested in the PIPS 3.0 system. Among the potential

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COMPARISON OF LOS ALAMOS NATIONAL LABORATORY (LANL) PARALLEL OCEAN PROGRAM (POP) MODEL FIELDS WITH PACIFIC SURFACE DRIFTER MEASUREMENTS

LT Michael R. Lemon, NOAA Corps
Master of Science in Physical Oceanography - Sept. 1997

Model fields from the Los Alamos National Laboratory (LANL) Parallel Ocean Program (POP) 1/6-degree global circulation model were compared to measurements from over 1300 satellite-tracked surface drifters deployed in the tropical Pacific (20S to 20N) between 1979 and 1994. Eulerian model/data statistics show the model mean velocities to be higher (up to 50% in the meridional component) than mean observed values, while the variability is 20% and 50% less in the equatorial and subtropical regions, respectively. A net heat convergence toward the equator is implied for both model and data with the largest values in the region of instability waves north of the equator. Mean velocity fields were used to produce simulated Lagrangian trajectories for uniform and non-uniform deployment strategies. Model time and length scales were too long and diffusivities too low compared to observations. Eulerian/Lagrangian differences were attributed to the lack of a mixed layer, inadequate representation of the wind forcing, and still too coarse model resolution.

GLOBAL OCEAN AND ARCTIC SEA ICE, *continued from page 39*

improvements are coordinate representations that more closely match the ocean grids than before, new anisotropic constitutive laws to predict the orientation of open water areas within the ice, multiple ice-thickness categories, and better algorithms for momentum and heat exchanges with the ice from above and below.

Ice data will be used in evaluating the models and in initializing PIPS test forecasts. In the past, satellite microwave data gave only the percent coverage of sea ice at various locations; and this was the only variable to initialize. Recent improvements in analysis of the data are producing maps of ice velocity with much denser coverage than is available from drifting ice buoys. This should greatly aid in evaluation of ice fields. Also, satellite altimetry methods are showing success in diagnosing ice freeboard and thus approximate thickness as an added aid to model validation. As these products improve and become available in nearly real time, they will be used to better initialize the sea ice forecasts. This will involve new methods of data assimilation that are being tested elsewhere under ONR sponsorship. The fully tested PIPS 3.0 system should become operational in early 2002.

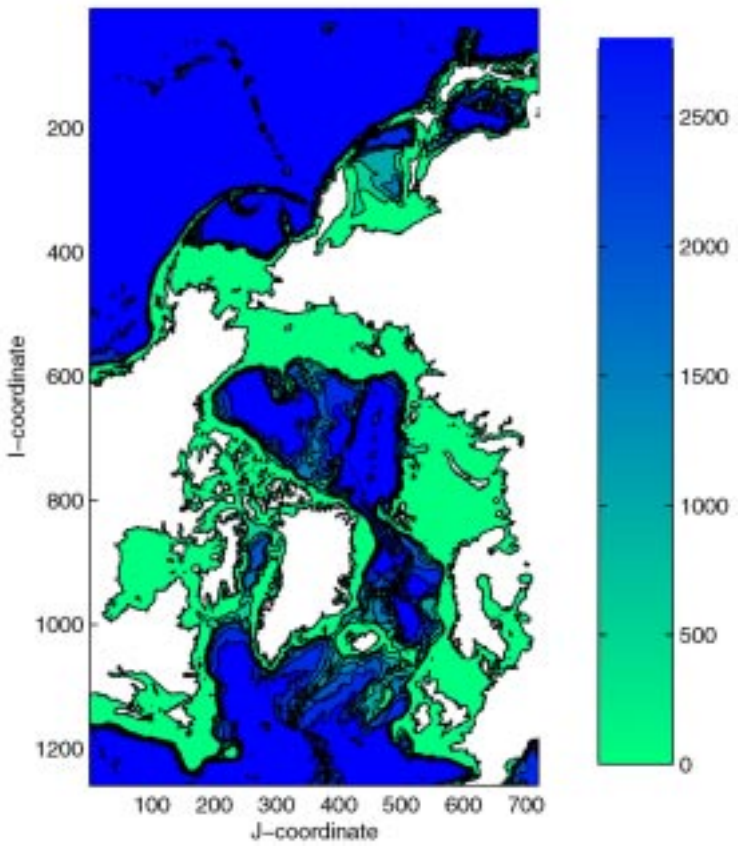

Figure 6. Domain of the new Polar Ice Prediction System, showing the 1280x720 grid for 9-km horizontal spacing and also the 40-level depiction of model depths (m).

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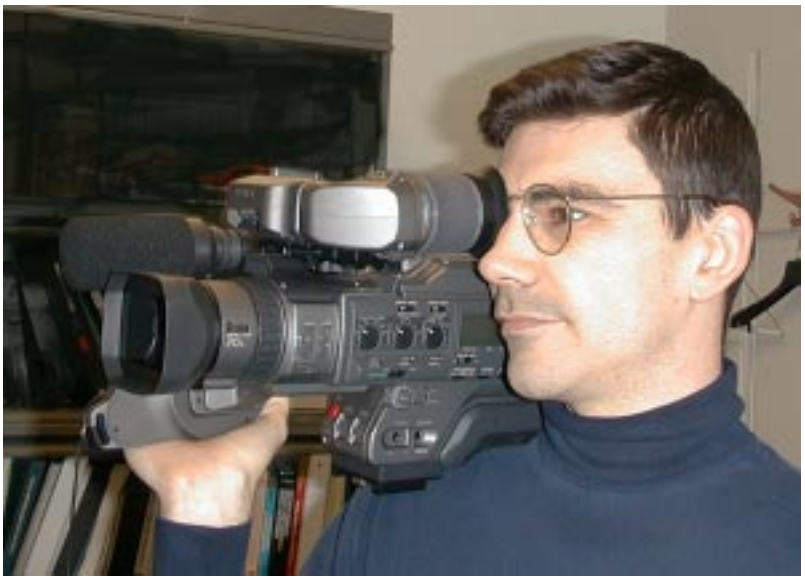
COMPARISON OF ADVANCED ARCTIC OCEAN MODEL SEA ICE FIELDS TO SATELLITE DERIVED MEASUREMENTS
LT David S. Dimitriou, USN
Master of Science in Meteorology and Physical Oceanography-September 1998

This study compared Arctic sea ice concentration derived from the NASA satellite passive microwave data against that simulated by the high-resolution coupled Arctic ice-ocean model described in this article. The spatial distributions of every 3 days (1979-1993) ice concentration from the model and observation were placed side-by-side and animated to provide an extremely visual representation of the comparison. Statistical analyses were utilized to quantitatively determine the performance of the model. The model showed a true representation of the seasonal cycle of ice concentration variation, with natural growth, advection and decay. The identification of strength and weakness of the model contributed significantly to the development of the Navy's PIPS 3.0.

ADVANCED NETWORKING LABORATORY, *continued from page 5*

14 Data Channel Simulator, capable of inserting propagation delays and bit-errors, connects the ASX-200s and models the IT-21 SHF satellite link, active during underway steaming. Each ELAN is configured similarly: One PC is configured as a server /router and the other simulates multiple workstations. The simulated ship's server/router is configured using RIP version 2, which allows the server to access both ship and shore subnets simultaneously. The server routes IP packets between the ship and shore ELANS. This is implemented with a single ATM NIC, which has the ability to emulate two, separate adapters. Figure 1 illustrates the network connections as described above.

In addition to LANE testing and implementation in a military environment, work in the lab includes native Windows NT driver/software development to support ATM QOS monitoring and testing in adaptation layer implementations in the Navy's IT-21 environment.



LT Dave DeMille, USN, records a digital video sequence with one of the lab's digital video camcorders.

The laboratory also boasts a large array of digital multimedia equipment primarily supported through a Silicon Graphics O2 video workstation an Apple PowerMac G3/266 (both with Firewire (IEEE-1394) and Adobe Premier™ capabilities). Several ancillary devices are available to facilitate direct digital input and output of multimedia content including camcorders, scanners, and color printers.

LT Joe Prisella, USN, and 1LT Abdullah Cay, Turkish Army, configure the ATM network for an upcoming experiment.

Traditional video compression schemes such as MPEG or H.263 were not designed to take into account the limitations of data transmission data over packet-based networks. The first problem is that networks invariably drop packets due to congestion, even in network architectures offering quality-of-service guarantees such as ATM networks. With any compressed data, the degree of compression magnifies the impact of a single lost packet so error robustness becomes an important issue to the end-user. Video compressors such as the schemes mentioned above are not particularly robust and degrade very poorly in the presence of network congestion. Any interruption in the data stream leads to visual artifacts that may persist for many frames past the initial point of corruption. Another problem with traditional video compression schemes is poor flexibility in dealing with heterogeneous internetworks in multicast scenarios.

A heterogeneous network is defined as one where available bandwidth varies from hop-to-hop and where end-users possess differing processing environments and display capabilities. Perhaps a simpler definition is that, within a heterogeneous network, end-users are stratified by their available bandwidth. This stratification poses a problem during transmission of real-time video such as in video teleconferencing scenarios since each user has different needs and

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ADVANCED NETWORKING LABORATORY, *continued from page 41*

tolerances. The high-bandwidth user expects high-quality video while the low-bandwidth user tolerates low-quality video at an acceptable frame rate. Meeting both sets of expectations with a single video stream is clearly impractical and transmitting multiple streams demands a greater expense in bandwidth.

To mitigate these problems, LCDR Robert Parker, USN, is investigating the use of layered video coding. With layered coding, the incoming video is compressed and transmitted as a series of separate streams arranged as a base layer and a series of enhancement layers that progressively increase quality. The base layer is coded at some minimum bit rate that provides a guaranteed, minimum level of quality. Layered coding solves the problem posed by heterogeneous networks by allowing users to subscribe to a number of layers consistent with their available bandwidth, a quantity that may even change during the course of a session. Layered coding also provides a means for mitigating the effects of congestion at high traffic nodes within a network to improve error robustness. Whereas delivery of a traditional video stream is all-or-nothing, transmitting multiple streams allows for more graceful degradation by allowing the node to drop the less important enhancement layers to ensure transmission of the more important base and lower enhancement layers. In effect, the node responds to congestion by temporarily reducing quality to a still acceptable level.

In particular, LCDR Parker's research is focused on specific

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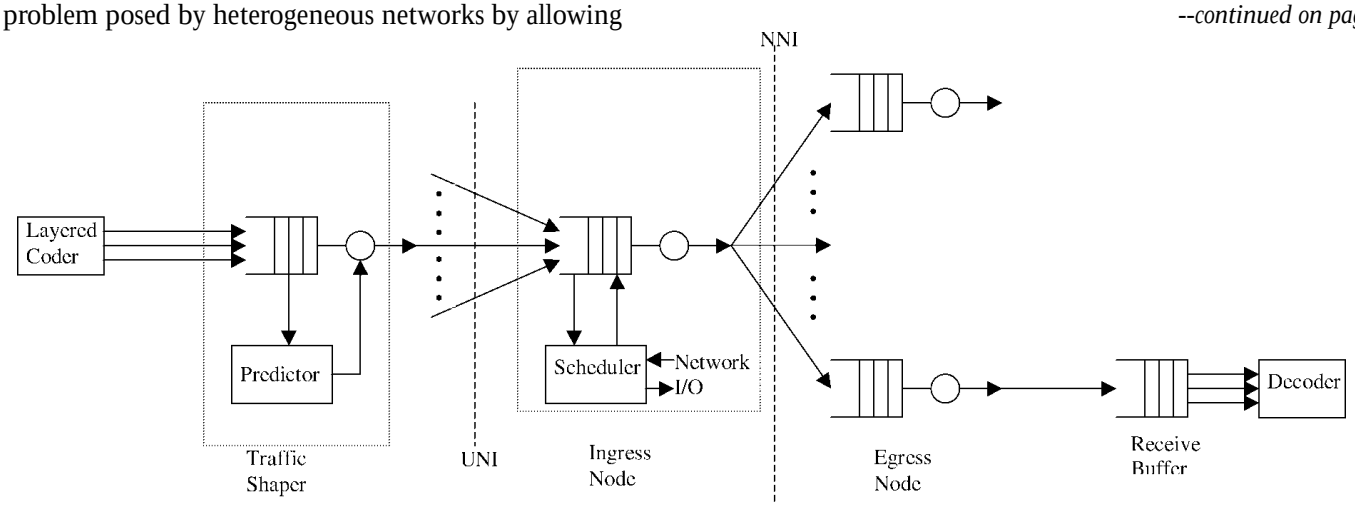

Figure 2. Specific elements for delivering layered video over ATM networks.

LOSS PERFORMANCE IN AN ATM CELL CAPTURE ENVIRONMENT
LT Mickey Stephen Batson, USN
Master of Science in Electrical Engineering-December 1998
Advisor: Assistant Professor John McEachen, Department of Electrical and Computer Engineering

Analysis of an Asynchronous Transfer Mode (ATM) cell capture system in a heterogeneous source environment is presented. Specifically, a two-stage queuing system is developed, fed by a multiplexed Constant Bit Rate (CBR) source and a Poisson distributed source. The resulting D+M/D/1 waiting time tail distribution is approximated analytically using a weighted M/D/1 queuing system and is used to verify the behavior of a computer model simulation. Cell loss encountered in the second stage is then observed for a variety of interarrival rates from the Poisson source. Based on observed results, the region of primary interest occurs where the arrival rate of the CBR stream is greater than 160 percent the mean arrival rate of the Poisson stream. It is concluded that under certain circumstances, the capture system can still effectively function with a low probability of cell loss. Further, a solid analytic foundation is developed for further theoretical analysis of the cell capture stage. (The Armed Forces Communications and Electronics Association (AFCEA) recognized LT Batson's thesis for academic and research excellence in a communication discipline.)

ADVANCED NETWORKING LABORATORY, *continued from page 42*

elements for delivering layered video over ATM networks as shown in Figure 2. These elements include:

- Designing a wavelet-based layered coder to support 10 frames-per-second, 64-96 kbps grayscale video traffic using a minimum of three layers. The coder is intended to provide data to realistically model layered video traffic within a network.
- Examining the effect of smoothing video traffic prior to the network's ingress node and predicting the resulting queuing performance.
- Design of optimal scheduling algorithms to maximize link utilization while supporting the opportunity afforded by layered video to gracefully degrade the transported video session in the presence of momentary congestion.

The lab is in the process of setting up a simulated Internet exchange using Cisco 2500 series routers. An Internet exchange is a place where major network service providers connect to allow their customers' data to transit each other's networks. The use of the Internet has not only become a reliable source of information for the public consumer and private sector, but also an important conduit for communications for the Department of Defense (DOD). Basic traffic analysis of router coordination traffic conducted by an adversary on the Navy's use of the public Internet can potentially supply a sizeable collection of logistical and location data that can reveal more than one might expect, especially when combined with other sources. Partial dependence of the Navy on many unclassified commercial communications systems, such as the Internet, will most likely continue as long as it is cost effective and reliable.

The objective of LT Doug Powers' USN, research is to examine the vulnerabilities of a major routing protocol that is used at the main Internet exchange points: the Border Gateway Protocol (BGP-4). This project is performed in support of several computer network defense and security measures that are currently being researched and implemented by the National Security Agency (NSA), NIWA, and the Information Operations Technology Center (IOTC).

The very efficient method by which a router using BGP-4 communicates with its neighboring routers in other autonomous systems is also the same attribute that makes it a lucrative source of valuable information for the information warrior. In particular, BGP exchanges routing information containing full AS paths and destination locations. Additionally, BGP enforces routing policies and communication paths based on configuration information. These policies are possibly vulnerable to undesired influences.

For more information on the Advanced Networking Laboratory, visit the lab's home page at http://www.netlab.nps.navy.mil/

Additional research in the lab focuses on a variety of topics including:

- Developing correlation metrics for ATM traffic content
- Analysis of random ATM cell stuffing mechanisms for utilization masking
- Modeling ATM cell encryption mechanisms
- Computer modeling of Signaling System 7 protocols
- Vulnerability analysis of IPv6 implementations

Future laboratory plans include expanding the wireless networking capabilities of the lab. In order to keep pace with the newest networking advances, the laboratory has incorporated wireless networking technologies into the lab. Specifically, the lab recently acquired two 2.4 GHz wireless 802.11 access points along with several wireless PCMCIA cards for use in the labs available laptop computers.

There are many opportunities to further exercise the capabilities of the lab. Current proposals would allow expansion in the study of ATM, wireless networking, and the addition of emerging technologies like asynchronous digital subscriber line (ADSL), Voice Over IP, or new multimedia applications (including interactive internet education). This will enhance the lab's ability to meet its primary goal: "to provide robust and dynamic hands-on education in high-speed network analysis."

SYMPOSIUM HONORS PROFESSOR,

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and Statistics, visited Stanford University on sabbaticals and retired from NPS in 1998 as a Distinguished Professor. During his career, Dr. Lewis designed circuits, studied system reliability and information retrieval, analyzed and simulated computer and queuing systems, performed ground-breaking research on time series, stochastic models, simulation, probability, data analysis and statistical computing, taught courses on those topics, attracted outstanding researchers to NPS, and supported the Navy in large-scale statistical analyses. His method for generating random numbers is used in nearly all computer simulations. He published over 70 papers in refereed journals and co-authored two books. He is a Fellow of the International Statistical Institute, the American Statistical Association, and the Institute for Mathematical Statistics.

AUTOMATED COMMUNICATIONS INTERCEPT, *continued from page 18*

We provide a polar display with angle from top dead center corresponding to true bearing, and distance from center of scope corresponding to frequency. There is some internal logic to roughly identify signals. The associated symbols on the screen can be "hooked" or selected to reveal more details on the individual signal. The user can specify that signal symbols stay on the scope after the signal is off the air (like decay on a radar repeater), thus even very short duration signals will remain on the display where tactically relevant data can be extracted, despite loss of signal. There are many other options for display and symbology control that have been refined through our work here and field demonstrations with operators. A screen shot is shown in Figure 1.

· *The system should provide detailed waveform analysis tools and automatic demodulation capability for non-voice signals.* This capability is accomplished through the use of a product called the w41pc demodulator/analyzer card. It is built by a Swiss company, Wavecom; fits in an ISA slot in the PC; and

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Figure 1. Screenshot from ACIDS.

ACIDS, front view. GPS receiver attached to monitor frame with velcro. All other components attached to computer case, less power supplies. The system will mount in and has been test mounted in a standard 19" equipment rack. The keyboard and mouse will need a 25"x6" shelf space for mounting on the front of the rack.

Rear view. RF and control cables not shown for clarity. The monitor arm can be mounted as shown on the corner of the computer case, to the front or rear edge of a 19" equipment rack, or to a desk edge. The receivers are surface mounted to the computer case. The keyboard and trackball are fixed to a horizontal surface using velcro.

AUTOMATED COMMUNICATIONS INTERCEPT, *continued from page 44*

offers a full battery of signals measurement and analysis tools including frequency shift measurements, bit-stream analysis, and automatic demodulation of many common signals. It is very user friendly and runs quite well with Windows NT.

The software for this card is routinely (about twice a year) improved and updated by Wavecom. For processing, the card uses two internal DSP chips and its own 66MHz processor for computationally intense work such as FFTs. This drastically reduces the load on the ACIDS processor and increases system performance.

Device	Architecture/Comms	Notes
Rack-Mountable PC with flat panel (LCD) display.	x86, Intel Pentium II 300MHz CPU	Mother board with 3 ISA and 4 PCI slots open for installation of required components and serial port expansion cards.
AOR AR5000 Receiver	S-232 @ 19.2 Kbaud	Spectrum scan and search.
Cubic 4400 DF Receiver	RS-232 @ 19.2 Kbaud	Signal Direction Finding. To be replaced by DTI2000 DF processor card when device driver is complete
iCOM PCR-1000 Receiver	RS-232 @ 38.4 Kbaud	For detailed signals analysis and measurements. Outputs are connected to the w41pc signals analysis card.
DTI2000 DF Processor	ISA	For faster DF processing. Not yet integrated. Of note, this is the DSP card that is used inside the Cubic 4400.
Wavecom w41pc signal analyzer & demodulator	ISA	For detailed waveform & bitstream analysis and for signal demodulation.
Garmin GPS-III	RS-232 @ 4800 baud	For nav and timing data
KVH fiber optic gyro	RS-232 @ 9600 baud	For maintenance of true heading on mobile platforms.
Wideband Discone Antenna	RG-213 (RF cable) to AR5000 and PCR1000	Signal search and analysis 1 - 2000 MHz
MA1316 & MA1310 DF Antennae	RG-213 (RF cable) and DF control cable to Cubic 4400 (eventually to DTI2000)	Signal direction finding 1- 1300 MHz

Table 1. Components of the current version of ACIDS.

· *Provide independence from host platform navigational systems by using a small GPS receiver and fiber optic gyro:* This part of the project is now operational and works quite well. These components are even available on cards and could be made smaller and even more efficient with limited difficulty.

Components

The components in the current version of the system include those shown in Table 1.

Future

We will be taking our prototype for a field demonstration at USNAVCENT (Bahrain) on 14 June. We will let the operators use the system for a couple of weeks, give us their feedback, and hopefully make some system improvements and changes based on that feedback. Further, we will evaluate ACIDS'capability to prosecute known signals of interest in that area.

Following the field demo in June, we will be travelling to SPAWAR Charleston to integrate ACIDS with T-RDF and/or Privateer so that units with those systems (some CGs, Amphibious Ships, and PCs) could just connect ACIDS (via RS-232 cable) to the T-RDF or Privateer DF subsystem if desired. This would alleviate requirements for expensive (and often difficult/impossible) shipboard installation of special DF antennas for ACIDS.

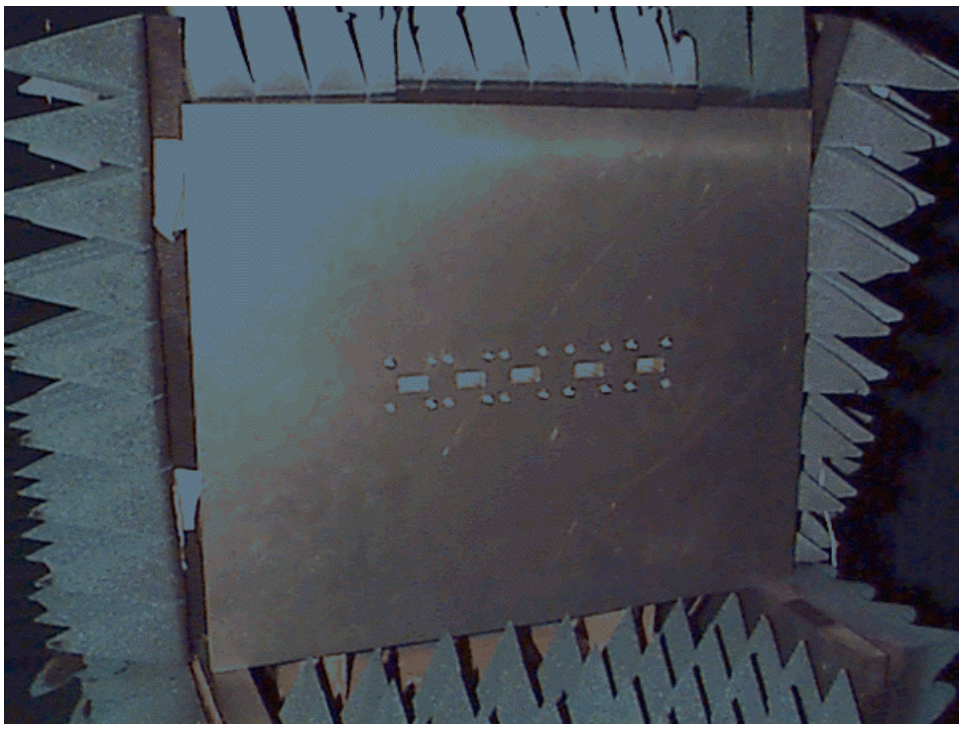
Device driver work for the DTI2000 will also be in progress from June - September with hopes of having an operational device driver for the card by September.

Other future work could include association of ACIDS with a rich signals database (this would make the project classified), use of higher speed interfaces (vice RS-232), more complete field testing, more thorough integration with fleet reporting and geo-positioning systems, and comparison of ACIDS to comparable systems from the Fleet and other government agencies.

INFORMATION WARFARE AND INFORMATION OPERATIONS, *continued from page 9*

the location and characteristics of the signal source, for example, whether the source is a radar, jammer, or communications transmitter.

The signal environment is extremely dense and the density is increasing. An efficient DF system must be able to operate over an extremely wide range of frequencies and have a wide field of view. Many emitters are on for only a short period of time. A DF system that requires time-consuming scanning and tuning, similar to tuning a radio dial and pointing the radio antenna, is likely to miss important emitters.



Direction finding antenna being tested in the NPS Anechoic Chamber.

Associate Professors David Jenn and Phillip Pace, Department of Electrical and Computer Engineering, have developed a new direction finding concept based on symmetric number systems (SNSs). The new approach yields an antenna and receiver with all of the desired DF features: wide instantaneous bandwidth and wide field of view. Another desirable characteristic is the array's short baseline, which results in a physically compact antenna. Conventional DF antenna designs that have short baselines suffer from low resolution. That is, the ability to "narrow down" the direction is reduced. On the other hand, increasing the antenna's length to improve its resolution can result in ambiguities: a single signal appears to come from multiple directions. The new SNS design does not suffer from the ambiguity problem and has the potential to be much smaller that other DF systems currently in use, yet provide high resolution over a wide range of frequencies.

Wideband Digital Compressive Receivers

Compressive receivers are advantageous in SIGINT applications requiring wide bandwidth in a dense emitter environment. Present implementations are limited in bandwidth by the analog nature of the design which requires a wideband dispersive delay line and also by the necessity of reading the output data at a digital rate which corresponds to the receiver's bandwidth.

Associate Professor Curtis Schleher, Information Warfare Academic Group, has been working on a wideband digital compressive receiver that mitigates the limitations in the conventional analog design. A new stepped-frequency 8 GHz bandwidth digital design using 1 GHz sampling was successfully demonstrated using MATLAB simulation. A bandwidth of 8 GHz was achieved using digital components that ran at a maximum of 1 GHz clock rate. A 32 MHz resolution has been measured as well as the capability of separating 25 simultaneous signals occurring at the input of the receiver. The bandwidth potential of this design was estimated as 16 GHz using 1 GHz digital components.

Directed Energy/High Power Microwave (DEW/HPM) Research and Course Development

NPS is becoming recognized as a national center of excellence in DEW/HPM to complement many years of leading-edge research in lasers. Most notably, a recent classified shipboard radar project involving Directed Energy Warfare/High Power Microwaves (DEW/HPM) was conducted which investigated use of current shipboard capabilities to defeat antiship missiles. Tests were conducted with the USS COWPENS (CG-63) and USS MAHAN (DDG-72), supported by Naval Air Warfare Center-Weapons Division (NAWC-WD) and the NAWC-WD/Naval

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Research Laboratory RP-3D which demonstrated new effects against current missile threats. This research has immediate tactical significance for fleet units to provide an additional tier of defense-in-depth for deployed battlegroups, and was briefed to SECNAV and numerous flag officers. These results were also presented at the national HPM Conference, HPM NINE, at Sandia Labs, Kirtland AFB, in May 1999. An HPM course at the SECRET NOFORN level is now offered as PH 4056/EC 4960, a joint Physics and Electrical and Computer Engineering course, and other HPM thesis projects are being conducted in conjuction with national laboratories. The next national HPM conference, HPM 10, will be held at NPS in May, 2001.

Complexity, Chaos, and Cryptography

Research is underway investigating the effects of chaos on electronic systems including various circuits, digital computer hardware and software. Networked systems including modern computer networks, and military systems such as Integrated Air Defense Systems (IADS) are susceptible. The result will be development of various attack waveforms through various media intended to induce chaos. This work also involves the impact of chaos and chaotic bit streams on cryptography and is a joint project of the IW Academic Group and the Department of Mathematics.

EA-6B-UAV Distributed Geometry in Information Operations

CAPT James R. Powell, USN, the NPS Chair of Information Warfare, is looking at UAVs from the Information Warfare/Information Operations angle. He believes that the EA-6B plus distributed UAVs (or UCAVs, Uninhabited Combat Air Vehicles) should be a large part of the vision for the future of Navy Tactical Air Electronic Warfare (TACAIR EW), whether as the ultimate EA-6B follow-on, or as an interim replacement for the platform. This kind of distributed geometry answers a lot of the J/S and azimuth problems struggled with in the past, as well as EA-6B survivability and positioning flexibility. The geometry factor applies to both threats where main beam positioning is required, and all kinds of communications where effective Electronic Attack (EA) will require closer stationing due to 1/R**2 losses vs. 1/R**4 range-J/S considerations coupled with spread spectrum where power and range-response time are factors (a repeater or follower jammer will not work for fast-hoppers at longer ranges). UAV EA payloads have been built and tested which are inexpensive such as JC2WC PIONEER jammers, and Northrop-Grumman T-RECS. They don't have to be high-power or high-tech in a closer, somewhat expendable application managed by a smart platform. Also, when they radiate doesn't mean they're immediately killed, especially when there are many in numbers, and, these platforms should be recoverable. Something like TALD/MALD should be affordable in numbers, useable and cost-effective for training, and would pale in cost compared to a manned platform. There are spread-spectrum data links that could be used to manage a number of UAV/UCAVs from a

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LOW BAND VHF ANTENNA DESIGN FOR THE GRUMMAN EA-6B AIRCRAFT
Capt Christian C. Miller, USMC
Master of Science in Electrical Engineering-June 1999
Advisors: Visiting Associate Professor Jovan Lebaric and Professor Clark Robertson, Department of Electrical and Computer Engineering

The overall effectiveness of an aircraft antenna depends on its inherent radiating pattern, its efficiency, and the effects of its host platform. Coupling between the antenna and aircraft skin effects antenna input impedance while shadowing, reflection, refraction, and diffraction by the aircraft structures effect the antenna radiation pattern. Placement of the antenna on the aircraft is critical to optimizing these effects. This thesis determines optimum antenna locations for an EA-6B aircraft by analyzing its characteristic modes using a modified Method of Moments code. With the optimum antenna locations determined, a survey of several broadband antenna designs is conducted. The candidate antenna must operate from 20-100 MHz with a Voltage Standing Wave Ratio (VSWR) less than four across the band. It must be vertically polarized and must have minimal aerodynamic effects. Input impedance and radiation patterns are determined for the candidate antennas using the well-known GNEC Method of Moments code. Ultimately, a new antenna design provides the best performance.

FLEET BATTLE EXPERIMENT ECHO, *continued from page 11*

the goal. The network was directed by the Mobile Inshore Undersea Warfare Unit (MIUWU). These activities occurred during Phase 1 in conjunction with Urban Warrior.

The ultimate purpose of the defense against asymmetric threats is to deter attack. This portion of FBE-Echo employed an actual OPFOR. The intention was to measure the degree to which they were kept off-balance and discouraged by Blue force protection activities. The placement of command and control within the mobile MIUWU was thought to be the key in the ability to take away OPFOR initiative. FBE-E was the initial effort in this threat area. The Intelligence Preparation of the Battlefield (IPB) is a key issue for improving the understanding of capabilities in this area.

Network-Centric Undersea Warfare (USW): The objective of network centric undersea warfare is a fully integrated undersea warfare capability contributing to full dimensional protection for forces in and beyond the Joint Area of Operations (JOA). Network-centric anti-submarine warfare using distributed collaborative planning for multi-sensor search and prosecution was the FBE-Echo concept for addressing this goal. An ASW cell with improved connectivity, standardized models and databases was employed for training and contingency operation planning in FBE-E.

The assumptions that drove this USW concept included availability of enhanced C4I systems that provide high data rate connectivity, fusion of a detailed underwater picture with surface and air pictures, search planning and assessment tools, battle management tools and remote sensor management tools. Sensor systems that provide passive acoustic, mono-static active acoustic, multi-static active acoustic, non-acoustic detections plus environmental characterization, and weapon systems for shallow water ASW, (for loitering and in support of distributed sensors, mine neutralization, and non-lethal options) were also assumed.

For FBE-E these assumptions were clearly not met. Many systems and or results were approximated or simulated by the ASW anchor desk as necessary to conduct the experiment. The anchor desk was an artificial entity used specifically to work the future concept. It was used to artificially provide connectivity to ships, submarines, aircraft, national assets, environmental information resources, sensor platforms and other command centers that would be required for implementation of this USW concept.

Capabilities explored in network-centric USW included a CONOPS for fusing all available information, distributed collaborative planning with shared models and databases, visualization of the essential elements of information (EEI), deconfliction of sensors, and management of unmanned sensors.

During the LOE, ASW operations included real time search planning, execution of these plans and an examination of alternative concepts for waterspace management enabled by a com-

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INFORMATION WARFARE AND INFORMATION OPERATIONS, *continued from page 47*

controlling EA platform, but control could be in the command sense with semi-autonomous UAV flight profiles. Another factor is EA-6B/UAV utilization in IW/IO, and not just SEAD. Access to networks in forward theaters of interest, and new means of telecommunications requires we look to offboard distributed geometries to modernize for future IO engagement. Lethal/loitering UAVs should also be considered for hard-kill of IT/communications nodes.

Two classified research projects have been completed on UAV EA payloads. Currently, LT Tim Barkdahl, USN, a student in the Department of Operations Research, is undertaking a modeling and simulation thesis to show the delta in adding distributed UAVs to the EA-6B mission. Other research is looking at three aspects of EA-6B follow-on platforms including methodology.

Cyberwar

Associate Professor John Arquilla, Information Warfare Academic Group, just published a book-length monograph for the National Defense Research Institute, *Toward an American Information Strategy*, that addresses both issues relating to DoD's defense against and potential use of IW, and formulates an approach to organizational redesign that will optimize the value of our existing information capabilities and resources. This work forms the basis of Professor Arquilla's involvement as an assistant to the Deputy Secretary of Defense in the process of developing a national information strategy.

Other recently completed work includes an article co-authored with UCLA historian Theodore Karasik, "Chechnya: A Glimpse of Future Conflict?" that examines the use of information warfare in the recently concluded Russo-Chechen War.

FLEET BATTLE EXPERIMENT ECHO, *continued from page 48*

mon tactical picture and improved communications to blue force submarines.

Precision Engagement: This pillar continued experimentation for the "Ring of Fire" which has been a strong portion of all of the FBEs to date. Also related are "Vicious Blaze" and "Silent Fury" efforts that address more deliberate targeting processes. The objective is to use Naval Fires of all types to allow the operation of Naval forces in an urban environment where a significant unconventional threat including terrorists, infiltration units from ORANGE (both including Weapons of Mass Destruction (WMD) threats) exists.

The overall goals were to explore three aspects of Naval Fires (NF): 1) Targeting NF in an urban environment with integration of multiple imagery sources and targeting tools, including the isolation of USMC areas of operations from enemy reinforcement; 2) Sensor to shooter capability against both fixed and mobile targets, particularly use of UAVs in permissive and non-permissive environments and with DD21 sensors and weapons; 3) Responsive deconfliction of Naval and other fires.

The desired effect of these capabilities was to suppress enemy activity levels to those that could be dealt with by the relevant in-country forces and to allow Ship to Objective Maneuver (STOM) with minimal losses by friendly forces. Secondarily, adaptability of personnel to the functionality of the various systems and the potential automation of the processes is of interest.

To accomplish these objectives, a network of ISR sensors and command and control and weapon fire control systems was constructed using actual and simulated systems. The Land Attack Weapon System (LAWS) was the cornerstone of the network and was located in all the command spaces onboard the CORONADO and on board the support ships as well. Major data information flows into this network included UAV pictures and other imagery, the Common Operational Picture (COP) and target data packages from the various mission-planning systems.

Full Dimension Protection: This area's objective was to explore the ability of an Expeditionary Force to make use of in-place civilian sensors to help establish a defensive grid. Sensors included airport and harbor radar and the supporting civilian communications system. UAVs, national assets, and appropriate military systems were also used as available. Fusion and control was conducted from the CORONADO and the MIUWU.

Civil Military Operations: A USMC Urban Warrior event involved both military and civilian officials in a simulated biological terrorist incident in Monterey on March 13. A Civil Military Operations Center (CMOC) was set up ashore. During this period, a small group in the Joint Medical Center and a CMOC space aboard the CORONADO developed civil-military doctrine for Navy support of such operations.

· Consequence Management of Toxic Releases: This experiment was a conducted aboard the CORONADO only while in San Francisco Bay. Two simulated sabotage-induced toxic releases were modeled with special software (CAPS) and expertise. Subject-matter experts located in the afloat CMOC space provided a synopsis of the possible results which were then evaluated by the staff.

· Virtual Work Space (VWS): This experiment tested the VWS as a tool to support coordination between the Joint Medical Center (JMC) and the CMOC space aboard the CORONADO. The VWS was implemented by installation of cameras, microphones plus a projector on one wall of each of the spaces so that a virtual picture of what was happening in the other space was available to all the participants. The VWS operated successfully throughout the experiment.

The task of reconstruction, simulation and analysis has begun with the conclusion of the experiment and will continue for several weeks. The next FBE is already in the planning stages. In addition there are some LOEs scheduled prior to the end of the year. Student and faculty participation is key to the continued success of this NPS project.

The Institute for Joint Warfare Analysis was founded in 1994 with the mission of addressing the problems of the joint defense arena with the academic disciplines resident at NPS, and enhancing attention to joint warfare within ongoing curricula and faculty and student research. The institute sponsors an applied research program with focus on JV2010 and Forward…From the Sea, develops partnerships with other DoD organizations, markets NPS programs to major program offices and operational commands, and supports curricula through course development and thesis support.

CONFERENCE CALENDAR

CONFERENCES/MEETINGS AT THE NAVAL POSTGRADUATE SCHOOL

Date	Title	Sponsor
10-11 Jun 99	Bio-Chem 2020 (SECRET)	Defense Intelligence Agency
22-24 Jun 99	45th Tri-Service Radar Symposium (SECRET/ NOFORN)	Naval Research Laboratory
28-30 Jun 99	Very Large Hadron Collider (VLHC) Annual Meeting (UNCLAS)	Lawrence Berkeley National Laboratory
20-22 Jul 99	Joint Interim Mission Model Meeting (SECRET/NOFORN)	Survivability/Vulnerability Information Analysis Center
17-19 Aug 99	Challenges to Nonproliferation Intelligence in the 21st Century (UNCLAS)	NPS and DCI Non-Proliferation Center
30 Aug 99- 3 Sep 99	Software Technology Review and Update (UNCLAS)	NPS
8-10 Sep 99	Shallow Water Acoustic Modeling Workshop (UNCLAS)	NPS and Office of Naval Research
18-21 Jan 00	AIAA Strategic & Tactical Missile Systems Conference (SECRET/NOFORN)	American Institute of Aeronautics and Astronautics
20-24 Mar 00	16th Annual Review of Progress in Applied Computational Electromagnetics (UNCLAS)	NPS/Applied Computational Electromagnetics Society
1-4 May 00	Forty-Fifth Annual Joint Electronic Warfare Conference (SECRET	Naval Air Warfare Center
6-10 Nov 00	AIAA 2000 Missile Sciences Conference (SECRET)	American Institute of Aeronautics and Astronautics

NPS has excellent facilities for hosting conferences, workshops, symposia, and meetings. The wide range of facilities can accommodate both small and large groups. Facilities available include:

King Hall Auditorium – 1,400 seats
Glasgow Hall – 280 seats
Engineers' Auditorium – 129 seats
Ingersoll Hall – 180 seats

Additional rooms are available for smaller functions or breakout sessions. Conferences classified through SECRET can be accommodated on the NPS campus. Sensitive Compartmented Information Facility (SCIF) facilities exist and may be available for small groups on a more restricted basis. For more information, contact the NPS Conference Coordinator, Elaine Christian, at 831-656-2426 or by e-mail, echristian@nps.navy.mil.

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DIRECTORY OF FY99 NPS TECHNICAL REPORTS

REPORT NO.	AUTHOR	TITLE
NPS-AA-99-001	Harman	Dynamic Effects of the RAH-66 Comanche 20MM Gun on Target Accuracy and Sensor Aiming Error
NPS-CS-99-004	Berzins/Luqi/Shing/Saluto/ Williams	Re-Engineering the Janus (A) Combat Simulating System
NPS-EC-99-002	Ciezki/Ashton	PEBB Feedback Control Law Library - Volume 1 - Three-Phase Inverter Control Algorithms
NPS-EC-99-003	Ciezki/Ashton	Analysis of a PWM Resonant Buck Chopper for Use as a Ship Service Converter
NPS-EC-99-004	Steenman	Investigation of Near-Field Electromagnetic Source Imaging Using Inverse Green's Function Integrations
NPS-EC-99-006	Hippenstiel/Ha/Aktas	Localization of Wireless Emitters Based on the Time Difference of Arrival (TDOA) & Wavelet Denoising
NPS-MA-99-001	Frenzen	Convolution Methods for Mathematical Problems in Biometrics
NPS-ME-99-002	Calvano/Harney	The Maritime Preposition Force Ship 2010
NPS-MR-99-001	Sopko	Observation and Analysis of Coastally Trapped Wind Reversals
NPS-OR-99-001	Gaver/Jacobs	In Search of Military Unit Formations: G-String Model
NPS-OR-99-002	Gaver/Jacobs	Analytical Models for Battlespace Information Operations (BAT-IO) Part 2
NPS-OR-99-003	Buttrey/Larson	Determining Characteristic Groups to Predict Army Attrition
NPS-OR-99-004	Baker/Morton/Rosenthal/ Williams	Optimizing Strategic Airlift
NPS-SP-99-001	Graswald/Panholzer	Contributions to Attitude Dynamics of the Petite Amateur Navy Satellite (PANSAT)

CONFERENCES, *continued from page 31*
distance estimation and cognitive map formation. These topics were then related back to virtual environments as discussion focussed on how these technologies might be used as training aids for spatial tasks and also how virtual environments might be used as "virtual laboratories" to further study spatial psychological phenomena. The workshop was very successful, both in terms of the content covered during the meetings and the level of interaction between participants. A report based on the discussions at this workshop has been prepared for the Office of Naval Research in an effort to propose a comprehensive program on these and related topics.

15TH ANNUAL REVIEW OF PROGRESS IN APPLIED COMPUTATIONAL ELECTROMAGNETICS

The 15th Annual Review of Progress in Applied Computational Electromagnetics (ACES) was once again held at NPS in March. Research Associate Professor Richard W. Adler acted as the local host for the eleventh time. The conference was well attended by participants from government, military and civilian institutions, with approximately 150 attendees. The focus of the conference was to provide a forum for information exchange among practitioners of applied computational electromagnetics. Highlighted topics related to the design, selection, and performance of current and emerging electromagnetic modeling codes and techniques. Software demonstrations of eight numerical electromagnetic codes showed continued expansion of the use of the PC platform and Windows NT vs. Unix. The Student Paper Contest attracted ten entries. There were six short courses and six hands-on workshops covering a variety of electromagnetic applications.

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