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NAVAL POSTGRADUATE SCHOOL

RESEARCH

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BEARTRAP POST MISSION ANALYSIS SYSTEM

Professor Murali Tummala, Department of Electrical and Computer Engineering
Professor Charles W. Therrien, Department of Electrical and Computer Engineering
Assistant Professor Robert J. Barsanti, Department of Electrical and Computer Engineering
Michael K. Shields, M.K. Shields Company

Post mission analysis for Navy Beartrap missions has up to now been performed using diverse legacy systems that require considerable manual effort and take several days to process the information. In 1995, PMA264D made a decision to fund development of a personal computer based integrated system and approached NPS to lead development of this new system. Work on the project began in 1996 with Professors Murali Tummala and Charles W. Therrien of the Department of Electrical and Computer Engineering as co-principal investigators. Dr. Michael K. Shields, a former NPS student and military instructor at the time, was engaged as the chief engineer. The new system was called Beartrap Post Mission Processing System 2000 (S2K).

The major tasks in the project consisted of the desig0n and development of graphical operator interface, modification, testing and implementation of several signal processing algorithms including target tracker, design and implementation of a data acquisition module, and integration and testing of the various hardware and software subsystems of S2K. Currently, the project is in transition from a research and development effort to a testing phase. The sponsor has commenced the final operational testing and certification process prior to fleet deployment in the very near future.

Beartrap Post Mission Analysis

The U.S. Navy performs Beartrap missions to gather magnetic and acoustic data in order to identify and track submarines. Magnetic data are collected using a magnetic anomaly detector while the acoustic data are measured by sonobuoys laid in a predefined pattern. NPS work focused on acoustic data. Beartrap missions are flown by specially equipped P-3 maritime patrol aircraft and ship-based LAMPS helicopters to gather acoustic sound pressure level information. Figure 1

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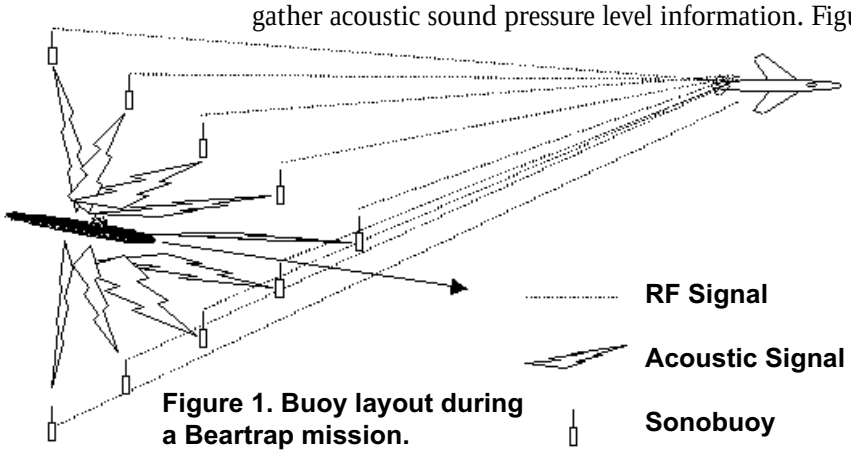

Figure 1. Buoy layout during a Beartrap mission.

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NPS RESEARCH

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FEATURED PROJECT

BEARTRAP POST MISSION ANALYSIS SYSTEM, *continued from page 1*

illustrates typical buoy layout in a wedge pattern.

Beartrap missions collect acoustic signals via radio frequency links and record in various formats on analog and digital tapes. In addition to acoustic data, other mission information is also recorded. This collection of data for the event is delivered to a post-mission processing center at a shore facility where initial quick look processing is performed. The data are then forwarded to Office of Naval Intelligence (ONI) for detailed processing and inclusion into the national database. The goal of the quick look is to provide feedback to the tactical units in a time sensitive manner. S2K is the new system to perform the quick look [1].

If the mission was conducted on a friendly asset, then

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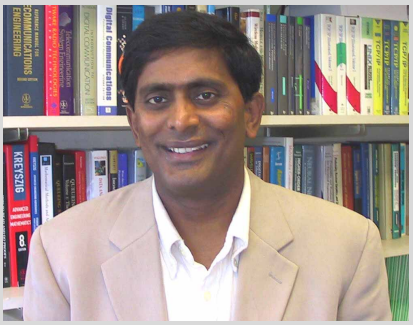
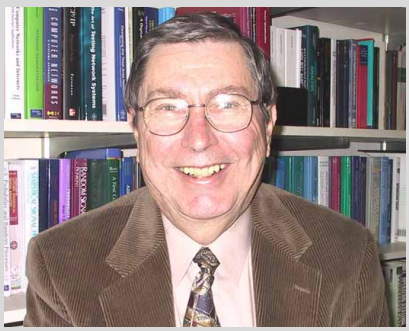
About the INVESTIGATORS



Murali Tummala

Murali Tummala is a Professor in the Department of Electrical and Computer Engineering. Dr. Tummala completed his undergraduate degree at the Institution of Engineers in Calcutta and received his M.S. and Ph.D. in Electrical Engineering from the Indian Institute of Technology, Bombay. Before joining the faculty at NPS, Dr. Tummala was a National Research Council Resident Research Associate at NPS, and worked as a Project Engineer at the Advanced Center for Research in Electronics at the Indian Institute of Technology. He is a senior member of IEEE and a member of Sigma Xi and Eta Kappa Nu.

Dr. Tummala is currently conducting research in the general areas of signal processing, communications, and networking. He currently teaches courses in the areas of communications, signal processing, and networking. Dr. Tummala is the recipient of the Admiral John J. Scheiffelin Award for Excellence in Teaching.



Charles W. Therrien

Charles W. Therrien is a Professor in the Department of Electrical and Computer Engineering. He completed his undergraduate and graduate work at M.I.T., all in the area of Electrical Engineering. Before joining NPS, Dr. Therrien was a member of the technical staff at M.I.T. Lincoln Laboratory. He is a senior member of the IEEE.

His research interests are in the general areas of signal and image processing, stochastic processes, estimation, and statistical decision theory. His teaching interests include digital signal and image processing, signals and systems, stochastic processes, decision and estimation, and communications.

LCDR Robert J. Barsanti

LCDR Robert J. Barsanti, USN, is an Assistant Professor in the Department of Electrical and Computer Engineering. LCDR Barsanti earned his commission through Officer Candidate School in 1982 after receiving his B.S. in Electrical Engineering from Polytechnic Institute of New York. Operational assignments followed aboard the *USS Sam Rayburn*, *USS Casimir Pulaski*, and the *USS Albuquerque*, and at the Naval Nuclear Power Training Unit in Charleston, SC.

LCDR Barsanti has completed Naval Nuclear Power Training, Submarine Officer Basic School, the Submarine Officer Advance Course, and Nuclear Weapons Officer School. He reported to the NPS and earned dual Master Degrees in Electrical Engineering and Engineering Acoustics. He was awarded a Ph.D. in Electrical Engineering in

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BEARTRAP POST MISSION ANALYSIS SYSTEM, *continued from page 2*

information on that asset's acoustic signature is provided to the fleet for counter-detection prevention. If the mission was conducted on a non-friendly asset, the information is forwarded to those friendly assets that are prosecuting the target to improve their detection and tracking ability. In either case, the goal is to provide near real-time information to help operational and tactical commanders improve the effectiveness of their forces. Additionally, feedback is provided to the crews that flew the Beartrap mission.

S2K Work at NPS

S2K was developed to run on a personal computer with the Windows NT or Windows 2000 operating system. In the future, S2K will be migrated to Windows XP or future upgrades. While mission processing can be performed on any platform, special analog to digital conversion boards and an array of fast hard drives are required for the digitization of the data tapes. The S2K application gives the operator the ability to display the raw data in the time and frequency domains. Figure 2 shows the S2K application window displaying interactive process flow. The appearance of this window is similar to any Windows-based application, such as Microsoft Word. By clicking on an appropriate block, the operator is able to expand that box and explore further functionality. For example, the figure illustrates the detailed functional blocks underneath the Generate Grams block. This feature can be effectively used either as a training tool or online help at the system functional level for the operator.

The system provides several other types of output displays.

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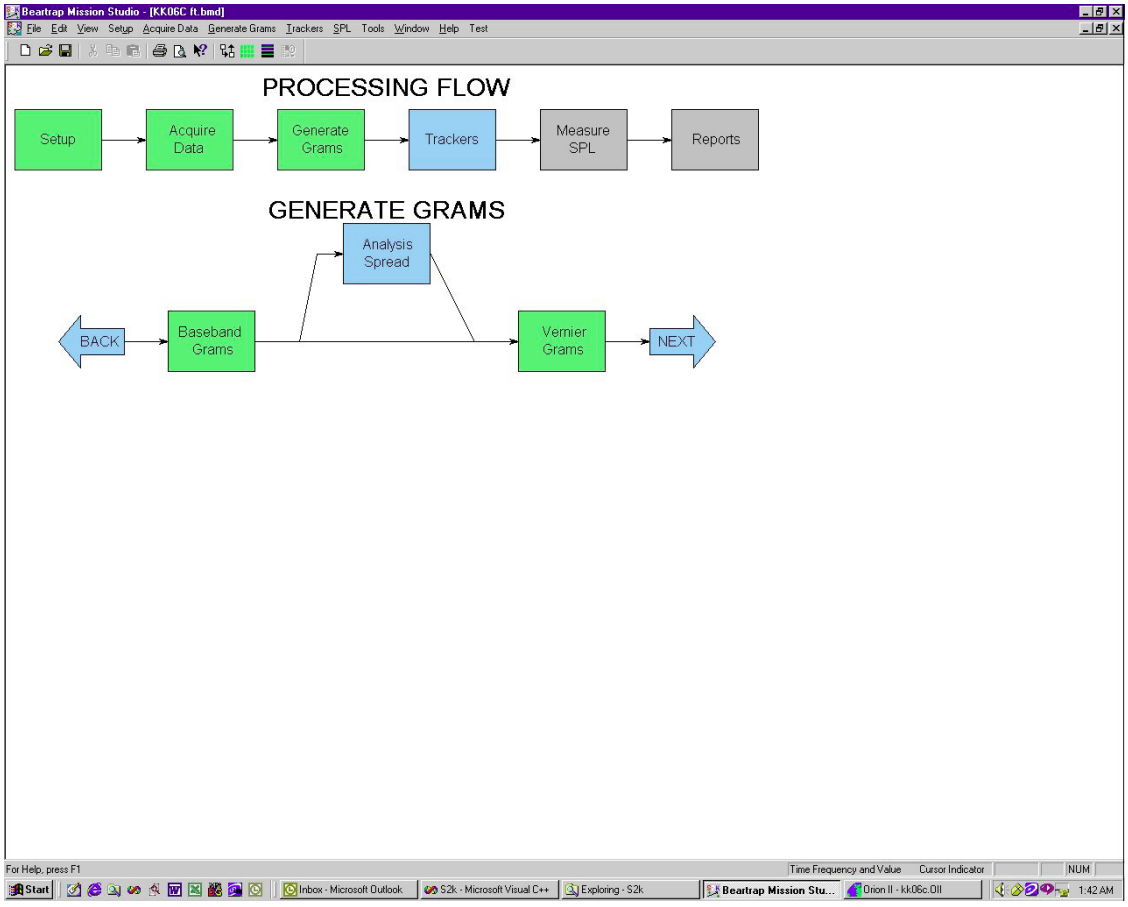

Figure 2. Process flow interaction.

INVESTIGATORS, *continued from page 2*

June 2001.

LCDR Barsanti is the recipient of the National Defense Service Medal, Sea Service Deployment Ribbon, Humanitarian Service Medal, two Navy Achievement Medals, and three Navy Achievement Medals.

Michael K. Shields is a former Naval Officer and NPS graduate receiving his Ph.D. in Electrical Engineering. He has over seventeen years of experience as a consulting engineer, electrical engineering professor, engineering manager, electrical engineer and nuclear propulsion engineer. He is currently President of M.K. Shields Company. His areas of expertise include the design and analysis of digital signal processing algorithms and systems for signal processing, communication, and unmanned vehicle command and control.

BEARTRAP POST MISSION ANALYSIS SYSTEM, *continued from page 3*

Figure 3 shows the time-frequency signature (gram) of a narrowband acoustic signal. The operator has the ability to zoom onto a portion of the gram with the help of mouse clicks.

In addition, operator tools are provided to identify signals of interest, perform analysis on those signals, generate an estimated track of the target submarine, and perform sound pressure analysis of the identified signals. Figure 4 shows the time-frequency signature of a broadband acoustic signal along with a dialog box that assists the operator in generating hyperbolic curves of time delay difference. The operator can adjust the related parameters by entering appropriate values in the dialog box. Using this tool, the operator is able to obtain the target position by overlapping two hyperbolas taken from two different pairs of sonobuoys.

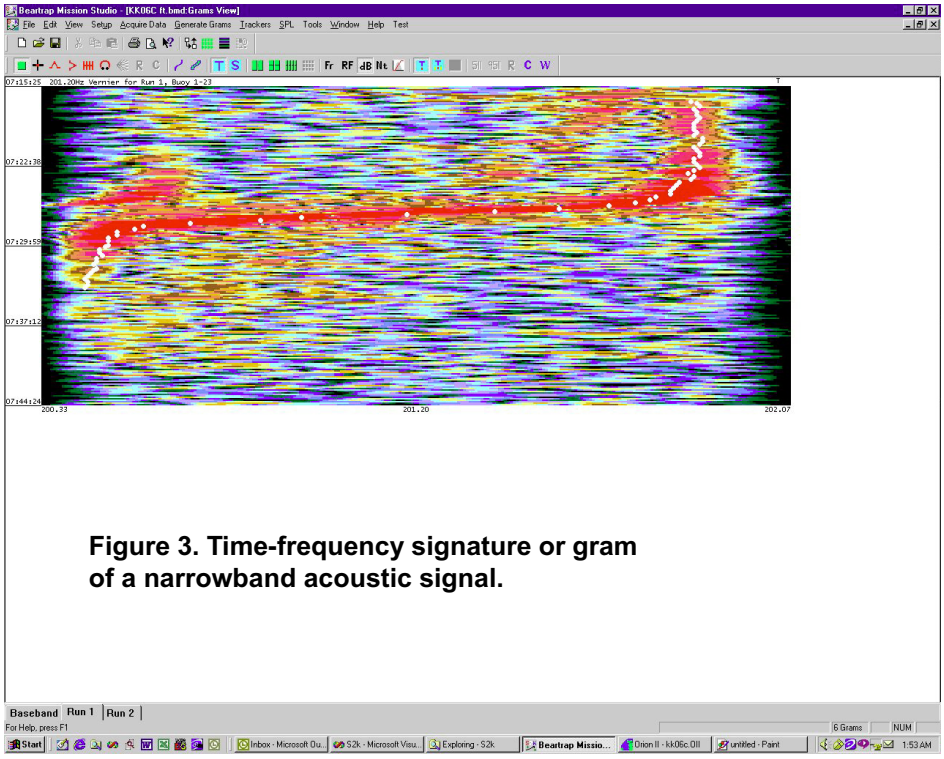

Figure 3. Time-frequency signature or gram of a narrowband acoustic signal.

Figure 5 shows a photograph of the S2K post mission processing system hardware suite. It consists of three interconnected pieces of hardware: a tape reproducer unit, anti-aliasing filter unit, and the processing unit. The tape reproducer unit has sixteen sonobuoy data channels, and channels for a time code, the aircraft intercom, and servo tracks for controlling the tape replay speed. The filter unit has three groups of switched capacitor anti-aliasing filters. All eighteen channels are programmed and controlled by an onboard microprocessor, via an RS-232 serial communication interface. The processing unit is an Intel Pentium based personal computer.

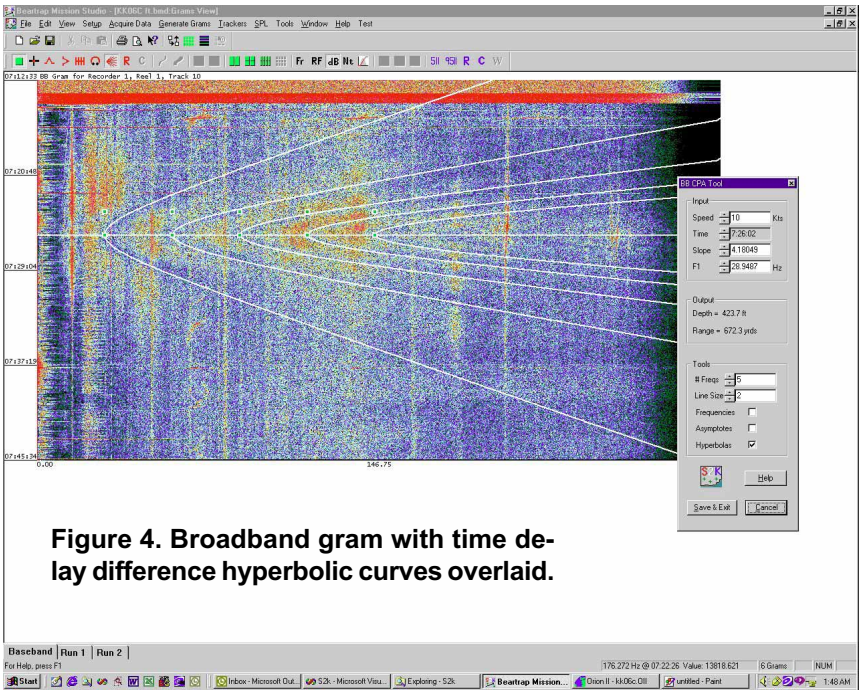

Figure 4. Broadband gram with time delay difference hyperbolic curves overlaid.

In addition to the standard personal computer components, the processing unit contains an analog-to-digital conversion bank and three high-capacity, high-speed hard drives for storing digitized data. The analog-to-digital conversion bank is comprised of three data acquisition boards with onboard FIFO memory. Each board has a digital signal processor, and all channels have their own onboard sample and hold amplifiers. The analog converter is a 1.25 MHz 12-bit successive approximation digital-to-analog converter. The processing unit uses a dual monitor video card and has two twenty-one inch

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BEARTRAP POST MISSION ANALYSIS SYSTEM, *continued from page 4*

monitors.

The S2K application consists of over 600 (Visual C++) source code files. The level of effort included signal processing algorithm development and algorithm improvement in both MATLAB and C++, the development of an operator interface tools in C++, the design and implementation of hardware interface modules, and design and implementation of various C++ classes to efficiently store the various types of data.

A beta version of the S2K system has been deployed at five sites including Brunswick, Maine, Jacksonville, Florida, and the Office of Naval Intelligence at Washington, DC, where the system is undergoing operational testing. During the lifetime of the project, the S2K effort

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Figure 5. S2K Post Mission Analysis system hardware suite.

FUNCTIONAL OVERVIEW OF S2K

Beartrap post mission processing System 2000 (S2K) is designed to replace the current Automated Quick Look (AQL) system as well as to incorporate tools to perform processing that is currently performed on other systems, including the Scientific Atlanta Fast Time Analysis processors and the Kay speech processors. The S2K system performs the analysis of mission data in several steps that can be repeated with different input parameters as necessary. These steps are shown in Figure A.

The preliminary portion of S2K consists of four steps that must be accomplished before any processing on the mission can be accomplished. The first step is the Mission Data dialog box. This dialog box obtains the mission name and other basic mission information that is used to initialize S2K. The second and third steps are to perform calibration checks. The final preliminary step is to import mission digital data.

There are two different types of calibrations performed by S2K. The first is a system calibration check. The second is an aircraft calibration check. In the system calibration check step, a specially prepared calibration tape is digitized and the signal levels and frequencies for the various test signals on the tape are measured. These measurements are compared to the actual values and if the differences are within tolerance the system passes the check. Once the system calibration check is complete, the aircraft calibration is performed. The aircraft calibration uses a tape from each tape deck on the aircraft that actually flew the mission. These tapes, which are recorded as part of the mission,

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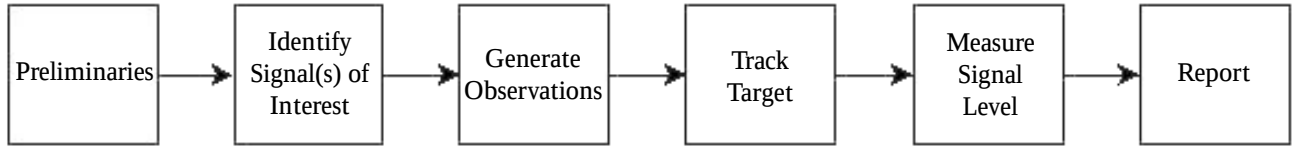


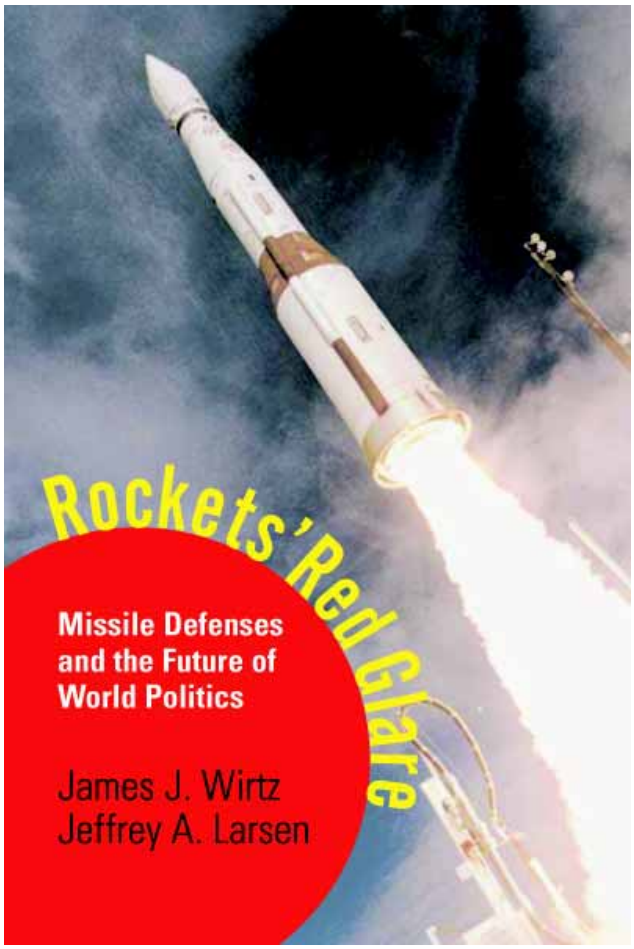
Figure A. S2K Process Flow Overview.

FEATURED PROJECT

U.S. MISSILE DEFENSES: THREE SCENARIOS AND THEIR INTERNATIONAL CONSEQUENCES

Professor James J. Wirtz, Department of National Security Affairs
Jeffrey A. Larsen, Scientific Applications International Corporation[1]

The United States is developing missile defenses that will offer some protection against ballistic missile warheads launched against North America.[2] The decision to deploy a modest national missile defense has already been made--it was signed into law in 1999. At that time, President William Clinton announced that implementing this decision would depend on an assessment of the nature of the threat, the technological capabilities of the system, its cost, and the impact on relations with allies and potential adversaries. While the goals of these limited defenses are modest, the U.S. effort to deploy a national or global missile defense system constitutes a major departure in American defense strategy and may lead to unforeseen and, in some instances, unwelcome international political consequences. Since the United States and the Soviet Union signed the Anti-Ballistic Missile (ABM) Treaty on 26 May 1972, Americans have relied on the threat of nuclear retaliation to deter missile attacks against the United States. Faced with emerging threats produced by the proliferation of long-range ballistic missiles that can be armed with chemical, biological or nuclear warheads, however, the idea of supplementing deterrence by using active defenses to destroy incoming warheads is gaining domestic political support within the United States. Americans can expect to have some form of national missile defense by the end of the decade.



To take a fresh look at the missile defense issue, we assumed that the United States will deploy missile defenses and has either modified or abandoned the ABM Treaty. We then estimated how these changes might affect policies and politics globally. By assuming that the United States will soon deploy missile defenses, we do not suggest that critics of U.S. national missile defense (NMD) are necessarily incorrect, that new technologies will work flawlessly, or that only positive developments will flow from the deployment of missile defenses. Instead, we believe that by imagining deployments have already occurred, we could begin to identify the unanticipated or unintended consequences of a U.S. decision to build missile defenses.

The Politics of Estimating Consequences

Critics and advocates alike appear certain about what will happen if the United States deploys missile defenses. For instance, critics suggest that missile defense cannot be achieved with todays technologies and that U.S. officials will not realize this until the worst possible time: during a crisis when their defenses are put to the test. For some critics, defenses are all cost and no benefit. They charge that missile defense produces arms races and alliance acrimony or simply will not work.[3] By contrast, NMD supporters highlight benefits while downplaying costs or technical uncertainties. They suggest that the costs of NMD would be forgotten, for example, if the system were to stop an accidental missile launch from hitting an American city.

One-sided estimates are unrealistic. At a minimum, they ignore the opportunity costs involved in either deploying or not deploying missile defenses. Those involved in political advocacy feel no compulsion to explain the down side of their policies. Yet rarely do public policies produce consequences that are all good or all bad. At most one can say that some course of action will produce more good than harm, but there is always a price to be paid

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U.S. MISSILE DEFENSES, *continued from page 6*

for whatever course of action is taken. Policies inevitably have multiple effects, most of them unintended or unanticipated.[4]

Two important observations suggest that it might be unusually difficult to predict the consequences of deploying national missile defense or altering the ABM Treaty. First, because the superpowers agreed to limit missile defenses, the ABM Treaty constituted a de facto global ban on missile defense. The Treaty's effects reached across the entire international community. When the United States and the Soviet Union decided not to deploy missile defenses, it was unlikely that their allies would have the political will, to say nothing of economic or technical resources, to develop defensive systems on their own. Many governments have based their foreign and defense policies on the absence of missile defenses. British, French and Chinese leaders, for example, could size their offensive missile forces knowing that they would only have to penetrate a very limited Soviet missile defense around Moscow. The efforts of so-called rogue states to acquire long-range missiles also are encouraged by banning significant missile defenses. The North Korean decision to produce a limited number of long-range missiles, for instance, is justified only in the absence of missile defenses.

Soviet and American leaders agreed to live with mutual assured destruction to avoid an expensive arms race between offensive and defensive systems. Other states have been free riders on the absence of strategic defenses ever since. With the Cold War long over, however, the United States has become more sensitive to the costs of preserving this global regime banning missile defenses, especially when small, hostile regimes brandish long-range missiles armed with chemical, biological or nuclear warheads. Whether or not growing American disenchantment with the ABM Treaty reflects a unipolar moment of American global dominance or an increasingly multipolar world is a question best answered in hindsight.[5] But the Cold War regime banning missile defenses is under pressure.

Which Missile Defense? Three Scenarios

Any effort to estimate the effect of missile defense deployment on the ABM Treaty and worldwide strategic relationships confronts an immediate obstacle. There is considerable uncertainty about the size and capability of the missile defense that eventually will be deployed by the United States. Although President Clinton decided not to announce definitive NMD plans in the final months of his presidency, his preferences probably would not have survived long into the next administration. During the 2000 presidential election, George W. Bush described his vision of a robust and far-reaching missile defense system. His plan is based on this overarching premise: It is time to leave the Cold War behind. America must build effective missile defenses, based on the best available options, at the earliest possible date. Our missile defense must be designed to protect all 50 states--and our friends and allies and deployed forces overseas--from missile attacks by rogue nations, or accidental launches.[6] In a major policy speech in May 2001, President Bush recommitted his administration to this path by calling for the end of restraints on missile defenses imposed by an outdated treaty that no longer served America's interests.[7] Debate about NMD and the relevance of the ABM Treaty to U.S. national security can be expected to continue long after the Bush administration announces its missile defense plans. Given this evolving policy and political milieu, estimates of the impact of U.S. missile defense deployment must consider a range of policy options.

To respond to this uncertainty, we explore the consequences of three missile deployment and treaty options. The options vary in several ways. First, deployment options differ in terms of the number of incoming warheads they can destroy and their ability to defend American territory regardless of the direction of the incoming attack. Second, they vary in terms of where interceptors are deployed. Third, they vary in terms

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About the INVESTIGATOR

James J. Wirtz

James J. Wirtz is a Professor and Chairman of the Department of National Security Affairs. Dr. Wirtz earned the B.A. and M.A. from the University of Delaware the M.Phil. and Ph.D. in Political Science from Columbia University. He was a John N. Olin Fellow at the Center for International Affairs at Harvard University. Prior to joining NPS, Dr. Wirtz held faculty positions at Franklin and Marshall College, Penn State University, and the State University of New York, Binghampton. Dr. Wirtz teaches courses on nuclear strategy, international relations theory, and intelligence.

INSTITUTES FOR RESEARCH AND EDUCATION

In colleges and universities today there is an emerging demand for graduates with knowledge and skills in highly interdisciplinary systems that must be optimized in their totality rather than sub-optimized in their parts. This need is also present for the Navy and other military services. The Naval Postgraduate School has recently realigned itself to better provide graduate education with these characteristics. It has done this through the formation of a matrix organization consisting of four graduate schools and three institutes. The graduate schools provide the academic rigor and focused research and the institutes are to utilize the knowledge found in the schools to provide a focus for interdisciplinary education and research in areas of current and emerging military challenges. The three institutes are:

- Institute for Information Superiority and Innovation
- The Modeling, Virtual Environments, and Simulation (MOVES) Institute
- Institute for Defense Systems Engineering and Analysis

NPS has some unique characteristics that facilitated the formation of these institutes.

- A unique student body, joint, with both military and civilian workforce, and international, providing a unique ability to conduct joint and coalition programs.
- Unique facilities and a faculty with extensive experience in Navy/DoD research and development, active education and research programs in classified areas, demonstrated ability to conduct interdisciplinary education and research programs, and a close proximity to Silicon Valley. Thus, NPS is Navy/DoD focused with strong links to relevant industry and academic institutions.
- Adaptive and responsive to a Navy in transition; demonstrated ability to transition officer knowledge to other fields; responsive to changing education and research needs.
- NPS is a Corporate University that maintains academic excellence.

The institutes provide or facilitate the offering of:

- Degree programs, academic minors, and executive education in interdisciplinary areas.
- Short courses, workshops and conferences for career enhancement and improved knowledge and skills in areas of emerging requirements.

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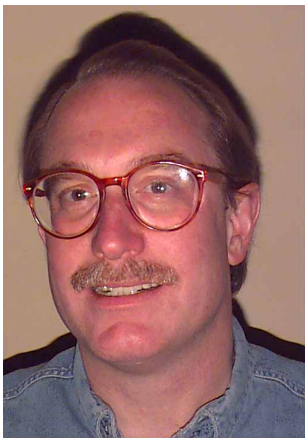
INSTITUTE FOR INFORMATION SUPERIORITY AND INNOVATION (I2SI)

The Director of I2SI is Dr. Cynthia Irvine of the NPS Computer Science Department. The vision of the Institute is to be the center for innovative research and education in enabling information technologies, operations and strategies, with focus on their development and application for national security. I2SI brings together existing NPS education and research capabilities. A few Affiliated Research Centers include: the Cryptologic Research Center, the Center for Information Assurance Studies and Research and those in Information Operations. Institute research supports force superiority through a trustworthy infrastructure and related analyses, tool sets and constructive materials for both defensive and offensive operations. Initial key focus areas that contribute to Information Professional Education and Innovative Fleet Technology include: threat psychology, motivation and assessment; electromagnetic emissions collection, geo-location, and analysis; knowledge flow and information cognition; information dissemination, processing, and display; trustworthy information presentation and network infrastructures; and techniques to actively counter adversaries. VADM Richard W. Mayo, USN, chairs the Steering Group.

Cynthia Irvine

THE MODELING, VIRTUAL ENVIRONMENTS, AND SIMULATION (MOVES) INSTITUTE

The Director of The MOVES Institute is Dr. Michael Zyda, also of the NPS Department of Computer Science. The mission of The MOVES Institute is to be the world-class institute for research, application and education in the grand challenges of modeling, virtual environments and simulation. The Institute works with all NPS curricula but additionally has the closely allied MOVES M.S. and Ph.D. degree programs. The MOVES Institute's research, application and education focus is on 3D visual simulation, networked virtual environments, computer-generated autonomy, technologies for immersion, defense and entertainment collaboration and evolving operational modeling. A member of the Institute's Steering Group is VADM Richard W. Mayo, USN.



Mike Zyda

INSTITUTES FOR RESEARCH AND EDUCATION, *continued from page 8*

- Opportunities for student thesis and faculty research that range from basic to applied and which have significance for the present Navy and the Navy-after-next.
- Student interaction with senior Naval leadership.

All three institutes utilize Steering Groups that consist of senior Navy/DoD and government leadership and which utilize invited participants from industry and academia in the specific focus areas of the institutes. Each has a unique facility on the campus, providing education and research opportunities for students and faculty from across the campus and for researchers from government laboratories, industry and academia.

The MOVES Institute
Naval Postgraduate School

INSTITUTE FOR DEFENSE SYSTEMS ENGINEERING AND ANALYSIS (IDSEA)

The Director of IDSEA is Dr. Phil DePoy, the NPS Chair of Expeditionary Warfare. The vision of IDSEA is to provide unique graduate education and research that increases the knowledge and skills of military officers and the supporting civilian workforce in systems engineering and analysis and large-scale experimentation. IDSEA did not start from an existing curriculum or department. It did incorporate the applied research work of the previously existing Institute for Joint Warfare Analysis. A major initiative is coordination of a yearly systems engineering project. The project this year is CROSSBOW – a warfighting system concept consisting of small carriers, manned and/or unmanned aircraft, supported by small, swift combat logistics support ship and accompanied by small inshore combatants. It is utilizing 54 students from seven departments in a coordinated interdisciplinary program. The Steering Group is chaired by VADM Dennis McGinn, USN, OPNAV (N7).

Phil DePoy

CRYPTOLOGIC RESEARCH CENTER

Department of Electrical and Computer Engineering

The Cryptologic Research Center (CRC) has quickly become one of the most robust and proactive centers at the Naval Postgraduate School. Established in 1998 in response to customer needs, the CRC fosters a research environment that spotlights and promotes innovative Cryptologic research in three Center laboratories. Since Cryptology encompasses a wide range of technologies, the CRC is truly an interdisciplinary center, and is a perfect example of how several academic departments at NPS can work together to provide the mix of students and qualified faculty required to address major Cryptologic issues faced by the Department of Defense today.

Since the information age has brought about incredible advances in technology, today's Cryptologic environment has become not only broader in scope, but more technically challenging as well. The National Security Agency/Central Security Service (NSA/CSS), one of the CRC sponsors, has begun a period of metamorphosis that is transforming the way they execute their Signals Intelligence (SIGINT) mission to cope with the exploding information technology of today and tomorrow. Additionally, there is a national shift in the focus of Maritime Cryptologic Systems currently underway, with an emphasis on replacing inefficient, stovepipe approaches with common DoD-wide solutions and ensuring that new capabilities are compatible, interoperable, and meet the warfighter's needs. With the NPS's unique student and faculty resources, it is sought out by these and other sponsors and funded at more than one million dollars annually to do research in some of these critical areas. These rapid changes and paradigm shifts and the corresponding complexity provide both challenges and opportunities for the NPS.

The CRC was designed to proactively respond to those challenges levied by the Cryptologic Community and to support the NPS-assigned NSA/CSS Cryptologic Chair by providing a central resource to establish a clear, intuitive and thorough methodology for management of Cryptologic research and resources, teaming/partnership initiatives, short courses, workshops and lecture series. Administratively, the CRC falls under the auspices of the Department of Electrical and Computer Engineering, but operationally, participants include faculty and students from the Departments of Electrical and Computer Engineering Department, Computer Science, National Security Affairs, and Information Systems as well as students from the Space Systems Academic Committee. A CRC Director, annually appointed among CRC members, chairs the CRC and conducts bi-weekly meetings to facilitate communications between NPS faculty and sponsors. Collectively through these meetings, the CRC members determine the overall research focus and direction of the CRC, set policy and guidelines for the CRC, deal appropriately with any sponsor issues and insure that research requirements are met and communicated to the sponsor.

Figure 1. The Cryptologic Research Laboratory is one of three CRC labs.

The CRC operates three laboratories,

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CRYPTOLOGIC RESEARCH CENTER, *continued from page 10*

the Computer Network Research Lab, located in Glasgow Hall, the Cryptologic Research Lab (Figure 1), located in Spanagel Hall, and the Space Systems Research Lab, located in Root Hall. These labs draw students and faculty from all NPS curricula. The Faculty Director of the Computer Network Research Lab (CNRL) is LCDR Chris Eagle, USN, Chairman of the Department of Computer Science. The CNRL is managed by Randy Borchardt, a Research Associate in the Department of Electrical and Computer Engineering. The CNRL is a classified laboratory located in the Secure Compartmented Information Facility (SCIF). It is primarily sponsored by NSA/CSS's Systems and Network Research Center. This laboratory's main mission is to provide a closed environment wherein students and faculty can conduct research in computer network intrusion and counter-intrusion techniques with no fear of damage to outside systems. The Faculty Director of the Cryptologic Research Laboratory is Professor Tri Ha, a faculty member in the Department of Electrical and Computer Engineering. The CRL is managed by Nathan Beltz, an employee of SPAWAR Systems Center, a CRC partner organization. The CRL is an unclassified incubator located in Spanagel Hall and sponsored by NSA/CSS's Applied Technology Division. This laboratory's primary mission is to provide a well-equipped test-bed to evaluate, identify and classify live signals (Figures 2 and 3). The Faculty Director of the Space Systems Research Laboratory (SSRL) is Professor Herschel Loomis of the Department of Electrical and Computer Engineering and in the Space Systems Academic Committee. The SSRL is located in the Root Hall SCIF. Sponsored primarily by the National Reconnaissance Office, it offers resources to evaluate geolocation algorithms and other space-related technologies.

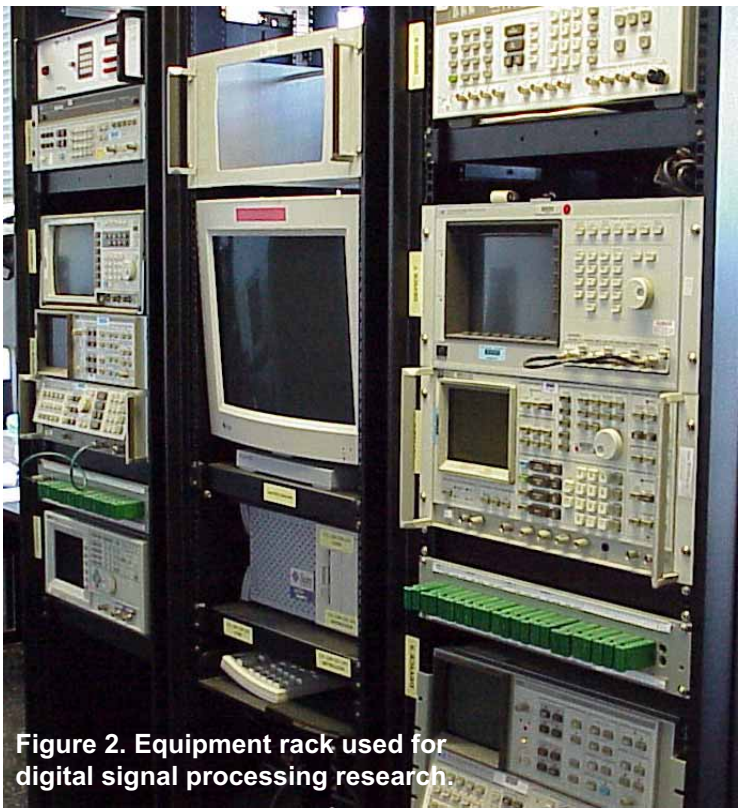

Figure 2. Equipment rack used for digital signal processing research.

Figure 3. The Cryptologic Research Lab provides a well-equipped test bed to evaluate, identify and classify live signals.

By tracking research efforts in these laboratories, the CRC team provides a seamless approach to quickly assembling student and faculty talent, funding resources and endorsements necessary to explore new ideas and expand the capabilities and resources in these labs through sponsored work. This approach ensures that all Cryptologic sponsors needs and expectations are validated, understood, managed and fulfilled by the CRC researchers and it also enables funding resources to be shared across academic departments and groups in support of critical research for the Cryptologic community. For further information, please contact the CRC Program Manager, Rita Painter (rpainter@nps.navy.mil).

ELECTRONIC MANEUVERING BOARD DECISION AID FOR THE OFFICER OF THE DECK

LT Joey L. Frantzen, United States Navy
Master of Science in Computer Science – September 2001
LT Kenneth L. Ehresman, United States Navy
Master of Science in Computer Science – September 2001

The U.S. Navy currently bases the majority of our contact management decisions around a time and manning intensive paper-based Maneuvering Board (MOBOARD) process. The use of maneuvering boards is a perishable skill that has a steep learning curve. In order to overcome inherent human error, it is not uncommon to have up to four people simultaneously involved in solving just one maneuvering problem. When given situations occur where multiple contacts exist, the current system is quickly overwhelmed, forcing Commanding Officers and Officers of the Deck (OODs) to make decisions with incomplete information. The end result is a delay or inability to convey accurate information in a timely manner, leading to avoidable hazardous situations.

Background

Prior to Maneuvering Boards, the traditional mariner relied upon the seaman's eye and the knowledge gained from many hours of standing watches on the bridge. This knowledge pool helped the ship driver make the right decision when confronted with other vessels. The evolution of radar allowed vessels to see contacts at great distances and measure the bearing and ranges of those contacts (Figure 1). The Maneuvering Board quickly followed the radar allowing ship drivers an alternate visual representation of radar contacts based upon trigonometric fundamentals. This now allowed OODs and Commanding Officers a better way to frame the problem in more concrete terms.

The OOD decision-making process is designed to try and reduce uncertainty by gathering information, and transforming this information into knowledge and understanding. The utilization of radar and Maneuvering Boards aids a Commander/OOD in reducing the level of uncertainty. This process is known as the OODA Loop: Observation, Orientation, Decision, and Action (Figure 2).

Figure 1. SPA-25 Radar Repeater.

Whenever trying to establish Command and Control there exists two fundamental factors that shape the environment: uncertainty and time. The MOBOARD model lies within the Orientation phase of the OODA Loop. The Electronic Maneuvering Board Decision Aid reduces the level of uncertainty and the amount of time inherent to the Maneuvering Board process.

Increasing Collisions at Sea

Since 1996, there has been a marked increase in the number of collisions at sea, resulting in the loss of millions of dollars and thousands of operational hours for ships that are critical to our force structure (Figure 3).

There are many variables that play a significant part in the reasons for more frequent collisions at sea over the past five years. These factors range from inexperience and training to crew fatigue. Looking back into our crystal ball we can see many instances where Commanding Officers and OODs could have benefited from a better system and a better means by which contact information was being displayed and presented to them. The time-tested method we use to make maneuvering decisions works. The problem is that technology has not kept pace with the increase in the ocean's traffic density. What is required is a faster and more accurate means by which this method is executed.

Paper vs. Digital

The argument for or against traditional paper-based

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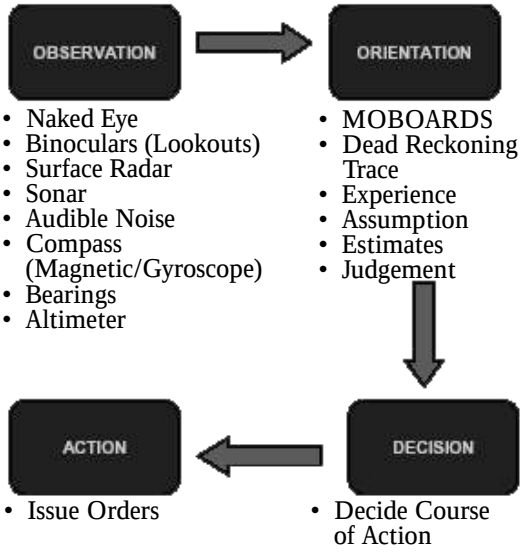

Figure 2. The OODA Loop on the Bridge.

ELECTRONIC MANEUVERING BOARD DECISION AID, *continued from page 12*

MOBOARDS versus Digital-Based MOBOARDS is based upon two simple factors.

Traditional paper-based MOBOARDS are done with a pencil and straightedge. This process can be inaccurate and is often prone to human error. Even a very experienced sailor can make mistakes when doing a MOBOARD solution, especially in time critical situations, periods of rough seas, night time operations, or situations where there are multiple contacts.

Digital-based MOBOARDS will speed this process up and eliminate the inherent human error innate to the paper-based MOBOARD process. By decreasing the time required to produce a MOBOARD solution, it in turn decreases the time required to complete the orientation process and thus speeds up the overall decision process. Having more time and more accurate information in an understandable and an easy to assimilate presentation is every Commander's desire. This is what Digital-based MOBOARDS provide.

Figure 3. *USS Denver* after collision at sea.

Manning the Future Navy

With the evolution of Smart Ship and the DD-21 initiative (Figure 4) the manning of Navy Ships has become a high profile issue. The future Navy will no longer have the luxury of 350-manned combatant ships. The Navy of the future will require less men and women who are more technically proficient and better trained. The bridge of the next generation will still rely on good seamanship, experience, and a trained eye while instead of using paper-based tools, the tasks and aids used to process contacts and information will be done in a digital-based medium. The modern Navy will have to depend on exceptional sensors and computer systems that are able to frame an abundance of information into a manageable and clear presentation. The Electronic Maneuvering Board Decision Aid is designed to meet this emerging need. With this computerized decision tool the requirements for multiple junior officers doing MOBOARDS or several Operation Specialists in Combat maintaining a DRT contact picture will be reduced greatly. GPS will automatically be updated into the system, instantly giving the Commanding Officer and OOD latitude and longitude information of all the local area contacts at the mere click of the mouse.

Additionally our computer program will have the ability to maintain a digital log; vice having a paper-based Deck Log maintained by the Quartermaster (QM). This may be another avenue by which the U.S. Navy can reduce the manning requirements on the bridge while maintaining and improving upon the safety of ships at sea. The Quartermaster will no longer be required to log each course and speed change, OOD watch changes, casualties, etc. This will all be maintained in a central database allowing for a visual playback of events for any post-operations analysis. This feature will allow the evaluator to view a list of events as well as display a visual contact picture chronologically corresponding with these logged events. Thus, the end result is better post-operations analysis and understanding of the environment on the bridge at the time of the operation, mishap, or exercise.

Figure 4. DD-21 Concept Design.

Our Research

The purpose of our research was to implement a stand-alone system that provides timely and accurate contact information for U.S. Navy Commanding Officers, OODs, and CIC watch teams. By creating a reliable, automated system in a format that is familiar to all Surface Warfare Officers we will provide the Navy with a valuable decision-

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STUDENT RESEARCH

MEASUREMENTS AND MODELING ENHANCEMENTS FOR THE NPS MINIMUM RESOLVABLE TEMPERATURE DIFFERENCE MODEL, VISMODII

1st Lieutenant Mustafa Celik, Turkish Army
Master of Science in Systems Engineering – September 2001
Advisors: Visiting Associate Professor R. J. Pieper, Department of Electrical and Computer Engineering, and Professor A.W. Cooper, Department of Physics

Minimum Resolvable Temperature Difference (MRTD) measurement has long been used to describe the performance of thermal imaging systems. Computer models, such as U.S. Army's FLIR92, that were developed to predict the MRTD were reported to have deficiencies in dealing with sampling and aliasing effects. The models also include assumptions regarding the observer recognition process and therefore cannot predict the MRTD of an imager that incorporates an objective automatic target recognition device instead of a subjective human observer. The Visibility Model II developed for second generation imaging systems at the Naval Postgraduate School (NPS) in the mid 90s takes sampling and aliasing issues into account and makes no assumptions about the observer. Modeling enhancements in VISMODII and its extension to predict objective MRTD are proposed and tested in this thesis. A parallel thesis at the NPS has shown that aliasing effects on image appearance are fundamentally different from noise. The improved VISMODII model accounts for the fact that unlike noise, aliasing may have a visual enhancing effect and therefore may lower MRTD. Experiments were conducted to measure subjective and objective MRTD. Experimental results demonstrated that the VISMODII model successfully predicts the MRTD both for the subjective and the objective schemes.
(LT Celik has been working with 1st LT Kenter (Turkish Army), and Professors R. J. Pieper and A. W. Cooper in a unified program relating to the performance modeling of current and developing thermal imaging systems. In particular, the systems of interest include those of the type Forward Looking InfraRed (FLIR). A co-authored paper based on LT Celik's and LT Kenter's work has been accepted for the 35th Asilomar Conference on Signals, Systems and Computers to be held in November 2001.)

EXPLOITATION OF TRANSMISSION CONTROL PROTOCOL ERROR HANDLING AS A MEANS OF COVERT COMMUNICATIONS

Maj William K. Geissler, United States Marine Corps
Master of Science in Electrical Engineering – September 2001
Advisors: Associate Professor John McEachen and Professor Murali Tummala, Department of Electrical and Computer Engineering

Steganography is the "art" of hiding information so that the information's very existence is not detected. As a method of covert communications, steganography is used to hide information within other communications media. This thesis examines the various techniques of hiding information within Local Area Network (LAN) or Wide Area Network (WAN) communications traffic, with special emphasis on typical internetwork traffic using the Transmission Control Protocol (TCP) and Internet Protocol (IP). Current means of steganography within network traffic is limited in terms of throughput and robustness. A novel means of covertly transmitting data within TCP packets is presented which demonstrates how the manipulation of TCP should be able to increase the effective throughput of covertly transmitted data significantly, since an entire 1460 byte TCP packet may be used for information transfer. A new TCP routing application was developed to embed the hidden information into the cover media, and to retrieve the information at the receiving end. A flexible testing architecture was designed and implemented that may also be used to test other steganographic techniques. Reliable transmission techniques for the hidden information were identified for the steganographic protocol, to increase the robustness of the hidden information. Finally, steganalytic techniques and tools have been identified to counter the use of this technique by unfriendly forces.

USING MULTIPLE COLLABORATIVE AGENTS FOR ADAPTIVE QUALITY OF SERVICE MANAGEMENT IN C4ISR NETWORKS

LT Raymond Rivera, United States Navy
Master of Science in Systems Technology and Master of Science in Information Technology Management
Advisors: Associate Professors Alex B. Bordetsky and John S. Osmundson, Department of Information Sciences

C4ISR networks of the future are increasingly reliant on fast, efficient information exchange over wide distances. In the 21st century, information superiority is the key to battlespace dominance. C4ISR networks are the enablers to this goal and central in the Navy's movement towards Network Centric Warfare. At a minimum, C4ISR networks must be capable of providing voice, video, and data capabilities to the warfighter. At the same time, the information exchange must be accurate, timely, and secure in order to be useful. These factors make the effective management of C4ISR networks paramount. As the growth of information technology increases, so does the need for coordination and maintenance.

The evolution of C4ISR networks and their management systems over the years has resulted in a variety of network management issues. Although all C4ISR networks are required to follow the same basic guidelines and interoperability standards under the Joint Technical Architecture (JTA) and Defense Information Infrastructure Common Operating Environment (DII-COE), there are many different considerations that must be reconciled. These include diverse services, networks, and technologies; multiple vendor equipment; loosely organized management applications; multiple management protocols; and multiple data representations. C4ISR networks must be capable of adapting end-to-end resources and Quality of Service (QoS) across heterogeneous, and oftentimes, mobile networks.

In general, management of these networks occurs at Network Operations Centers (NOCs). NOCs utilize network parameters including traffic patterns, bandwidth utilization, network response times, and e-mail response times. Unfortunately, with increasing requirements for fast information exchange, these techniques need improvement and adaptive management capability. Adaptive management capability of C4ISR networks could be achieved through the usage of multiple collaborative, intelligent agents to overcome the nominal deficiencies in C4ISR network management. Although agent technology is relatively new, it has already demonstrated exciting potential in a variety of applications that lend themselves to this research. Basic agent characteristics of autonomy, adaptability, scalability, and co-operability allow the sharing of information over the entire span of the network. Intelligent agents assess information, adapt to existing conditions, predict future network conditions, and advise on anticipated future conditions. With multiple, collaborative agents, knowledge and expertise can be shared, eliminating the need to store all knowledge locally. In the context of a dynamic environment with unique application

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ASSESSING RUSSIAN AND CHINESE REACTIONS TO U.S. MISSILE DEFENSE

LCDR Michael W. Baze, United States Navy
Master of Arts in National Security Affairs – September 2001
Advisors: Professors James Wirtz and David Yost, Department of National Security Affairs

The United States government intends to deploy strategic missile defense (MD) capabilities to address an emerging ballistic missile threat. Many opponents of MD have argued that this deployment will incite arms races with other nations and lead to decreased international stability. Such consequences could pose a serious threat to U.S. national security. This thesis employs arms race theory as an analytical framework to assess the potential implications of U.S. MD deployment, focusing in particular on the likelihood of arms competition with Russia and China. Two questions are explored. First, what are the potential incentives driving Russian and Chinese reactions to U.S. MD? Second, what are Russian and Chinese capabilities to engage in arms competitions? Perceptions of U.S. unilateralism play a significant role in both nations' assessments of MD. Russian concerns, however, appear to be dominated by prestige considerations and perceptions of diminishing superpower status. Chinese concerns seem to center on U.S. MD's potential threat to China's military modernization program and power projection capabilities in the Asia-Pacific region. Both nations possess some ability to engage America in arms competition, although Russias economic limitations are more severe. By enhancing understanding of potential Russian and Chinese reactions to U.S. MD, this thesis seeks to identify ways to minimize the potential for arms competitions. The thesis concludes with an analysis of policy options as America moves forward with MD.

USNA FEATURE

UNITED STATES NAVAL ACADEMY TRIDENT SCHOLAR PROGRAM

The United States Naval Academy instituted the Trident Scholar Program in 1963 to provide an opportunity for a limited number of exceptionally capable students to engage in independent study and research during their senior year. Under this program, midshipmen in the top 10 percent of their class at the end of the first semester of their junior year are invited to submit proposed research projects and programs of study for evaluation. Midshipmen selected to participate are afforded an unusually exciting educational experience, and there has been a gratifying response to the program. The number of scholars selected has ranged from a low of three to a high of sixteen. Nine scholars were in the Class of 2001 and fifteen scholars are in the newly appointed Class of 2002.

Five of the projects are profiled here, with additional profiles forthcoming in future issues of the *NPS Research*.

A MULTINATIONAL EMPIRICAL ANALYSIS OF HUMANITARIAN ASSISTANCE

Amanda L. Donges (Quantitative Economics major)
Advisors: Assistant Professor Matthew J. Baker, Economics Department, and Associate Professor Gary O. Fowler, Mathematics Department

In an age of globalization, the development of productive nations is paramount. Over the past century, the United States has worked to aid in the advancement of underdeveloped countries, with the hope of expanding trade and fostering worldwide growth. We strive for the goal of world prosperity through the implementation of numerous political and economic tools. Humanitarian assistance is a means by which we facilitate progress around the globe.

The distribution of humanitarian aid is a complex and daunting action for any country to take. The U.S., if choosing to offer aid to a country, must determine which form of assistance is most beneficial. Relief must be operationalized and adapted to fit various forms of economic, political, societal, and cultural environments. The benefits accruing to humanitarian aid are also affected by the form in which the assistance is received. Certain countries may utilize monetary sums better than military assistance or tangible goods. As a result of a country's inabilities to properly utilize and exploit all forms of grants, the United States must weigh the gains of each type of humanitarian aid, and make a selection based on these findings.

Midshipman Donges with advisors Assistant Professor Matt Baker and Associate Professor Gary Fowler

In order to assist in making such determinations, and in assessing the merits of particular types of humanitarian aid, I intend to gather data that illustrates the trends and behaviors of potential aid recipients, and then construct an econometric model of the impact of aid on per capita GDP growth and other measures of well being.

The methods I intend to use are extensive, but based upon basic statistical tools, such as

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USNA FEATURE

LOCALIZATION AND MAP BUILDING IN MOBILE ROBOTS TO ASSIST OUTDOOR MILITARY OPERATIONS IN URBAN TERRAIN

Edward H. L. Fong (Computer Science major)
Advisors: Assistant Professor Frederick L. Crabbe, Computer Science Department, and Dr. Alan C. Schultz, Naval Research Laboratory

When a mobile robot is introduced into an unfamiliar environment, it must be able to successfully navigate in its surroundings in order to perform its given tasks. One example would be to assist soldiers and marines in their operations on urban terrain, moving ahead and sending back data such as maps, pictures, or environmental conditions. To do this, a robot must explore its environment, generate some sort of map of the world it sees, and place itself accurately on that map. This Trident project involves designing and implementing algorithms that will provide a robot with the ability to accomplish these tasks while moving around in an unfamiliar, urban environment.

Dr. Alan Schultzs team at the Naval Research Laboratory has already incorporated some of these exploration and localization capabilities into a mobile robot located indoors. When placed in an unfamiliar environment, the robot generated a map of its surroundings through a technique called frontier exploration. It would create a map of the area within its sensor range, move to an unmapped region, map it, and continue this cycle until all the area within its traversable boundaries are accounted for. To resolve the errors that the robot encounters when it uses dead reckoning to calculate its position, they introduced a technique called continuous localization. This process required the robot to generate another map that it correlated with the main map and then re-plot its position on a frequent basis. Thus the mobile robot could robustly map and navigate itself in an unfamiliar and changing laboratory environment.

A Nomad 200 robot named ARIEL (Autonomous Robot for Integrated and Localization) that was used by the team at the Naval Research Laboratory for 2-3 mapping and localization.

However, the environment outside differs to a great extent from the laboratory settings in which the robots were tested.

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A MULTINATIONAL EMPIRICAL ANALYSIS OF HUMANITARIAN ASSISTANCE, *continued from page 16*

Multiple Linear Regression Models, time-series analysis, and hypothesis testing. In addition, econometric tools will aid in the comparison and evaluation of possible courses of action that the United States may take. Vector Autoregression (VAR) Models are well equipped for forecasting the response of variables, such as per capita GDP growth to changes in humanitarian aid policy. Furthermore, causality tests can be used to reveal the casual relationship between variables over time, and provide insight into such questions as: does the political state of the country determine the effectiveness of aid, or does the effectiveness of aid determine the political state of the country?

Statistical software packages, such as SAS Version 8 and Enterprise Guide are the backbone of this studys regression generation. Both of these programs will help take a multitude of data gathered from the World Development Indicators and the PRS Group, and transform it into a clean set of simultaneous equations exploring the nature of humanitarian aid. In the end, the estimated equations will provide potential answers to various questions. First, does the form of humanitarian aid offered play a role in its effect? Second, do country specific variables, such as political conditions, influence the performance of humanitarian aid, and if so, to what extent? Finally, one can make a determination based on the formulated models, if it is beneficial to offer a certain category of country aid, or if it is not in the beneficiary's best interest.

A study of this nature should provide a resource for potential benefactors to consult. If they are interested in providing assistance to a low-income country, the benefactor can refer to the regressions corresponding to a sample low-income country set. Based on the statistical data and macroeconomic theory, such a person can determine what form of humanitarian assistance should be granted, and how it will affect a country. Furthermore, the given benefactor can use the values of the countries independent variables to compute the values of its own dependent variables, providing supplemental information. With this knowledge, one can make key decisions regarding assistance.

USNA FEATURE

BIOPHYSICAL CHARACTERIZATION OF A BIFUNCTIONAL IRON-BINDING ENZYME

Pritha M. Mahadevan (Chemistry major)
Advisor: Assistant Professor Virginia F. Smith, Chemistry Department

Proteins are the most prevalent class of biological macromolecules, and are present in every form of life. Numerous biological products such as enzymes, hormones, antibodies, and muscle are examples of the diversity of protein function. Enzymes, however, are the most versatile, catalyzing virtually all cellular reactions.

Moreover, recent findings reveal that enzymes are even more versatile than originally thought: Although classical biochemistry has taught us that every protein has one corresponding gene and only one specific function, enzymes have been discovered that can interchange forms and conduct two distinct functions, depending on the cellular conditions.

One such enzyme with two specific functions is the mammalian iron responsive element (IRE) binding protein IRP-1. When free iron levels within the cell are low, IRP-1 plays a regulatory role to increase acquisition of iron and stimulate release of stored iron. But when iron levels return to normal, an iron-sulfur cluster forms within the protein and IRP-1 assumes its other form of cytoplasmic aconitase, an enzyme involved in energy metabolism.

We are interested in learning how this enzyme converts between its two forms. To do this, we will investigate how it acquires its three-dimensional structure, or folds, under different experimental conditions. Before the folding properties can be investigated, however, it will be necessary to synthesize and purify the enzyme. The enzyme to be studied is the human form of the protein, but it will be produced from bacteria using recombinant DNA methods. The gene for the protein is encoded in a plasmid inserted into a non-virulent laboratory strain of E.coli. A plasmid is an extra piece of genetic material that allows the protein to be expressed in

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LOCALIZATION AND MAP BUILDING IN MOBILE ROBOTS, *continued from page 17*

There are differences in elevation, variations in ground composition, and the presence of non-ideal reflective surfaces. When outdoors, the robot must determine in which plane it is traversing (as opposed to the 2-D calculations in the laboratory environment). It must be able to account for ramps, curbs, hills, and ditches realizing that if it is on a negative incline, the barrier it senses is actually the ground before it instead of an obstacle. When traversing from smooth pavement to another ground material (i.e. sand), the robot should be able to record and account for such a situation when calculating its position and movement. In addition, the outside environment also contains many objects that are poor reflectors of the robots sonar pulses (decreasing the effectiveness of its sensors).

The primary objective of this Trident project is to extend Dr. Schultz's integration of exploration and localization for mobile robots so that it would work robustly in an outdoor setting. The first task is to develop multiple map structures that the robot can use to represent a 3-D environment. Using those structures, we can test to determine how well each one performs based on the amount of storage space needed, accuracy of the map, and the speed at which map correlations can be accomplished (for localization purposes). By comparing these results, we can determine which structure (or a combination of features from different structures) would best meet the needs of an outdoor robot. After deciding on the best way to represent the environment, we can then incorporate and test different localizations schemes to determine which method would be most efficient for the robot to use.

The ATRV-Junior robot (manufactured by Real World Interface) to be used for this project.

The goal is to develop a 3-D map structure and localization algorithm for a mobile robot that would let it explore and map an urban-like environment on its own. Such a robot could prove very useful by searching and gathering information in dangerous and hostile areas.

DEVELOPMENT OF A DIGITAL SIGNAL PROCESSOR (DSP) BASED CHAOTIC COMMUNICATIONS SYSTEM WITH EMPHASIS ON MILITARY COMMUNICATION

Noah F. Reddell (Electrical Engineering major)
Advisors: Associate Professor Erik M. Bollt, Mathematics Department, and CDR Thaddeus B. Welch, III, USN, Electrical Engineering Department

In the past, chaos has often been overlooked and written off as random behavior due to noise. Now, exciting new insights in the field have lead to huge leaps in understanding during the latter half of the 20th Century. Mathematicians and engineers are even discovering ways to exploit certain properties of chaotic systems. One emerging example of useful chaos is the use of chaotic systems for communication.

Most of the work developing this idea has been done either on a purely theoretical basis or in component based electrical circuits that are not flexible or practical. The aim of my project will be to explore the advantages of communicating using a chaotic carrier, and to design and create such a system with the goal of covert military communication in mind.

The project will take a unique approach towards exploring the benefits of chaos. We will use digital signal processors for implementing chaotic systems. These high-speed processors will produce a chaotic carrier from software rather than in an electrical circuit. The use of digital signal processors will be more practical from an engineering standpoint and also very

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BIFUNCTIONAL IRON-BINDING ENZYME, *continued from page 18*

greater quantities than would occur naturally.

The bacterial cultures are grown in a broth, and then the cells are harvested by centrifugation. The cells collected are broken open chemically, and the aconitase protein is selectively removed from the mixture of cellular products using an affinity tag that has been placed at the beginning of the protein. The tag causes the protein to bind strongly to Ni ions that have been attached to a solid resin. The protein is additionally purified as necessary, and the purity of the protein is assessed by means of gel electrophoresis.

A series of experiments has been designed to characterize this bifunctional protein. Using a variety of spectroscopic and enzymatic methods, the thermodynamic and kinetic properties of this important and interesting protein will be investigated.

The equilibrium properties will be analyzed by denaturing the aconitase both chemically and thermally. Aconitase's iron-sulfur center provides a maximum absorbance wavelength of 450 nm when fully functional, and as the aconitase becomes denatured due to various experimental techniques, the absorbance of light at a specific wavelength can be measured. Analysis of the spectroscopic signal will make it possible to determine an equilibrium constant for the folded and unfolded forms under various conditions. These equilibrium constants can then be used to determine how stable the protein is by calculating its Gibbs free energy.

Another interesting area of study is the kinetics of the conversion of aconitase. Standard enzyme kinetic analysis techniques will be used to understand the factors that govern the interconversion between the two forms of the protein.

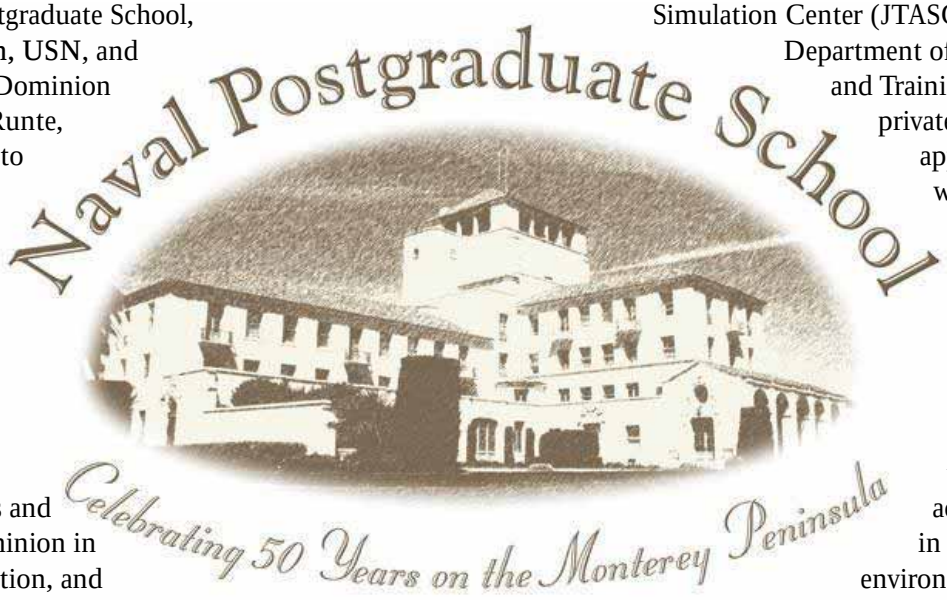
Recent biological research shows strong indications that nitric oxide and hydrogen peroxide will induce the removal of the iron-sulfur center. The nature of interactions between the iron-sulfur proteins and oxidants will be analyzed in order to better understand the role of the aconitase protein and investigate the possibility that the iron-sulfur centers serve in a capacity of stress regulation.

The importance of protein characterization research cannot be emphasized enough. Now that the Human Genome Project has revealed the sequences of all our genes, our challenge is determine the structures, functions and regulation of the proteins they encode. The future of medicine will lie in our ability to understand and correct genetic errors that result in improper protein production in the human body.

Midshipman Pritha M. Mahadevan

NAVAL POSTGRADUATE SCHOOL AND OLD DOMINION UNIVERSITY ENTER INTO EDUCATION AND RESEARCH PARTNERSHIP AGREEMENT

The Naval Postgraduate School has entered into an education and research partnership agreement with Old Dominion University in Norfolk, Virginia, that will facilitate military officers completing graduate education, including doctoral degrees via work done at both institutions. The Superintendent of the Naval Postgraduate School, RADM David Ellison, USN, and the President of Old Dominion University, Roseann Runte, signed the agreement to establish a framework for future collaboration on research and education.



Only three universities offer degrees in Modeling and Simulation - NPS in Modeling, Virtual Environments and Simulation, Old Dominion in Modeling and Simulation, and the University of Central Florida in Industrial Engineering with a subspecialty in Modeling and Simulation. This partnership builds a larger body of knowledge in this new field of research, and has potential to add tremendous value to the human capital of the Department of Defense, and especially the Navy, says Professor Mike Zyda, Director of the NPS Modeling, Virtual Environments and Simulation or MOVES Institute. Within six months, we expect to have some secondary agreements that define the collaboration more thoroughly.

With this agreement, officers have an opportunity to begin or complete graduate education in Modeling and Simulation in either Norfolk or Monterey, supported by expert professors, advisors and research opportunities at either location. This new strategy should enhance degree completion, through the doctoral level, says Old Dominion Professor Bowen Loftin, Director of Simulation Programs at the university's Virginia Modeling, Analysis and Simulation Center (VMASC) in Suffolk, Virginia, an enterprise center of the College of Engineering and Technology. We want to tell officers there is a chance to get this done.

A cooperative venture between Old Dominion and the U.S. Joint Forces Command's Joint Training Analysis and Simulation Center (JTASC), VMASC transfers Department of Defense Simulation and Training technology to the private sector for business applications. Coupled with the University's Center for Advanced Engineering Environments, VMASC represents a formidable resource in Old Dominion's objective to become the academic world leader in virtual collaborative environments and modeling and simulation.

The MOVES Institute's mission is to be the world-class institute for research, application and education in the grand challenges of Modeling, Virtual Environments and Simulation. The institute is similar to VMASC, and operates both independently and in collaboration with the various Navy and Defense modeling and simulation centers. They carry out basic and applied research; analyze continuing modeling, virtual environments and simulation programs; create advanced prototypes; and develop real technologies and applications for the defense community.

The research product directions for MOVES include 3D visual simulation, networked virtual environments, computer-generated autonomy, human-computer interaction, technologies for immersion, defense and entertainment collaboration, and next generation modeling.

INTERAGENCY AGREEMENT BETWEEN NPS AND NASA AMES RESEARCH CENTER ESTABLISHES JOINT INSTITUTE OF AEROSPACE SCIENCES

The National Aeronautics and Space Administration (NASA), as represented by the Ames Research Center and the Naval Postgraduate School entered into an Interagency Agreement to establish the Joint Institute for Aerospace Sciences.

The study of the broad area of aerospace sciences continues to be of critical importance to NASA and to the Navy because of the increasing complexity and cost of aerospace vehicle and space-based systems. Because of these common interests, there exists a significant potential for joint activities between the two organizations to accelerate technology development and provide for personnel grown. Both NPS and NASA possess unique capabilities that are ideally suited for such cooperative activities. NPS has outstanding expertise in the faculties of the Departments of Aeronautics and Astronautics, Mechanical Engineering, Mathematics, Physics, Electrical and Computer Engineering, and Computer Science. NASA Ames is the Center of Excellence for Information Technology and has lead Center responsibilities in computing information and communication technologies, aerospace operation systems, aviation system capacity, and major supporting roles in space transportation and aviation safety. Consequently NASA Ames is actively involved in a spectrum of technologies that parallel those being pursued at NPS. In addition, both NPS and NASA Ames possess a spectrum of computational and simulation research facilities that support these technology developments.

MEMORANDUM OF AGREEMENT BETWEEN NPS AND THE NAVAL SURFACE WARFARE CENTER, CRANE DIVISION, ESTABLISHES NAVY FIRES OFFICE

Within the context of Naval Warfare Strategy for the 21st Century, Navy Fires is a primary component in the U.S. Navy's vision for dominance in the arena of littoral warfare and support of expeditionary forces. Of particular importance is the establishment of an updated Surface Warfare Gunnery Doctrine based on the results of research and analysis of current and future gunnery systems and ammunition. Information and data to base new doctrine is being gathered and analyzed from modeling and simulation, fleet battle experiments, limited objective experiments, live fire exercises, and other tests and demonstrations. The Institute for Joint Warfare Analysis and the Systems Technology Battle Lab at NPS and the Systems Analysis and Research Branch of the Naval Surface Warfare Center (NSWC), Crane Division, have been major participants in these efforts. This Memorandum of Agreement formalized the relationship between the two organizations and provides mutual support and an integrated approach to the development of analytical and operational tools critical to future Navy Fires doctrine and operations. NPS and NSWC-Crane will establish a Naval Fires Office within their respective organizations to host and support counterpart personnel while working at their facility.

LETTER OF INTENT SIGNED BETWEEN THE CALIFORNIA TECHNOLOGY, TRADE AND COMMERCE AGENCY, THE CALIFORNIA STATE UNIVERSITY SYSTEM, AND NPS

The California Technology, Trade and Commerce Agency (CTTCA), the California State University System (CSU), and the Naval Postgraduate School (NPS) have stated that each has objectives and programs that are complimentary to the others and have agreed to encourage formal and informal relationships of mutual benefit to further their educational, research, and service missions.

CTTCA works to ensure that California business has access to markets across the country and around the world. The CSU is the nation's largest comprehensive public university system. The School of International Graduate Studies at NPS offers programs to help stabilize emerging democracies throughout the world.

This agreement provides the basis for establishing a cooperative working relationship among and between the parties to facilitate any or all of the following: reciprocal internships, student and scholar exchanges, policy and program information exchanges, development of overseas points of contact to promote and facilitate educational opportunities and programmatic interests, link active military bases in California with one or more CSU campuses, and workforce development between CTTCA, military bases, and CSU sites.

RELATIONSHIPS

STATEMENT OF INTENT BETWEEN THE NATIONAL UNIVERSITY OF SINGAPORE AND NPS ESTABLISHES TEMASEC DEFENCE SYSTEMS INSTITUTE

The Naval Postgraduate School (NPS) and the National University of Singapore (NUS) have entered into a Statement of Intent to form a collaboration to establish and operate a Singapore-based institute to be named Temasek Defence Systems Institute (TDSI) for graduate education and research in the area of defense technology and systems engineering and analysis. TDSI shall be a part of NUS.

The flagship project of TDSI is the Master of Engineering (MEng) Degree in Defense Technology and Systems (DTS). This degree, to be jointly awarded by NPS and NUS, is a platform for the education and the integration of operation staff and technologists to plan, design, develop, create, operate, and system the integrated military forces of the 21st century. The goal is to produce graduates who will understand the dynamic complexity of a military force and be able to create maximum leverage by the integration of operations and technologies. The objectives of the MEng (DTS) curricula are to provide the students with a learning environment steeped in experimenting and doing, and to create bonds among the students from the operation, scientific, technological, and defense industry communities.

MEMORANDUM OF UNDERSTANDING AMONG THE U.S. ARMY SOLDIER AND BIOLOGICAL CHEMICAL COMMAND, NATICK SOLDIER CENTER, U.S. ARMY YUMA PROVING GROUND, AND NPS SUPPORTS AERODYNAMIC DECELERATOR SYSTEMS

A Memorandum of Understanding among the U.S. Army Solider and Biological Chemical Command, Natick Solider Center (NSC), the U.S. Army Yuma Proving Ground (YPG), and the Naval Postgraduate School (NPS) formalized a relationship to identify and develop open technology areas and novel approaches/systems with maximum potential of providing critical improvements and new capabilities to Aerodynamic Decelerator Systems (DCS). This MOU also formally establishes the Aerodynamic Decelerator Systems Center (ADSC) to foster the advancement of ADS research and technology among government agencies, academia, and non-profit public institutions.

The NSC has the DoD mission for personnel, cargo, and precision airdrop systems research and technology development. YPG is the U.S. Army development test agency for airdrop systems. NPS has extensive expertise in advance mission planning and guidance, navigation and control (GN&C) algorithm development and rapid prototyping of GN&C capabilities.

NPS AND U.S. AIR FORCE SPACE AND MISSILE SYSTEMS CENTER SIGN MEMORANDUM OF AGREEMENT FOR INTEGRATION AND LAUNCH OF NPSat-1

The Naval Postgraduate School has entered into a Memorandum of Agreement with the U.S. Air Force Space and Missile Systems Center, Detachment 12, DoD Space Test Program (STP). The Memorandum of Agreement establishes the basic working agreement between STP and NPS for the integration and launch of NPSat-1 (See *NPS Research*, Vol. 11, No. 2). NPSat-1 will be launched as a secondary payload on the STP Mission Launch Vehicle mission currently scheduled for launch in FY06.

MEMORANDUM OF UNDERSTANDING BETWEEN NAVAL SURFACE WARFARE CENTER, PORT HUENEME DIVISION, AND NPS ESTABLISHES DISTANCE LEARNING PROGRAM IN SYSTEMS ENGINEERING

The Naval Postgraduate School (NPS) and the Port Hueneme Division of the Naval Surface Warfare Center (PHD NSWC) have entered into an agreement to establish a Master of Science Degree in Systems Engineering Distance Learning Program.

PHD NSWC intends to be responsive to its Naval Sea Systems Command (NAVSEA) and Program Executive Office (PEO) customers and, at the same time, acknowledges its responsibility to enhance the skills and capabilities of its workforce. Within the scope of the DoD's Revolution in Military Affairs and Revolution in Business Affairs, the nature of engineering expected from NAVSEA field activities is changing. Future tasking will require more broadly based, higher level skills and will be centered on effective systems engineering which applies requirements definition, functional analysis and allocation, and design synthesis to all NAVSEA and PEO programs.

NPS seeks to continue to provide excellence in graduate level degree programs, extend its present business base, take

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C4ISR NETWORKS, *continued from page 15*

profiles, this framework is ideally suited for translating the warfighter's service level requirements. The end result is a more efficient, responsive, and potent C4ISR network.

In the kernel of the proposed multiple agent adaptive management testbed are agent shared memory and majority rule architectures for agent conflict resolution. The case-based reasoning (CBR) technique will be used as the foundation for building the agents shared memory of QoS management solutions. It allows the individual agents to share their associations of feedback controls in response to application and user QoS profiles.

The committee type multi-participant group decision support technique will be adopted for resolving the conflicts among multiple agents in allocating the networking resources in response to the conflicting QoS requirements. The conflict resolution architecture is composed of an artificial neural network (ANN) with two hidden layers. Each node in the second hidden layer represents the committee solution for QoS resource allocation that the multiple agent system (MAS) learned while managing the C4ISR task and adapting to the conflicting QoS requirements. In accordance with the Telecommunications Management Network (TMN) functionality, the agent architecture effectively translates the warfighters service layer application requirements across the network. The fundamental frameworks of Service Level Management (SLM) and Policy Based Management (PBM) are used to effectively gather the specific application requirements. From these requirements, the multiple agent testbed becomes the enabling framework for the intelligent adaptive capability of collaborative work.

Using these building blocks for our research, we investigate an actual C4I application at the Pacific Region Network Operating Center (PRNOC) and use it for ongoing modeling and simulation research at the Naval Postgraduate School. In this instance, we are investigating the adaptive allocation of bandwidth under dynamic conditions via multiple collaborative agents.

(LT Rivera was awarded First Student Paper Award at the 6th International Command and Control Technology Symposium, Track 2: Command and Control Experimentation, United States Naval Academy, Annapolis, Maryland, June 2001. LT Rivera's thesis research was sponsored by the J-9 Experimentation Directorate project under the direction of Associate Professor William Kemple.)

DISTANCE LEARNING, *continued from page 22*

advantage of distance learning technology, and collaborate with a wider range of DoN organizations and other institutions of higher learning.

Under this agreement, NPS will design and deliver a Systems Engineering Curriculum that, upon successful completion of the established coursework and projects, will result in the conferring of an accredited Masters of Science Degree in Systems Engineering to participants at PHD NSWC. NPS shall also issue Certificates of academic accomplishment to students who complete significant segments of the degree program.

MULTI-BLOCK PARALLEL NAVIER-STOKES SIMULATION OF UNSTEADY WIND TUNNEL AND GROUND INTERFERENCE EFFECTS

Major Breno Moura Castro, Brazilian Air Force
Doctor of Philosophy in Aeronautical and Astronautical Engineering
Advisor: Distinguished Professor Max F. Platzer, Department of Aeronautics and Astronautics

A numerical investigation of unsteady wind tunnel and ground interference effects is carried out in the time domain to study the transonic flutter characteristics of the NLR 7301 section inside a wind tunnel and the thrust generation characteristics of a NACA 0014 airfoil plunging near a ground plane. A parallelized, multi-block deforming grid, unsteady flow-solver is coupled with a two-degree-of-freedom structural model.

For the transonic flutter problem, two types of porous-wall boundary conditions are implemented and tested for the boundaries representing the tunnel walls. The type of porous boundary condition is found to influence significantly both steady and unsteady solutions. Results show that the free-flight flutter behavior may differ significantly from the behavior found in a porous wind tunnel because of the strong dependence on the tunnel porosity parameter and the proximity of the walls.

An analysis of the trailing edge boundary condition is performed for the airfoil in ground effect. The computations show that this boundary condition influences the solution only when non-linearities are present in the flow-field, although parameters averaged through a cycle of oscillation are not affected significantly. The same behavior is observed for the influence of the turbulence model on the fully turbulent, unsteady computations. However, the best agreement with low Reynolds number, experimental data is obtained when the flow is assumed laminar and no turbulence model is applied.

ASIAEX PROGRAM A HUGE SUCCESS!

Research Professor Steven R. Ramp and Professor Ching-Sang Chiu
Department of Oceanography, Naval Postgraduate School
James F. Lynch, Department of Applied Ocean Physics and Engineering, Woods Hole Oceanographic Institution
Peter H. Dahl, Applied Physics Laboratory, University of Washington

Introduction

With the docking of the *R/V MELVILLE* in Naha, Okinawa on June 14, 2001, the Asian Seas International Acoustics Experiment (ASIAEX) field program came officially to a close. The 2001 field program marked the culmination of five years of planning and was a triumph over countless political and logistical, as well as scientific hurdles. Approximately 35 principal investigators from 18 major institutions participated in the work at sea. The resulting data set, collected over 108 days on eleven cruises aboard six research vessels in two marginal seas, is the largest and most comprehensive of its kind ever collected, and will serve to advance the state of the art in understanding acoustic propagation in shallow water.

The ASIAEX program was divided into two major components, a volume interaction experiment in the South China Sea (SCS), with Taiwan and Singapore as the primary collaborators, and a boundary interaction experiment in the East China Sea (ECS), with the Peoples Republic of China (PRC) and Korea as the primary international partners. The overarching goal of the volume interaction experiment was to understand acoustic propagation through shallow water when strong oceanic variability in the form of fronts, eddies, boundary layers, and internal waves, is present. The goal of the boundary interaction experiment was to develop models that can predict the mean reverberation level and fluctuations using measured environmental parameters. Both experiments were multi-ship operations and required close cooperation between acousticians, physical oceanographers, and geophysicists. All the partnering nations contributed human and financial resources to the program, which allowed a larger and more comprehensive experiment than would otherwise have been possible.

Figure 1. Ships used during the ASIAEX 2001 field program. Clockwise from top left: *OCEAN RESEARCHER 1*, *OCEAN RESEARCHER 3*, *SHI YAN 3*, *MELVILLE*, *SHI YAN 2*, AND *FISHERIES RESEARCHER 1*.

The SCS volume interaction experiment was executed exclusively from the Taiwanese research vessels *OCEAN RESEARCHER 1* (OR1), *FISHERIES RESEARCHER 1* (FR1), and *OCEAN RESEARCHER 3* (OR3) (Figure 1). All cruises were staged from Pier 11, Kaohsiung, Taiwan, where the group leased a 10,000 sq. ft warehouse for the duration of the program. This was the largest equipment mobilization in the

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ASIAEX PROGRAM, *continued from page 24*

history of the Woods Hole Oceanographic Institution (WHOI), with over 230,000 pounds of gear shipped to the warehouse. The OR1 cruises were to a) deploy oceanographic moorings; b) survey the area with the SEASOAR towed undulating vehicle and hull mounted ADCP, and c) recover oceanographic moorings. The FR1 cruises were to deploy and recover the heavier sound sources and acoustic receiving arrays. The OR3 conducted three cruises to characterize the environment along the primary transmission paths using a towed CTD, high frequency acoustics, and a towed acoustic source. The OR1 and OR3 required extensive deck modifications to be outfitted for the cruises. The equipment shipping, staging in Kaohsiung, and deck modifications were all carried out under the able direction of Mr. John Kemp (WHOI).

The ECS boundary interaction experiment was a three-ship operation involving the U.S. research vessel *MELVILLE* and the PRC vessels *SHI YAN 2* and *SHI YAN 3*. The *MELVILLE* staging out of Naha, Okinawa was handled by the University of Washingtons Applied Physics Laboratory (APL/UW) and the Scripps Institution of Oceanographys Marine Physical Laboratory (MPL/SIO). The *SHI YANs* are both home-ported in Guanzhou, PRC and made a brief stop at Ningbo City enroute to pick up gear and personnel from the Institute of Acoustics, Chinese Academy of Sciences (IOA/CAS) in Beijing. Following the field work, the *MELVILLE* made a port call in Shanghai before returning to Naha to offload and ship all the gear home.

South China Sea Operations

The science plan for the SCS volume interaction experiment called for simultaneous observations of the water column properties (temperature, salinity, and velocity) and acoustic propagation characteristics at very high resolution in space and time. This was accomplished by a combination of moored and shipboard observations near the continental shelf

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ASIAEX 2001 PRINCIPAL INVESTIGATORS

Name	Institution	Responsibility
Dr. Louis Bartek	University of North Carolina	ECS Sub-bottom Profiling, G&G
Mike Caruso	Woods Hole Oceanographic Institute	Remote Sensing: SST and Ocean Color
Eng-Soon Chan	National University of Singapore	SCS Towed CTD
Chi Fang Chen	National Taiwan University	Volume Interaction
Ching-Sang Chiu	Naval Postgraduate School	Volume Interaction, Acoustics Mooring, Lead U.S. PI, OR1 Leg I, Associate International Science Coordinator
Wen-Ssn Chuang	National Taiwan University	SCS Physical Oceanography
Peter Dahl	Applied Physics Laboratory, University of Washington	Boundary Interaction, Reverberation, Wave Buoy Chief Scientist, *MELVILLE*
Tim Duda	Woods Hole Oceanographic Institute	Volume Interaction, LOCO Moorings
Glen Gawarkiewicz	Woods Hole Oceanographic Institute	Volume Interaction, SEASOAR, Lead U.S. PI, OR1 Leg II
Xian-Yi Gong	Hangzhou Applied Acoustics Research Institute	Broadband Propagation and Reverberation
Bill Hodgkiss	Marine Physical Laboratory, Scripps Institution of Oceanography	Towed Source, Direct Path Bottom Reverb
Sik Huh	Korea Ocean Research and Development Institute	ECS Coring, G&G
John Kemp	Woods Hole Oceanographic Institute	Lead U.S. PI, FR1 Leg II , SCS Logistics Coordinator
Seong-Ryul Kim	Korea Ocean Research and Development Institute	ECS Coring, G&G
Jianjun Liu	Institute of Acoustics, Chinese Academy of Sciences	Broadband Propagation and Reverberation, Chief Scientist, *SHI YAN 2*
Tony Liu	NASA Goddard Space Flight Center	Remote Sensing: Synthetic Aperature Radar
Jim Lynch	Woods Hole Oceanographic Institute	Volume Interaction, Acoustics Moorings, Lead U.S. PI, FR1 Leg I
Jim Miller	University of Rhode Island	Boundary Interaction, Broadband Shot Tomography

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PROJECT NOTES

ASIAEX PROGRAM, *continued from page 25*

break between the southern tip of Taiwan and Dongsha Island (also called Pratis Reef) bounded by 21 to 22.5°N, 117 to 119°E. First, the acoustic and oceanographic moorings were deployed by the OR1 and FR1. Then, the repeat surveys of the environment were carried out from the OR1 and OR3. Finally, The OR1 and FR1 went out again to recover all the moorings. The sub-bottom structure along the acoustic transmission paths was also sampled on the FR1 recovery cruise, using the FAU chirp sonar. The WHOI/NPS/NTU/UM moored array consisted of eight densely-instrumented oceanographic moorings with seven deployed in an across-shelf line spanning 800 to 50 m and the eighth moored alongshore on the 80 m isobath (Figure 2). These moorings

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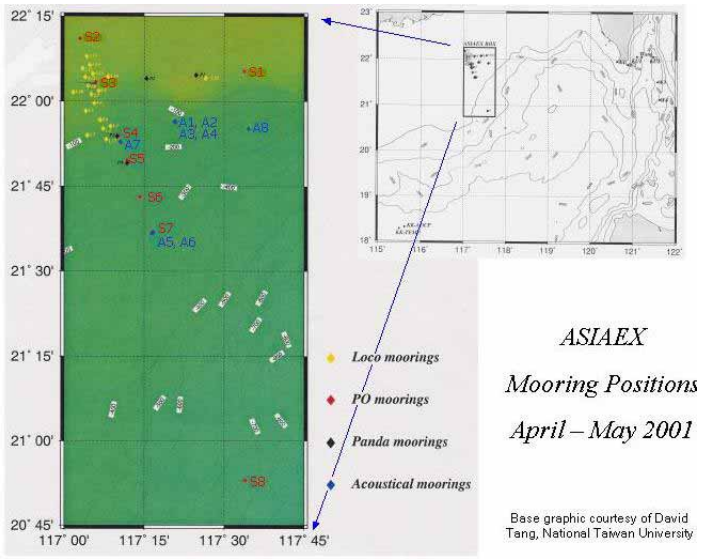

Figure 2. Location of Moorings deployed in the South China Sea during the ASIAEX experiment, April to May 2001. The red diamonds numbered S1-S8 are the physical oceanography moorings and the blue diamonds numbered A1-A8 are the acoustics moorings. The low-cost (LOCO) moorings are indicated in yellow and the PANDA moorings in black.

ASIAEX 2001 PRINCIPAL INVESTIGATORS, *continued from page 25*

Marshall Orr	Naval Research Laboratory	Towed CTD, Underway Acoustics, Lead U.S. PI, OR3 Leg I
Neal Pettigrew	University of Maine	Environmental Moorings
Rob Pinkel	Scripps Institution of Oceanography	Hull-mounted Sonars and ADCP
John Potter	National University of Singapore	PANDA Moorings
Steve Ramp	Naval Postgraduate School	Environmental Mooring,Lead U.S. PI, OR1 Leg III International Science Coordinator
Steve Schock	Florida Atlantic University	SCS Chirp Sonar, G&G
Ping Shi	South China Sea Institute of Oceano-graphy, Chinese Academy of Sciences	Research Vessels *SHI YAN 2* and *SHI YAN 3*
D. J. Tang	Applied Physics Laboratory, University of Washington	Boundary Interaction, IMP-2 Observations
David Tang	National Taiwan University	Environmental Moorings, Chief Scientist, FR1 Legs I and II
Chau Chang Wang	National Sun Yat-sen University	Towed CTD, Underway Acoustics, Chief Scientist, OR3 Leg II
Joe Wang	National Taiwan University	Volume Interaction, SEASOAR, Chief Scientist, OR1 Leg II
Ruey-Chang Wei	National Sun Yat-sen University	Volume Interaction, Chief Scientist, OR3 Leg I and III, Kaohsiung Logistics Coordinator
Steve Wolf	Naval Research Laboratory	Towed CTD, Underway Acoustics, Lead U.S. PI, OR3 Legs II and III
Jin Yan	Institute of Acoustics, Chinese Academy of Sciences	Boundary Interaction, Lead Chinese PI on *MELVILLE*
Yiing-Jang Yang	Chinese Naval Academy	Environmental Moorings, Chief Scientist, OR1 Legs I and III
Renhe Zhang	Institute of Acoustics, Chinese Academy of Sciences	Boundary Interaction, Chief Scientist, *SHI YAN 3*
Jixun Zhou	Georgia Tech	Boundary Interaction, Lead U.S. PI, *SHI YAN 3* NICOP Program Coordinator

FACULTY PARTICIPATION IN RF/EO PROPAGATION STUDIES IN HAWAII

Faculty, staff, students, and equipment in the Departments of Meteorology and Oceanography were part of a month-long (from mid-August to mid-September) field experiment on Radar (Rf) and optical (EO) propagation over the waves near Oahu, HI. The experiment is ONR-funded and called the Roughness and Evaporation Duct (RED) experiment. The experiment is a major ONR-funded one addressing both Rf and EO propagation. Professor Ken Davidson of the Department of Meteorology is the NPS Principal Investigator.

Profiles affecting Rf refraction and turbulence and aerosol affecting EO are atmospheric features being studied. The primary platform is FLIP (floating instrumented platform), operated by the Scripps Institute of Oceanography, which is at the seaward and transmitting end of both the Rf and EO paths (Figure 1). Profiles of mean and turbulent properties of the atmosphere, and bubble production of aerosol are being studied by collaborators on FLIP. An NPS instrumented buoy (Figure 2) is located at the mid-point of the EO path and an NPS chartered vessel is used to collect information along the Rf path. The instrumented buoy is collecting mean and turbulent airflow values, and surface temperature and wave values. Kite-borne sondes are used to measure temperature and humidity profiles from within one meter of the surface to 120 meters above. The buoy and kite system were prepared by Meteorology faculty (Professor Davidson, Research Associate Paul Frederickson, and Research Professor Peter Guest) and staff (Keith Jones) and Oceanography staff (Marla Stone) designed and directed deployment of the fragile instrumented buoy. Air-Ocean student LT Debra Mabey, USN, has participated with the kite-borne profile project from its design through collection on the leased vessel in RED. LT Mabey's thesis research will involve the RED combined meteorology and Rf propagation data set.

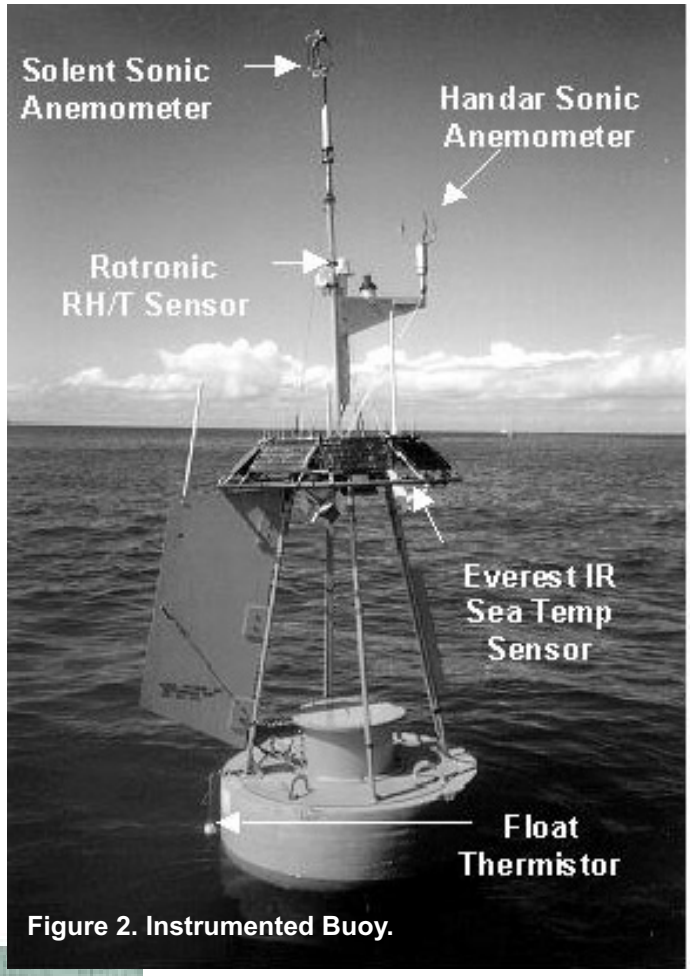

Figure 2. Instrumented Buoy.

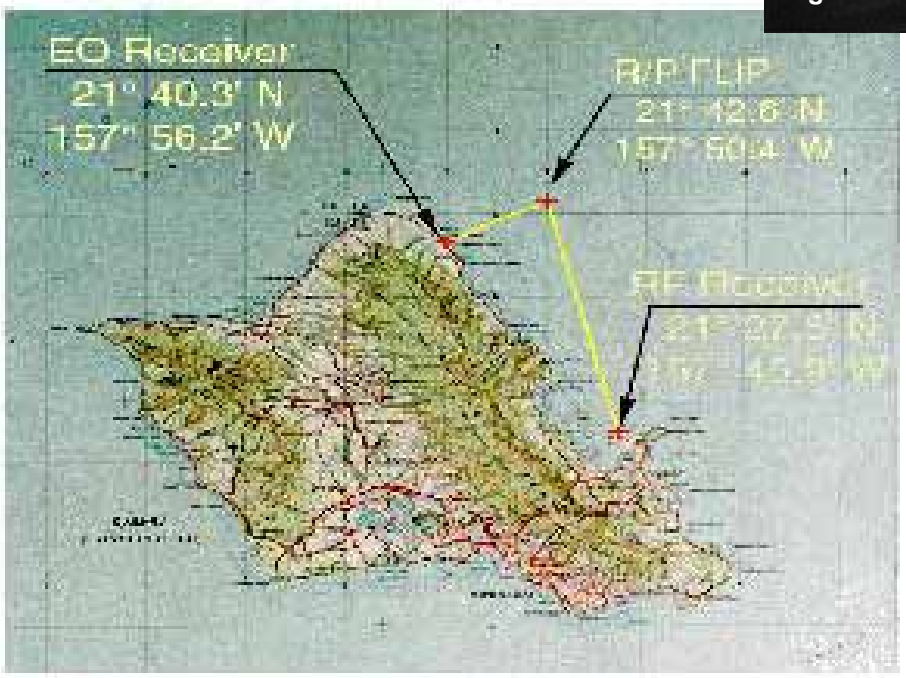

Figure 1. Position of FLIP and the EO and Rf paths. The NPS buoy is on the EO path.

This is the 11th year of ONR funding for the group's participation in field experiments on Rf and EO propagation. Previous studies going back to the early 90s have been off the Netherlands, off Florida, in Monterey and San Diego Bays, and off Duck, NC and Wallops Island, VA.

CONFERENCES

THE MOVES INSTITUTE: MODELING, VIRTUAL ENVIRONMENTS AND SIMULATION FOR A BETTER TOMORROW

The MOVES Institute (http://movesinstitute.org) opened its doors to the general public for the first time with an event held on the 28th through the 30th of August 2001 at the Naval Postgraduate School. The open house displayed work never previously seen in a public setting, according to Professor Michael Zyda, Institute Director.

Highlights of the event included live demonstrations of leading edge research in networked virtual environments (net-VEs), including the long-in-development NPSNET-V system. The NPSNET-V architecture is designed to be the core underpinning of future Internet-based 3D games, net-VEs and simulation systems. NPSNET-V is an architecture for constructing scalable, dynamically extensible, net-VEs. Included in that architecture is the first time ever notion of a Virtual Reality Domain Name Service (VR-DNS), a method for discovering Internet-based virtual worlds wherever they may be.

Additional presentations demonstrated the NPSNET-V dynamic behavior protocol, a mechanism for interoperating and interacting with unfamiliar, newly discovered characters and objects in the net-VE. Researchers Don McGregor, Andrzej Kapolka, Michael Capps, Don Brutzman and Michael Zyda lead net-VE development in the Institute and were the presenters.

Computer-generated autonomy (CGA), the modeling and simulation of human and organizational behavior inside of a net-VE, was another major area seen at the open house. The theme throughout these talks was how we develop computer code that lets us model computer characters that are adaptable and capable of learning, computer code that can be inserted into our net-VEs. Highlights of the CGA session include talks by John Hiles on Software agents: smarter, easier to create, more capable and A symbolic reactive agent architecture for multi-agent systems. Hiles was a member of the Maxis team

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Attending The MOVES Institute Open House were from (left to right), Maurice Gauthier, Computer Services Corporation, Dr. R. Bowen Loftin, Old Dominion University, VADM Richard Mayo, USN, RADM David R. Ellison, USN, Superintendent, NPS, and Professsor Michael Zyda, Director, The MOVES Institute.

THE EFFECTS OF NATURAL LOCOMOTION ON MANEUVERING TASK PERFORMANCE IN VIRTUAL AND REAL WORLDS

1st LT Eray Unguder, Turkish Army
Master of Science in Modeling Virtual Environments and Simulation – September 2001
Advisors: Assistant Professor Rudy Darken and Research Associate Barry Peterson, Department of Computer Science

This thesis investigates human performance differences on maneuvering tasks in virtual and real spaces when a purely natural active locomotion technique is used as opposed to an abstraction through a device such as a treadmill. The motivation for the development of locomotion devices thus far has been driven by the assumption that a perfect locomotion device will result in human performance levels comparable to the real world. This thesis challenges this assumption under the hypothesis that other factors beyond the locomotion device contribute to performance degradation. Therefore, even a perfect device will not result in identical performance or behavior on maneuvering tasks. An experiment was conducted to identify and study the effects of these other factors.

The experiment studied sidestepping, kneeling, looking around a corner, and backward movement as a subset of maneuvering tasks related to a building clearing exercise. The participants used natural locomotion in the experiment; they physically walked through the environment

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THE MOVES INSTITUTE, *continued from page 28*

that brought out SimCity Supreme, SimAnt and SimFarm. A joint presentation by Michael van Putte, Brian Osborn and Dave Back examined architectures that allow software agents to learn.

Human-computer interaction (HCI) was covered through a number of institute researcher presentations. Rudy Darken started off by defining the scope of institute interests in training in the net-VE, human factors in the net-VE, and intelligent tutoring systems. Perry McDowell provided an update on the institute Context Machine efforts. Krist Norlander presented his work on VE interface effects on collaborative personality traits. Eric Bachmann provided an update on the institute's sourceless limb tracking project. Barry Peterson wrapped up with a presentation on tutoring interactions, real, virtual and otherwise.

Defense and entertainment collaboration, a topic pioneered by the institute through its leadership of the National Research Council study entitled *Modeling and Simulation Linking Entertainment and Defense*, is a large part of the institutes research agenda. Michael Capps described, for the first public time ever, the MOVES Institute War Game Laboratory, a videogame research and production facility. The laboratory has an R&D team of some twenty artists, level designers, game programmers and researchers, a facility and capability not duplicated at any other university or government laboratory. Members of the R&D team have recently come from such videogame production firms as Electronic Arts, Goldtree, Emergent Design, Sony, Daylight Productions, Kalisto, Homeland Federation, and John Mason Associates.

John Hiles and Brian Osborn took up the topic of interactive, computer-generated stories and demonstrated, for the first time in a public presentation, the working Hiles-Osborn Story Engine (HOSE). The HOSE is capable of maintaining computer and interactive characters within the bounds of a defined story. The HOSE is capable of allowing an emergent story as well. No other story engine has achieved the level of

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EFFECTS OF NATURAL LOCOMOTION ON MANEUVERING, *continued from page 28*

under all conditions. The independent variable was the characteristics of the visual and haptic display. There were three treatment conditions: real world (no head-mounted display, physical objects present), virtual world (head-mounted display, no physical objects present), and real and virtual world combined (head-mounted display, physical objects present).

The results suggest that performance and behavior are not the same across conditions with the real world condition being uniformly better than either of the virtual conditions. This evidence supports the claim that even with identical locomotion techniques, performance and behaviors change from the real to the virtual world.

1st LT Unguder was the recipient of The MOVES Institute's George L. Phillips Award in Modeling, Virtual Environments and Simulation.

The maneuvering tasks in virtual and real environments (left to right: kneeling task in VE only condition, backward movement task in VE+Real Condition, kneeling task, and sidestepping task).

MEETING NATO'S BIO-DEFENSE CHALLENGES

The Naval Postgraduate School was the site of a major event in late June this year: a formal NATO seminar organized by the schools newly created Center for the Study of Asymmetric Conflict (CSAC) to help the Alliance's Senior Defense Group on Proliferation (DGP) meet NATO's Bio-Defense Challenges. The goal of this seminar which was attended by over 100 people was to promote a common understanding among NATO nations and groups of the political and operational consequences posed by the threat or use of biological weapons (BW) against the Alliance, and the possible steps that could be taken to create a more coherent and effective Alliance approach to bio-defense.

Designed to build on the success of a NATO seminar the Hungarians hosted in Budapest last summer, which also focused on bio-defense, the Monterey seminar brought together DGP representatives, their staffs, and other officials from NATO nations and NATO headquarters and groups to examine opportunities for improving NATO policy guidance, operational concepts and doctrine, military R&D and capabilities, and training and exercising to ensure that NATO forces can successfully deal with the threats posed by the proliferation and the possible threat or use of biological weapons.

The seminar was attended by DGP representatives from nearly all nineteen NATO nations and certain policy, intelligence, technical and operational experts in capitals who are closely involved with the Alliance's work to counter the proliferation and possible use of weapons of mass destruction. Peter Lavoy, Assistant Professor of National Security Affairs at NPS and also director of the recently formed CSAC, served as the conference's coordinator.

A combination of four formats were used to achieve the seminar objectives:

- Initial presentations by NATO and non-NATO specialists to promote a common understanding of new developments and works in progress;
- Scenario-based discussions to help participants better understand the current preparedness of NATO forces to operate under BW conditions and the strategic and policy implications of various courses of action that the DGP might recommend following the seminar;
- Wrap-up presentations by key NATO group representatives on possible next steps; and
- Concluding discussion of next steps for the DGP and the Alliance as a whole.

With growing concern over the possibility of confronting potential adversaries armed with nuclear, biological, or chemical (NBC) weapons, many NATO nations have expressed interest in utilizing threat scenarios, or situation depictions, to help clarify the needs of NATO planners, programmers, and trainers of the forces who ultimately might confront NBC threats. The set of situation depictions developed for this seminar were intended to provide a broad framework to assist NATO members assess defense requirements for dealing with adversaries that might use BW agents. They spanned a range of plausible BW threats in the 2002-2010 timeframe that could affect key NATO functions and capabilities. The goal was to provide a tool to help NATO nations, groups and commands deepen their understanding of the implications of BW threats; assess the strengths and weaknesses in current and planned capabilities; and help identify improvements in capabilities, organization, planning, doctrine, and training to counter potential BW threats.

All participants agreed that the seminar was an enormous success. A classified seminar report is being prepared and disseminated by CSAC in coordination with NATO's WMD Centre. This report will be used by the DGP to enhance the Alliances bio-defense effort in upcoming NATO meetings. For more information about this activity, contact Ms. Iliana Bravo, Research Associate, Center for the Study of Asymmetric Conflict, NPS (831-656-3587, ipbravo@nps.navy.mil).

THE MOVES INSTITUTE, *continued from page 28*

sophistication shown at this event.

Defense and entertainment collaboration wrapped up with a presentation by Russ Schilling on net-VE sound design lessons learned from the entertainment industry, and a presentation by Michael van Putte on the Institute's SimSecurity, game-based learning virtual laboratory.

Institute-affiliated invited speakers included VADM Richard Mayo, USN, "The Future of Naval Modeling and Simulation," Dennis McBride, "When Humans and Machines Take IQ Tests Together: How Modeling and Simulation Fundamentally Change(s) Society," and George Solhan and Dylan Schmorrow, "From Technical to Tactical: The ONR Virtual Technologies and Environments (VIRTE) Program."

FACULTY NEWS

OPERATIONS RESEARCH PROFESSOR RECOGNIZED AS A DISTINGUISHED PROFESSOR

Professor Gerald (Gerry) Brown was recognized as a Distinguished Professor at the September graduation ceremony. A distinguished professor is a senior role model among his/her colleagues. A distinguished professor has given continued effective service to the Naval Postgraduate School, and has conducted work that has had significant impact on the candidates field.

Professor Brown joined the faculty of the Naval Postgraduate School in 1973. He received his Ph.D. in mathematical methods from UCLA in 1974. He has received a number of international awards for his research and publications. He has also been recognized by NPS for his outstanding teaching.

Professor Brown is a leader in the Department of Operations Research. His OR specialty is optimization. In fact, he is recognized as the top expert in the world on optimization.

RADM Ellison congratulates Gerry Brown.

THIRD ANNUAL CLASSIFIED ADVANCED TECHNOLOGY UPDATE (CATU) SHORT COURSE

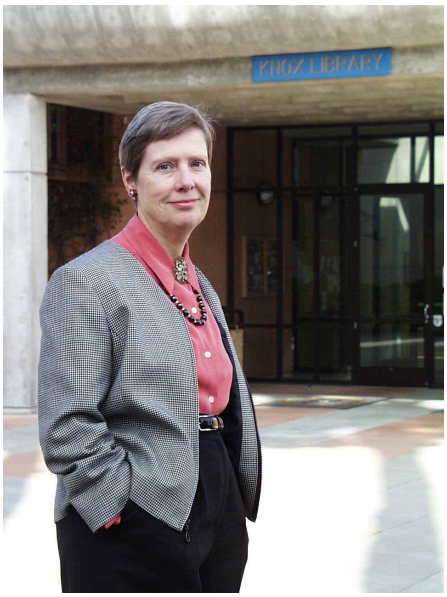
The Naval Postgraduate School held the Third Annual Classified Advanced Technology Update (CATU) Short Course from 23-27 July 2001. Approximately 180 representatives of various intelligence communities/functions/offices of the federal government, military services, and contractor elements were in attendance. The objective of the course is to provide an opportunity for Department of Defense senior technical personnel to stay current on a broad range of developing technology trends and national security imperatives that will affect their mission. The central theme for this year's CATU was information fusion and intelligence collection challenges. This year, we were fortunate to have two keynote speakers ideally suited to address this large group of senior technical experts. MG John F. Stewart, USA (Ret.), President of General Dynamics Electronic Systems, and William P. Crowell, President and CEO of Cylink Corporation and former Deputy Director of the National Security Agency, both provided topics of great interest to the CATU participants. Mr. Stewart's presentation, Operational Imperatives and Technology Trends, set the tone for the course, while Mr. Crowell's presentation specifically addressed security and, conversely, vulnerability issues that affect commercial and government electronic business activities. His presentation also addressed the future of encryption technology and the nature of the evolving threats associated with encrypted communications. In addition to the keynote speakers, thirty-five other guest lecturers, selected based upon their renowned work and recognized subject matter knowledge, provided technical presentations on their specific areas of expertise. The broad spectrum of technical subjects presented included specific topics in Cryptology, Information Operations, Overhead Reconnaissance, Digital Signal Processing, Communications, RF Weapons, Low Probability of Intercept and Geolocation.

Department of Defense forums such as the CATU allow military and civilian technical personnel to stay current on the technological trends in the aforementioned areas. NPS students and staff, with the requisite security clearance, were permitted free access to any presentations that were of particular interest to them. The NPS venue 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. The CATU was organized and facilitated by Ms. Rita Painter, the NPS/SPAWARSYSCEN Cryptologic Program Manager and Professor Herschel Loomis, Departrment of Electrical and Computer Engineering. The Fourth Annual CATU has been tentatively scheduled for July 2002.

FACULTY NEWS

NPS LIBRARIAN RECIPIENT OF NATIONAL RECOGNITION

Maxine Reneker, Associate Provost for Library and Information Resources, received national recognition at the American Library Association annual meeting in San Francisco in June 2001. She is the recipient of the 2001 Elizabeth Futas Catalyst for Change award for raising the visibility and value of libraries at NPS and beyond. The award recognizes a librarian who invests time and talents to make positive changes in the profession of librarianship.



Maxine Reneker

Throughout her career, Dr. Reneker has worked to bring about change in library organizations. "Reneker has created an enhanced visibility for the library and implemented significant institutional changes that go far beyond anything that could have been anticipated and have become permanent changes at the Naval Postgraduate School and elsewhere," according to Award Chair Louise S. Sherby.

Specifically, the award recognized her work in allowing the NPS Library staff to take risks that foster creativity and innovation; for being an active supporter of new services and effectively creating a new program of outreach to students, faculty, and the community at large; for mentoring and tutoring new students and encouraging them to become librarians who in turn have made positive contributions to the profession of librarianship; and for being a positive role model in serving the profession through her work in the American Library Association, the Association of College and Research Libraries, the American Society for Information Science and Technology, the Military Librarians Division of the Special Libraries Association, and the Golden Gateway Library Network in California.

METEOROLOGY PROFESSOR RECOGNIZED FOR MERITORIOUS CIVILIAN SERVICE

Dr. Lester E. Carr of the Department of Meteorology received the Navy Meritorious Civilian Service Award from the Commanding Officer, Naval Pacific Meteorology and Oceanography Center, Joint Typhoon Warning Center. Dr. Carr was cited for sustained meritorious civilian service in support of the Naval Pacific Meteorology and Oceanography Center/Joint Typhoon Warning Center (NAVPACMETOCCEN/JTWC) during the period August 1999 to August 2001. During the period, Dr. Carr consistently demonstrated exemplary professional guidance and leadership of the Systematic Approach to Tropical Cyclone Forecast Aid (SAFA) development team in direct support of JTWC operations. His personal insight and efforts in development a new JTWC operational forecast process that routinely used SAFA led to a quantum leap in forecast skill. Dr. Carr's development effort was a direct result of seven years of research and was instrumental in helping JTWC produce tropical cyclone forecasts that resulted in three consecutive record breaking forecast seasons. Dr. Carr's expertise, initiative, professionalism, and dedication to duty reflect great credit upon him and were in keeping with the highest traditions of the U.S. government.

RADM Ellison congratulates Les Carr.

FACULTY NEWS

GRADUATE SCHOOL OF BUSINESS AND PUBLIC POLICY

F.J. Barrett and K.F. Snider, "Dynamics of Knowledge Transfer in Organizations: Implications for Design of Lessons Learned Systems," NPS Technical Report, NPS-GSBPP-01-002, 12 April 2001.

M.J. Eitelberg, "Women and Minorities in the Military: Charting a Course for Research," in Mickey R. Dansby, James B. Stewart, and Schuyler C. Webb, eds., *Managing Diversity in the Military*, New Brunswick, NJ: Transaction Publishers, 2001.

G. Fann-Thomas, "Discourse and Innovation in Organizations," Association for Business Communication European Convention, Dresden, Germany, 23-26 May 2001.

C. Franck, "Dominant Battlefield Knowledge," Western Economics Association International Meeting, San Francisco, CA, 5-8 July 2001.

C. Franck and G. Hildebrandt, "Strategy to Forces to Budget for the QDR," Western Economics Association International Meeting, San Francisco, CA, 5-8 July 2001.

W.R. Gates and K.L. Terasawa, "NATO Expansion and Burden Sharing," Western Economics Association International Meeting, San Francisco, CA, 5-8 July 2001.

W.R. Gates and M.E. Nissen, "Designing Agent-Based Electronic Employment Markets," Western Economics Association International Meeting, San Francisco, CA, 5-8 July 2001.

W.R. Gates and M.E. Nissen, "Designing Agent-Based Electronic Employment Markets," *Electronic Commerce Research Special Issue: Theory and Application of Electronic Market Design*, 1(3), July 2001.

W.R. Gates and M.E. Nissen, "Intelligent Agents and Web-Based Markets for Detailing Naval Personnel," Military Personnel Research Science Workshop, University of Memphis, TN, 4 June 2001.

L.R. Jones, F. Thompson and W. Zumeta, "Curriculum and Course Design for Graduate Programs in Public Management," *Proceedings of the International Public Management Network Workshop*, University of Southern Denmark, Odense, Denmark, 17-19 July 2001.

L.R. Jones and F. Thompson, "Responsibility Budgeting and Accounting," *International Public Management Journal*, Vol. 3, pp. 205-227, 2000.

M.E. Nissen, "Agent-Based Supply Chain Integration," *Journal of Special Topics in Information Technology & Management*, 2:3 Special Issue, Electronic Commerce in Procurement and the Supply Chain, pp. 289-312, 2001.

M.E. Nissen, "Contracting Process Innovation," NPS Technical Report, NPS-GSBPP-02-001, March 2001 (http//web.nps.navy.mil/~menissen/papers/contractinnovationTR.pdf).

M.E. Nissen, "Facilitating Naval Knowledge Flow," NPS Technical Report, NPS-GSBPP-01-004, 2001, (prepared for the forthcoming DoN CIO Knowledge Management Community of Practice Tookit).

M.E. Nissen, "Navy Knowledge Flow Exchange," Command Third Fleet Seminar, *USS Coronado*, San Diego, CA, May 2001.

M.E. Nissen, "Toward a Program of Research on Knowledge Flow in the Very-Large Enterprise," NPS Technical Report, NPS-GSBPP-01-003, 2001 (http://web/nps.navy.mil/~menissen/papers/kflowTR.pdf).

E. Oxendine and M.E. Nissen, "Knowledge Process and System Design for the Naval Battlegroup," *Journal of the KMCI*, 1:3, pp. 89-109, 2001.

N. Roberts, "Coping with Wicked Problems," Social Science Research Center, Berlin, Germany, Summer,

--continued on page 34

Assistant Professor Mark Nissen completed his tour as the inaugural NPS representative to the Navy's Command Third Fleet (C3F) onboard the *USS CORONADO*, which is stationed in San Diego, CA. The NPS Representative is a permanent position on the C3F staff, which was established through a strategic partnership between VADM Bucchi of C3F and RADM Ellison of NPS. The idea is for various NPS faculty members to rotate through this staff position, better understand the Fleet's issues, operations and problems, and provide expertise and assistance. A steady stream of interaction and information now flows between C3F and NPS.

During this tour, Mark conducted the first increment of field research associated with his Young Investigator project, sponsored by the Office of Naval Research, to develop and test knowledge-flow theory for the very-large enterprise (VLE). Because the Navy represents an extreme VLE (e.g., in terms of its size, geographical reach, hazardous duty, time-critical mission), it represents an excellent focus for research such as this. This first field-research increment culminated with Mark's participation underway with the *CORONADO* and *CARL VINSON* battlegroup in the June 2001 Joint Task Force Exercise in the East Pacific Ocean. A number of key knowledge flows were identified, and a novel vector representation was developed to trace such flows through the enterprise. Throughout this research, the flow of knowledge is explicitly distinguished from that of information or data.

FACULTY NEWS

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2001. (Prof. Roberts received the Freider Naschold Award for Best Paper for this work at the International Public Management Network Conference held in Sidney, Australia. Formal presentation of the award was held at the International Public Management Workshop, Odense, Denmark, July 2001.)

Profs. N. Roberts and L. Jones have been chosen as the series editors of a new book series, *Research on Public Management*. The mission of the book series is to provide a forum for sharing ideas, concepts and results of research and practice in the field of public management, and to stimulate critical thinking about alternative approaches to problem solving and decision making in the public sector.

J. Suchan, "Modeling the Conceptualization and Implementation of New Instructional Technologies: A Structuration Approach," Association for Business Communication European Convention, Dresden, Germany, 23-26 May 2001.

G. Thomas, "Managing Diversity in the Navy," Defense Equal Opportunity Management Institute (DEOMI) Diversity Summit, Cocoa Beach, FL, 2001.

K.W. Thomas, *Motivacion y plenitud 8 horas al dia*, (Motivation and fulfillment eight hours a day), Mexico City: Mondadori, 2001. (Spanish translation of *Intrinsic Motivation at Work*.)

GRADUATE SCHOOL OF ENGINEERING AND APPLIED SCIENCES

Aeronautics and Astronautics

B.M. Castro, K.D. Jones, J.A. Ekaterinaris, and M.F. Platzer, "Analysis of the Effect of Porous Wall Interference on Transonic Airfoil Flutter," 31st AIAA Fluid Dynamics Conference, Anaheim, CA, 11-14 June 2001.

I.H. Tuncer and M.F. Platzer, "Computational Investigation of Flow Through a Louvered Inlet Configuration," 19th AIAA Applied Aerodynamics Conference, Anaheim, CA, 11-14 June 2001.

Electrical and Computer Engineering

R.T. Bluth, J.B. Knorr, and A. Pazmany, "Rapid Scan 3D Volumetric Weather Radar," 30th International Conference on Radar Meteorology, Munich, Germany, 14-19 July 2001.

B.E. Braswell and J.C. McEachen, "Modeling Data Rate Agility in the IEEE 802.11a WLAN Protocol," *Proceedings of the OPNETWORK2001*, Washington, D.C., August 2001.

B.E. Braswell, J.C. McEachen, and M.S. Batson, "A Baseline Model for IEEE 802.11A WLAN Protocol," *Proceedings of the OPNETWORK2001*, Washington, D.C., August 2001.

R. Hippenstiel and S. Mantis, "Wavelet Denoising of Signals Based on the Fourth Order Moment," Sixth International Symposium on Signal Processing and Its Applications, Kuala Lumpur, Malaysia, 13-16 August 2001.

J.B. Knorr and B. Neta, "Plotting Circularly Polarized Field Patterns Using Processed NEC 4 Output Files," *Applied Computational Electromagnetics Society Newsletter*, Vol. 16, No. 2, July 2001.

S.C. Mullin and J.C. McEachen, "Vulnerabilities in Multi-Protocol Label Switching Label Distribution," to appear in *Proceedings of the 2001 IEEE Military Communications International Symposium (MILCOM 2001)*, Washington, D.C., October 2001.

P.E. Pace, Tutorial: EO/IR Systems and Analysis, N91 Simulator Validation Working Group, Naval Research Laboratory, Washington, D.C., 27 June 2001.

P.E. Pace, D.J. Fouts, C. Guillaume, and C. Amundson, "Digital Target Imaging Architecture for Multiple Large-Target Generation: Critical Design Review," Naval Research Laboratory and the Office of Naval Research, 6 September 2001.

P.E. Pace, M.D. Nash, D.P. Zulaica, A.A. Di Mattesa, and A. Hosmer, "Relative Targeting Architectures for Captive-Carry HIL Missile Simulator Experiments," *IEEE Transactions on Aerospace and Electronic Systems*, Vol. 37, No. 3, pp. 810-823, July 2001.

M.A. Tope and J.C. McEachen, "Unconditionally Secure Communications Over Fading Channels," to appear in *Proceedings of the 2001 IEEE Military Communications International Symposium (MILCOM 2001)*, Washington, D.C., October 2001.

T.R. Weatherford, "Analysis of Single Event Induced Voltage Transients in InP-Based HBT Circuits," University of Michigan, Center for Ultrafast Optical Science, Ann Arbor, MI, Hughes Space and Communications Company, Los Angeles, CA, HRL Laboratories, LLC, Malibu, CA, July 2001.

T.R. Weatherford, "Analysis of Single Event Induced Voltage Transients in InP-Based HBT Circuits," *Journal of Radiation Effects*, Vol. 19-1, July 2001.

T.R. Weatherford and P.K. Schiefelbein, "SEE Analysis of Digital InP-Based HBT Circuits at Gigahertz Frequencies," IEEE Natural Space Radiation Effects Conference, Vancouver, BC, 17 July 2001.

Mathematics

B. Neta and J.B. Knorr, "Plotting Circularly Polarized Field Patterns Using Processed NEC 4 Output Files," *Applied Computational Electromagnetics Society Newsletter*, Vol. 16, No. 2, July 2001.

B. Neta and T. Fukushima,

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"Obrechkoff Versus Super-Implicit Methods for the Solution of First and Second Order Initial Value Problems," accepted for publication in *Computers and Mathematics with Applications*, Special Issue on Numerical Methods in Physics, Chemistry and Engineering, T.E. Simos and G. Abdelas, eds., 2001.

B. Neta and Y. Lipowski, "A New Trajectory Propagation Scheme," AAS/AIAA Astro-dynamics Specialist Conference, Quebec City, Canada, 30 July-2 August 2001.

B. Neta, S. Reich, and H.D. Victory, "Galerkin Spectral Synthesis Methods for Diffusion Equations with General Boundary Conditions," accepted for publication in the *Annals of Nuclear Energy*.

Prof. B. Neta was Co-Technical Chair of Spaceflight Mechanics 2000, sponsored by the American Astronautical Society and American Institute for Aeronautics and Astronautics, Clearwater, FL, July 2001. A two-volume book of the papers was co-edited by Prof. Neta as part of the *Advances on Astronautical Sciences Series*.

Mechanical Engineering

M.T. Perez-Prado, G. Gonzalez-Doncel, O.A. Ruano and T.R. McNelley, "Texture Analysis of the Transition from Slip to Grain Boundary Sliding in a Discontinuously Recrystallized Superplastic Aluminum Alloy," *Acta Mater.*, Vol. 49 (2001), pp. 2259-68.

M. Eddahbi, T.R. McNelley and O.A. Ruano, "The Evolution of Grain Boundary Character during Superplastic Deformation in an Al - 6 Pct Cu - 0.4 Pct Zr Alloy," *Metallurgy and Materel Transactions A*, Vol. 32A (2001), pp. 1093-1101.

Prof. T. McNelley has been elected Fellow of the American Society for Materials International (ASMI) and will be inducted during the Fall Meeting of ASMI in Indianapolis, IN, on 5 November.

T. Sarpkaya and C.F. Merrill, "Spray Generation from Turbulent Plane Water Wall Jets Discharging Into Quiescent Air," *American Institute of Aeronautics and Astronautics Journal*, Vol. 39, No. 7, pp. 1217-1229, July 2001.

T. Sarpkaya, R.E. Robins, and D.P. Delisi, "Wake-Vortex Eddy-Dissipation Model Predictions, Compared with Observations," *Journal of Aircraft*, AIAA, Vol. 38, No. 4, pp. 687-692, July-August 2001.

Meteorology

W. Blumen and R.T. Williams, "Unbalanced Frontogenesis, Part I: Zero Potential Vorticity," *Journal of the Atmospheric Sciences*, Vol. 58, pp. 2180-2195, 1 August 2001.

R.L. Haney and R.A. Hale, "The Use of Digital Filter Initialization to Diagnose the Mesoscale Circulation and Vertical Motion in the California Coastal Transition Zone," *Journal of Maritime Systems*, 29, pp. 335-363, 2001.

R.L. Haney, R.A. Hale, and D.E. Dietrich, "Offshore Propagation of Eddy Kinetic Energy in the California Current," *Journal of Geophysical Research*, 106, pp. 11709-11717, 2001.

H.C. Kuo, J.H. Chen, R.T. Williams, and C.P. Chang, "Rossby Waves in Zonally Opposing Mean Flow: Behavior in Northwest Pacific Summer Monsoon," *Journal of the Atmospheric Sciences*, Vol. 58, pp. 1035-1050, 1 May 2001.

H.C. Kuo, R.T. Williams, J.H. Chen, and Y.L. Chen, "Topographic Effects on Barotropic Vortex Motion: No Mean Flow," *Journal of the Atmospheric Sciences*, Vol. 58, pp. 1310-1327, 15 May 2001.

M.S. Peng, J.H. Powell, R.T. Williams, and B.F. Jeng, "Boundary Layer Effects on Fronts Over Topography," *Journal of the Atmospheric Sciences*, Vol. 58, pp. 2222-2239, 1 August 2001.

P. Valez-Belchi, A. Alverez, P. Colet, J. Tintor, and R.L. Haney, "Stochastic Resonance in the Thermohaline Circulation," *Geophysics Research Letter*, 28, pp. 2053-2056, 2001.

Physics

B. Denardo and S. Baker, "Nonreflecting Termination of a Mass-and-Spring Lattice," *American Journal of Physics*, Vol. 69, pp. 382-384, 2001.

GRADUATE SCHOOL OF OPERATIONS AND INFORMATIONAL SCIENCES

Information Sciences

A. Bordetsky, "Collaborative Technology for Multinational Peace Operation's Joint Interactive Planning," Building A Vision: NATO's Future Transformation, The Oslo Symposium, September 2001.

S.G. Hutchins, "Analysis of Human Factors Case Studies of Complex Military Systems: Here's How We Can Do Better," accepted for publication in the *Proceedings of the 45th Annual Meeting of the Human Factors and Ergonomics Society*, Minneapolis, MN, 13-16 October 2001.

S.G. Hutchins, D.L. Kleinman, S.P. Hocevar, W.G. Kemple, and G.R. Porter received Honorable Mention for authoring the Best Paper in Track 5, Network-Centric Warfare, 6th International Command and Control Symposium, Annapolis, MD, 19-21 June 2001.

M.N. Kamel, "International E-Commerce: Issues, Challenges, and Solutions," *Proceedings of the Business*

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Information Technology Conference (BITWorld 2001), Cairo, Egypt, June 2001.

M.N. Kamel and T.L. Lutman, "The Analysis, Design, and Implementation of the Defense Manpower Data Center Pay Data Warehouse," *Proceedings of the 18th Annual Federal Database Colloquium*, San Diego, CA, August 2001.

W. Rodgers and T. Housel, "Affect of Diverse Informational Sources on Auditors Analysis of Prospective," *Proceedings of the Workshop on the Future of Audit, Assurance, and the Profession*, European Institute for Advanced Studies in Management, Copenhagen, Denmark, 15-16 June 2001.

W. Rodgers and T. Housel, "The Effects of Financial Accounting, Forecasted and Non-Financial Information on Investors Decision Making," *Proceedings of the 5th International Seminar on Manufacturing Accounting Research*, Pisa, Italy, 6-8 June 2001.

N.F. Schneidewind, "Data Analysis of Software Requirements Risk," *Proceedings of the 12th European Software Control and Metrics Conference*, London, England, pp. 443-451, 2-4 April 2001.

N.F. Schneidewind, "Investigation of Logistic Regression as a Discriminant of Software Quality," *Proceedings of the 7th International Software Metrics Symposium*, London, England, pp. 328-337, 4-6 April 2001.

N.F. Schneidewind, "Knowledge Requirements for Software Quality Measurement," *Journal of Empirical Software Engineering*, Kluwer Academic Publishers, Vol. 6, No. 2, pp. 201-205, June 2001.

N.F. Schneidewind, "Software Requirements Risk and Reliability," *Proceedings of the Monterey Workshop 2001*, Monterey, CA, 18-22 June 2001.

N.F. Schneidewind, "Maintenance Process and Product Evaluation Using Reliability, Risk, and Test Metrics," *Advances in Computers*, Academic Press, Vol. 54, pp. 153-181, 2001.

N.F. Schneidewind, tutorial, Measuring and Evaluating Maintenance Process Using Reliability, Risk, and Test Metrics, IEEE Computer Society Chapters and Tutorials Program, Greensboro, NC, 19 July 2001.

N.F. Schneidewind, tutorial notes, A Roadmap to Distributed Client-Server Software Reliability Engineering, Quality Week 2001, San Francisco, CA, 29 May 2001.

N.F. Schneidewind, "Developments in Software Reliability," *IEEE Reliability Society Annual Technology Report*, August 2001.

G. Zolla, T. Boex, P. Flanders, D. Nelson, S. Tufts, and J.K. Schmidt, "Distributed Maintenance Error Information, Investigation, and Intervention," World Aviation Congress and Exposition, Seattle, WA, 2001.

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THE MODELING, VIRTUAL ENVIRONMENTS, AND SIMULATION (MOVES) INSTITUTE

A 1991 paper by Prof. M. Zyda was recently reprinted in a special issue of *Computers & Graphics* entitled "Seminal Contributions from *Computers & Graphics*." The text from the Introduction of that journal reads "As early as 1991, the best paper of that year by Michael DeHaemer and Michael J. Zyda successfully addressed a topic which is still highly relevant today: the simplification of polygonal approximations resulting from data acquisition steps by 3D digitizing cameras." The original reference for the paper is: DeHaemer, Michael J. and Zyda, Michael J., "Simplification of Objects Rendered by Polygonal Approximations," *Computers & Graphics*, Vol. 15, No. 2, 1991, Great Britain: Pergamon Press, pp. 175-184. The paper received "Best Paper 1991" award from an international selection committee appointed by the editor of *Computers & Graphics*, 29 Sep 92.

NPS WELCOMES VISITING FACULTY

Dr. Mark Johnson, currently an Associate Professor at the Institute of Marine Science at the University of Alaska, will join NPS as the Office of Naval Research Chair in Arctic Marine Science. A distinguished polar oceanographer, Dr. Johnson will devote his time at NPS towards two major efforts. He will lead the modeling effort of the Arctic Climate Observation Using Underwater Sound (ACOUS) Project. He will also write the science plan for a program to use observations and models to measure/predict the pathway and heat transport of Atlantic Waters into the Arctic Basin using conventional and acoustic methods.

Dr. Jeong Ho Noh of the Korean Agency for Defense Development, Naval Systems Development Center, recently joined NPS as part of the Engineer and Scientist Exchange Program (ESEP) Program. Dr. Noh will participate in acoustical tomography research with Professor Ching-Sang Chiu of the Department of Oceanography.

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Operations Research

S.E. Buttrey, D. Nolan, and D.T. Lang, "An Environment for Creating Interactive Statistical Documents," 33rd Symposium on the Interface of Computing Science and Statistics, Costa Mesa, CA, 13-16 June 2001.

T. Lucas and S.M. Sanchez, "Adaptive Exploration of Command and Control Simulations," 4MAS Conference, Quantico, VA, May 2001.

T. Lucas and S.M. Sanchez, "Adaptive Exploration of Command and Control Simulations," INFORMS International 2001, Maui, HI, June 2001.

D. Morton, J. Salmeron, and K. Wood, "A Stochastic Program for Optimizing a Sealift Deployment Subject to Attack," Workshop on Decision-Making Under Uncertainty, Molde, Norway, 18-20 May 2001.

S.M. Sanchez and K. Wood, "Stochastic Network Interdiction," INFORMS International 2001, Maui, HI, 7-21 June 2001.

Prof. S.M. Sanchez has been appointed to the INFORMS Education Committee. Its purpose is to foster the development of academic programs in OR/MS, encourage student pursuit of OR/MS education, and support the continuing professional education of both practitioners and academics.

SCHOOL OF INTERNATIONAL GRADUATE STUDIES

Defense Resources Management Institute

Prof. D. Angelis visited the Marine Corps Support Activity, Kansas City, KS, to help with the implementation of activity-based management. The Marine Corps is planning to integrate ABC/M into their POM/budgeting process beginning with the '04 POM.

Prof. D. Angelis is working with CAM-I to study the relationship between cost management and program management. She completed a survey of DoD program managers to identify the cost information needs of program managers.

J.C. Felli, "Discounting Operational Effectiveness," INFORMS International 2001 Conference, Maui, HI, June 2001.

J.C. Felli, "Javelin Diagrams," Decision Analysis Track, INFORMS International 2001 Conference, Maui, HI, June 2001.

F. Melese and J. Palmore, "A Game Theory View of Preventative Defense Against Ballistic Missile Attack," *Journal of Defense Analysis*, University of Illinois-Urbana, August 2001.

National Security Affairs

D. Porch, "France's Protracted Humiliation," *Military History Quarterly*, 2001.

INSTITUTE FOR INFORMATION SUPERIORITY AND INNOVATION (I2SI)

C.E. Irvine, T. Levin, J.D. Wilson, D. Shifflett, and B. Pereira, "A Case Study in Security Requirements Engineering for a High Assurance System," Symposium on Security Engineering for Information Assurance, Indianapolis, IN, March 2001.

C.E. Irvine, T. Levin, D. Shifflett, and M. Glover, "High Assurance Multi-Level Secure LAN for Commercial PCs," SPAWAR MSL Workshop, Norfolk, VA, May 2001.

C.E. Irvine and T. Levin, "Teaching Security Engineering Principles," Second World Conference on Information Security Education, Perth, Australia, July 2001 (will also appear in *Proceedings*).

C.E. Irvine, T. Levin, E. Spyropoulou, and B. Allen, "Security as a Dimension of Quality of Service in Active Service Environments," Active Middleware Services Workshop, San Francisco, CA, 6 August 2001 (will also appear in *Proceedings*).

Several faculty members in the Department of National Security Affairs contributed articles to the recently published *Oxford Companion to Military History*. Professor James Wirtz wrote entries on the Vietnam War, the Tet Offensive and Strategic Hamlets. Associate Professor Daniel Moran's contributions included Strategy, Air Power, the Operational Level of War and Clausewitz. The German Reichwehr, Erich Ludendorff, Hans von Seeckt and NATO were subjects addressed by Associate Professor Donald Abenheim. Professor Douglas Porch served as Advisory Editor for the United States.

The *Oxford Companion to Military History* is a prestigious work that provides a comprehensive overview of military history from antiquity to the present day. Its articles cover people, weapons, wars, campaigns and battles, strategy and tactics, logistics, fortifications, military life, institutions, literature, art and music. Although the scope of the work embraces all aspects of warfare across the world, its primary focus is on land warfare in Europe and America from the 18th Century to the present day, and aspects of naval and air history that bear directly on land operations.

BEARTRAP POST MISSION ANALYSIS SYSTEM, *continued from page 5*

involved three faculty members, one Ph.D. student, twelve Masters students, one system developer, and several additional programmers. The system was designed in a modular manner to fit the size and effort of thesis projects [2-13] while maintaining the goals of the project. Funding for this project was approximately $1.2 million over a five-year period, covering faculty salaries, equipment purchases, and hiring of programmers. Additional specialized equipment, such as tape drives and some test equipment was provided by the sponsor.

Additional Reading

[1] Tummala, M., Therrien, C.W., and Shields, M.K., "A New Look: Beartrap Post Mission Analysis System Initial System Design Proposal," Technical Report NPS-EC-96-014, Naval Postgraduate School, Monterey, CA, September 1996.

[2] Horning, E., "Implementation of Narrowband SPL Estimation Algorithm in a Personal Computer Environment," Masters Thesis, Naval Postgraduate School, Monterey, CA,

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FUNCTIONAL OVERVIEW OF S2K, *continued from page 5*

contain signals from a signal generator that are fed into the sonobuoy receivers and then the output of the receivers is recorded. The tapes are digitized and the signal levels are measured and compared to the true levels. The levels must be within tolerance for the mission data to be valid. If the levels are within tolerance, a correction table is generated and the correction table is used in the SPL calculations.

The final preliminary step is to input the mission digital data. These data are normally recorded on digital tape files that are processed by another application called ORION and is imported directly from ORION. In cases where the information is not available, or if the operator desires to modify the data, the Buoy and Bathy dialog boxes allow the operator to view and modify the buoy and bathymetric data. The preliminary steps are shown in Figure B.

The identification of signals of interest is accomplished in two steps (see Figure C). First the tapes are digitized and then baseband (LOFAR) grams are generated for the operator to examine and identify the signals. Prior to digitization, a dialog box allows the operator to insure that the tape deck and sampling parameters are properly initialized. Once the data is digitized, the grams are generated. If the signal is from a DIFAR buoy, the data must first be demultiplexed to allow access to the bearing information. Several dialog boxes allow the operator to select parameters for the calculation and display of the grams in the FTA view. The FTA view provides access to several tools that allow the operator to measure frequency, frequency ratios, Lloyd Mirror CPA, listen to the signal (at various speeds), and view an A-Line display. These tools allow the operator to mark runs (a time period of contact) frequencies of interest and broadband signals of interest to be further analyzed.

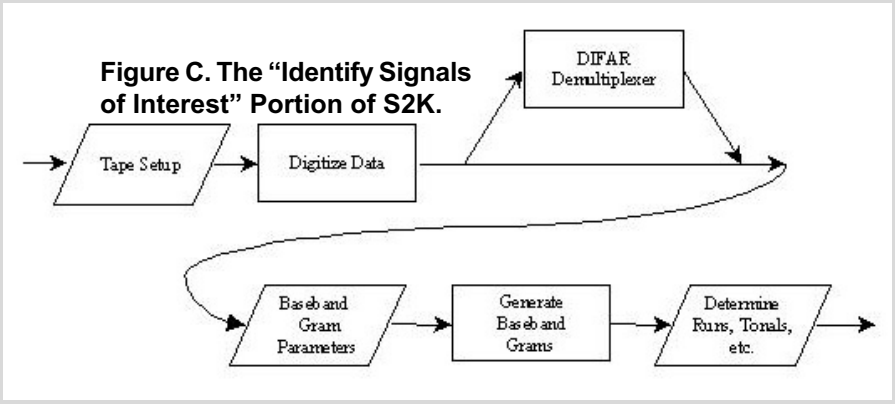

Figure C. The "Identify Signals of Interest" Portion of S2K.

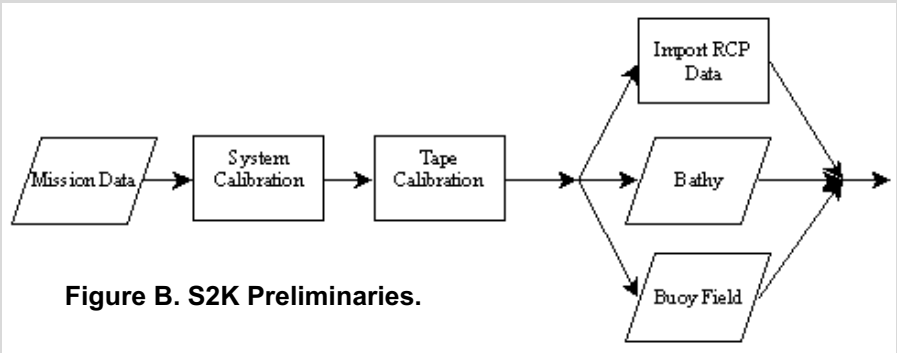

Figure B. S2K Preliminaries.

The third step in the processing of a mission with S2K is to generate observa-

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September 1997.

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[4] Khol, C. A., "Development of a Narrowband Zoom Processing Capability Using Commercial Processors," Masters Thesis, Naval Postgraduate School, Monterey, CA, June 1998.

[5] Minyard, J. D., "Development of Analysis Tools and Incorporation of Commercial Digital Signal Processors in a Signal Analysis Graphical User Interface," Masters Thesis, Naval Postgraduate School, Monterey, CA, June 1998.

[6] Race, H.R., "Development of a Digital DIFAR Demultiplexer and Bearing Tracker Module," Masters Thesis,

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tions. An observation is defined as a measurement of a specific target's parameters (e.g., received frequency) along with the time and standard deviation of that measurement. In its final version, S2K will provide the ability to use eight different types of observations. The first three of these, Lloyd Mirror CPA, narrowband CPA, and frequency ratios are measured by the operator using tools in the FTA view. The fourth and fifth, transient TDOA measurements and transient TOA position estimates, are measured by the operator using tools in the transient pre-track view. The final three measurement types--narrowband frequencies, DIFAR bearings, and broadband time differences--are generated by tracking algorithms.

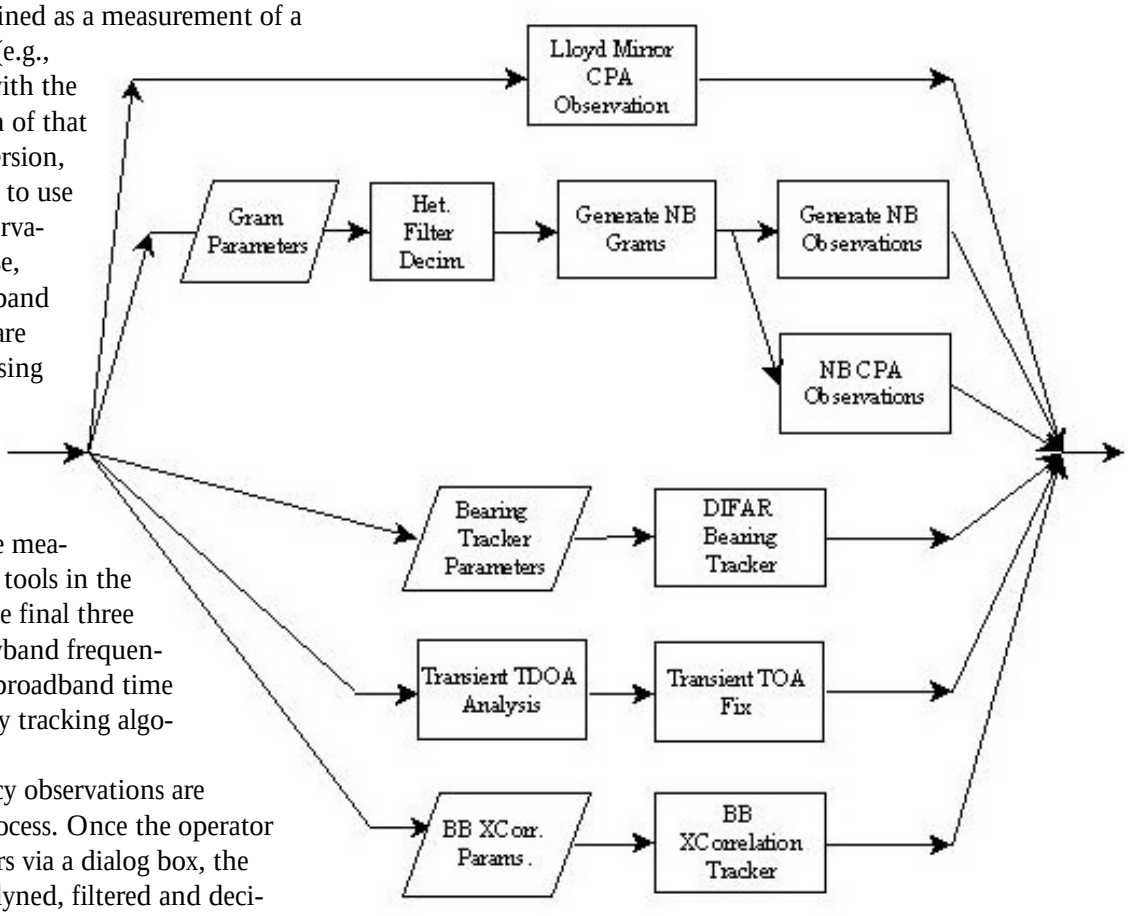

Figure D. The "Generate Observations" Portion of S2K.

The narrowband frequency observations are measured in a three-step process. Once the operator enters the desired parameters via a dialog box, the digital time series is heterodyned, filtered and decimated to produce a complex time series with the required sample frequency and bandwidth. The second step is to generate the high-resolution vernier gram. This vernier gram is displayed in the FTA view and the operator can use tools to make measurements including the NB CPA. The last step is to use the frequency PDF tracker to generate NB frequency observations. Currently, only the Lloyd Mirror CPA, narrowband CPA, and narrowband frequency observations are available. Figure D shows the flow of the generated observation portion of S2K.

The target tracker implemented in S2K is a portion of the EMST target tracker [14]. This is a batch oriented parametric tracker that models the track as a set of segments of constant acceleration and turn rate with no discontinuities in position or velocity at the segment boundaries. The target track is generated in a three-step process. First, an initial estimate of the first 450 second segment's parameters is chosen from

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BEARTRAP POST MISSION ANALYSIS SYSTEM, *continued from page 39*

Naval Postgraduate School, Monterey, CA, June 1999.

[7] Bitting, J.H., "Development of Software Modules for Calculation of Sound Pressure Levels in Broadband and Swath Acoustic Signals," Masters Thesis, Naval Postgraduate School, Monterey, CA, June 1999.

[8] Widow, R. A., "Development of Visual C++ Version of the Broadband Cross-Correlation Time Delay Tracker Module for S2K," Masters Thesis, Naval Postgraduate School, Monterey, CA, September 1999.

[9] Mullins, M.E., "Target Tracking in the Automatic Quick Look System," Masters Thesis, Naval Postgraduate School, Monterey, CA, December 1999.

[10] Danks, J.C., "Design and Development of the EER Module for Beartrap Post Mission Processing System 2000," Masters Thesis, Naval Postgraduate School, Monterey, CA, December 1999.

[11] Tidwell, B.S., "Toward an Object-Oriented Architecture for the Enhanced Multi-Segment Tracker (EMST)," Masters Thesis, Naval Postgraduate School, Monterey, CA, March 2000.

[12] McCabe, E.D. and Stone, C.D., "Development of the Beartrap Post Mission Processing System 2000 (S2K) HTML Help Project," Masters Thesis, Naval Postgraduate School, Monterey, CA, June 2000.

[13] Barsanti, R. Passive "Target Tracking with Uncertain Sensor Positions Using Wavelet-Based Transient Signal Processing," Ph.D. Dissertation, Department of Electrical and Computer Engineering, Naval Postgraduate School, Monterey, CA, June 2001.

[14] Barsanti, R.J., Tummala, M., and Therrien, C.W., "Enhanced Multi-Segment Tracker," Technical Report NPS-EC-00-09, Naval Postgraduate School, Monterey, CA, July 2000.

FUNCTIONAL OVERVIEW OF S2K, *continued from page 39*

several candidates. Second, track parameters of this segment and each successive 90-second segment are estimated in what is called adaptive mode. Finally, the entire set of observations is used to compute the entire track. In each step, the track solution is determined by a non-linear least squares fit of the target dynamic model to the observations using an iterative, modified Newtons search. This solution is the maximum a posteriori (MAP) estimate of the target parameters given the observations and the initial estimate of the target's track.

Once the target's track has been estimated, the source sound pressure level of the various signals of interest can be estimated using the received signal level, the estimated propagation loss (a function of range, hence the need for the track), and the calibration factors. These estimates are calculated at specified time intervals for all the buoys and are displayed in the SPL Edit View. The SPL Edit View allows the operator to look at the data in tabular form, the gram from which the SPL estimate was developed, an A-Line view of the gram, and a polar plot of the data for all buoys. This enables the operator to edit the data to throw out all points that are outliers. Once the SPL data has been edited, a report is generated and the report view allows the operator to edit the report. These final steps of S2K are shown in Figure E.

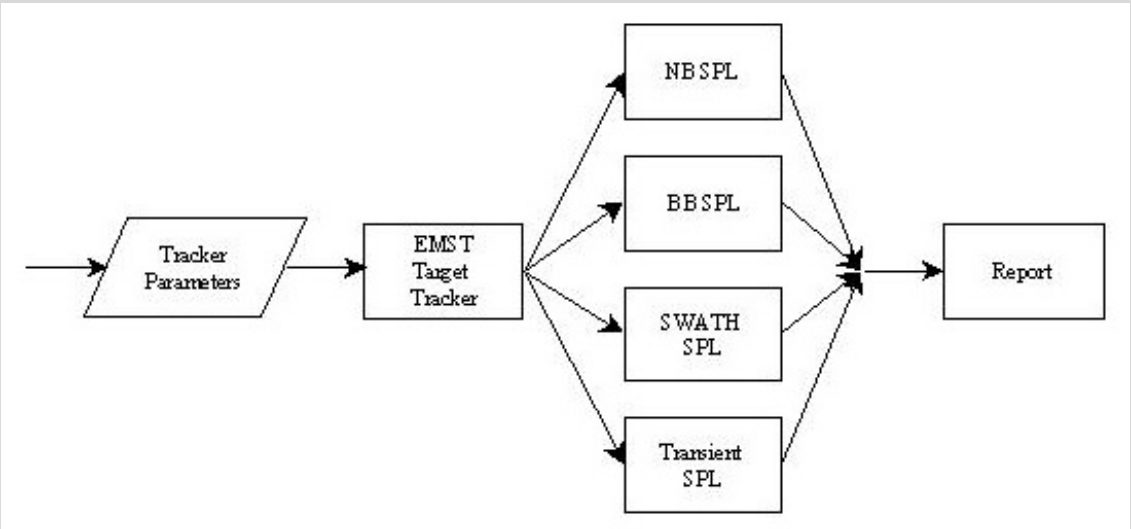

Figure E. Final three steps of S2K.

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of their impact on existing strategic relationships. Some options do not significantly interfere with the ability of great powers to target the United States, while others are so extensive that they might even call into question the situation of mutual assured destruction that still exists between the United States and Russia. Fourth, the options reflect different international political climates. Minimal deployments are assumed to occur in a relatively benign diplomatic setting. More ambitious missile defense deployments are assumed to produce international acrimony.

Although the options considered here are based on policies under consideration or systems under development, they reflect general types of missile defenses that are not entirely dependent on specific systems. These options reflect an American perception of missile defenses because they vary substantially in terms of the degree of protection they provide to U.S. territory, as well as the degree to which they reflect Americans' willingness to act unilaterally to achieve their security objectives. Assessing the impact on American security alone might not be the best way to measure the international impact of U.S. missile defense deployment, but it does provide a way to characterize missile defenses that will remain relevant in the years ahead.

This article draws upon a multi-author study that explored three aspects of the missile defense debate. First, it described the factors that shape the current debate about missile defenses and their impact on global affairs. Kerry Kartchner, U.S. Department of State, Robert Joseph, who currently serves on the National Security Council and Dennis Ward, who is a professional staff member on the Governmental Affairs Subcommittee on International Security, Proliferation, U.S. Senate, described the origins of the ABM Treaty, the changing political circumstances that have revived interest in deploying missile defenses and the new technologies that make missile defense possible. Second, the study explored how domestic politics influenced the missile defense debate and the impact missile defense would have on crisis stability and future arms control initiatives. Michael OHanlon of the Brookings Institution, Richard Harknett a professor at the University of Cincinnati and Julian Schofield, a professor at Concordia University (Montreal), contributed chapters to this section of the study. Third, the study offered a focused assessment of regional and national reactions to U.S. deployment of missile defenses. Brad Roberts, who is an analyst at the Institute of Defense Analysis, offered and assessment of Russian Chinas reaction to Missile Defense while Ivo Daalder (Brookings Institution) and James Goldgeir (George Washington University) described likely Russian reactions to various U.S. defense systems. Tim Hoyt (Georgetown University) explored how an emerging arms race in South Asia might be affected by missile defense deployments and Charles Ball (Lawrence Livermore National Laboratories) described allied perspectives on American interest in missile defenses. The entire work has been published as James J. Wirtz and Jeffrey A. Larsen (eds.), *Rockets Red Glare: Missile Defenses and the Future of World Politics* (Westview, 2001).

Scenario I: Limited Defense in a Cooperative Setting

The first scenario we consider is a threshold deployment of between twenty and one hundred interceptors in a new base located in central Alaska that would occur fairly quickly (i.e., sometime before 2007). This deployment option is similar to the initial operational capability of the missile deployment plan (dubbed the C1 option) advanced in the last years of the Clinton administration. Depending on the firing doctrine used in the defense (the number of interceptors that are fired at each incoming warhead), the smallest threshold system could engage a maximum of somewhere between five and ten warheads flying towards the United States over the North Pacific Ocean.

A threshold defense deployment would provide the United States with a capability to protect itself against an accidental missile launch or very small deliberate attacks that approach U.S. territory, especially from the northwest. Such a limited deployment poses no realistic threat to the Russian or Chinese ability to strike the United States with warheads carried by intercontinental ballistic missiles (ICBMs). This option would provide the United States with a significant denial capability, however, against an emerging North Korean missile threat to American territory.

Although threshold defenses would provide very limited capability against missile attack, they would nevertheless pose a fundamental challenge to the ABM Treaty. Estimating the impact of any NMD deployment scheme on the ABM Treaty is highly contingent on the exact capability and location of the missile defense deployed. Moreover, the way individual

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Treaty articles, amendments, negotiating records and operational histories are used to interpret the interaction between defensive missile systems and the Treaty greatly affects judgments about how the Treaty would need to change to accommodate a specific system.[8] It would be safe to assume, however, that the Treaty would have to be amended to allow national missile defense. Although the Treaty allows the deployment of a single missile defense site, it specifies that defenses need to be situated near national capitals or ICBM deployment areas. Thus it would have to be amended to allow construction of the Alaskan missile defense site and the systems new X-band radar on Shemya Island. The Treaty also would have to be modified to permit the use of space-based sensors in the missile defense architecture because they can substitute for ABM engagement radars. Additionally, the Treaty would require modification because the booster for the planned NMD interceptor is used for commercial purposes; the Treaty forbids giving non-NMD systems the ability to intercept strategic missiles.

Revising the ABM Treaty to allow these limited missile defenses would create some tense moments in Russian-American relations. But since a threshold defense would not present a credible threat to the Russian nuclear deterrent (even at the reduced force levels envisioned in a START III agreement), Russian leaders probably would want to continue to use arms control to constrain further U.S. defense deployments. They also might find it expedient to use ABM negotiations to obtain concessions from the United States on further reductions in offensive strategic forces or for concessions in other areas. ABM negotiations could be used to move the Russian-American strategic relationship away from the Cold War model based on mutual vulnerability, charting a new course in Russian-American relations that increases the role of defense in some sort of mutual security arrangement. Negotiations could remain a bilateral affair, which would greatly ease the task of reaching a settlement. Ideally, revising the ABM Treaty could lead to improved Russian-American relations if the give and take over NMD led to greater security cooperation.

In contrast, if Washington and Moscow reached the mutual expectation that it was in the best interest of the other side to preserve the ABM Treaty it could lead to deadlock and acrimony. Both sides would look to their negotiating partner to compromise over NMD deployments. They might interpret a lack negotiating progress as evidence of some potentially dangerous departure in strategic policy. We assume that cooler heads will prevail. Russian and American negotiators will find some way to accommodate the deployment of a modest interceptor force within the arms control regime limiting strategic defenses.

Our limited defense scenario embodies what in fact would be a major change in the existing arms control regime: a negotiated change in the ABM Treaty to permit limited national missile defenses. Yet, our limited defense scenario would not affect the

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NPS faculty working on defense and foreign policy issues benefit greatly from close interaction with many officers and officials. The origins of this particular study can be found in a bit of advice offered by Captain Joseph P. Bouchard, USN, in December 1998. Bouchard, an alumnus of the Department of National Security Affairs who was assigned to the National Security Council at the time, suggested that a planned retrospective on the ABM Treaty timed to coincide with its 30th birthday would be overtaken by events. Instead, he suggested that a study of the international consequences of missile defense deployments and new arms control initiatives to revise or replace the ABM Treaty would be more useful in the years ahead. With this initial concept in hand, the project participants benefited from the support offered by many organizations and individuals: Victor Utgoff, Tony Fainberg, Steven Boyd, and Gilbert Bernabe of the Advanced Studies and Concepts Office of the Defense Threat Reduction Agency (DTRA/ASCO); Dutch Miller, Alex Ivanchishin, Kurt Klingenberger, Mike Preston and Don Minner of the National Security Policy Division of the Air Staff (AF/XONP); Thomas Skrobala at the Navy Treaty Implementation Program; and Jim Smith, Brent Talbot and Diana Heerdt at the USAF Institute for National Security Studies (INSS). We also received advice and encouragement from Ted Warner, Frank Miller and Kent Stansberry in the Office of the Secretary of Defense and David Martin, Lara Gross and Mike Safrino of the Ballistic Missile Defense Office. Frank Jenkins, Mark Barbour, Jim Rutherford and Debra Van Putten of Science Applications International Corporation (SAIC) were generous with their time, describing many of the legal and technical issues embedded in the enormous documentary record surrounding the Anti-Ballistic Missile Treaty.

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bargain at the heart of the ABM Treaty because it would not reduce the vulnerability of the American people to a Russian nuclear attack. Countries with small missile arsenals that were seeking to use these arsenals to gain leverage over the United States would see the value of their strategic investment diminished. The United States might become more active in world affairs, intervening more in regional disputes or engaging in preventive attacks to block missile proliferation in the developing world. This is the sort of activity that worries America's European allies. They fear that the absence of strategic defenses will make them the logical retaliatory target following some U.S. military action. But by strengthening U.S. escalation dominance, missile defenses could increase the ability of U.S. military forces to deter the outbreak of war. Herein lies one of the paradoxes of the NMD debate: Threshold C1 might undermine crisis stability because it could embolden U.S. policymakers to become more interventionist, while at the same time making confrontation less likely in the first place by strengthening deterrence.

The real source of international concern about a Threshold C1 deployment is that many would see it as a harbinger of things to come. Chinese leaders, for example, believe that the United States will continue to enlarge its defense capabilities, diminishing the benefits China is likely to gain from its strategic force modernization programs and making Washington more willing to intervene in future disputes over Taiwan. NATO allies worry that the United States might be tempted to withdraw into a Fortress America, even though 100 interceptors at a single site would offer a weak defense of the battlements. The sale of advanced countermeasures to small missile states in response to Threshold C1 deployments would do little to ease these kinds of concerns, and could make matters worse by increasing pressures on U.S. policymakers to improve their missile defenses.

Scenario II: Enhanced Defenses and Limited Cooperation

The second scenario we consider is more speculative, even though it also is based on a plan proposed by the Clinton administration (the C3 plan) and other systems that are already under development. In this scenario, we expanded the Clinton administration's C3 proposal to deploy 250 ground-based interceptors by adding sea-based and air-based systems currently under development. This C3 Plus system would have limited restrictions on radars and associated command and control networks, permitting the maximum operational effectiveness of planned national missile defenses. It would encompass several systems that realistically could not be deployed before 2011, and would provide a more robust defensive capability than the Threshold C1 system. A C3 Plus system would greatly reduce American, and in some cases allied, vulnerability to missile attack. A C3 Plus deployment might be a logical answer to critics who charge that Threshold C1 deployments come with all of the drawbacks and few of the potential benefits of missile defenses. C3 Plus also includes theater systems that were not necessarily intended to defend American territory, but which could be included in missile defenses to create a layered defense or to supplement NMD systems in a crisis. For example, it might be possible to integrate the Navy Theater Wide and Air Force airborne laser systems into a national missile defense to increase its ability to defeat a missile attack.

Capability 3 was proposed by the Clinton administration in 1999 as a long-term option; the C3 Plus option we describe here is based on this proposal and reflects early plans by the Bush administration for a more robust missile defense.[9] In our scenario, these enhanced defenses would include interceptors located in both Alaska and Grand Forks, North Dakota. The latter location would improve defense against missiles approaching the United States from the northeast and would help provide overall coverage of the United States. If moved close enough to an opponents missile field (e.g., off the coast of North Korea), the airborne laser could destroy missiles while still in their boost phase. Navy warships also could be deployed off America's shores to bolster defenses along likely threat axes. Given expected intercept rates, C3 Plus might be able to stop upwards of one hundred warheads from reaching the United States.

If the United States were to deploy a C3 Plus system, it would have a significant impact on the international strategic landscape. C3 Plus would protect the United States from attacks launched from a variety of directions and would raise the bar for states interested in holding U.S. urban areas at risk of ICBM attack. Small states such as North Korea, Iran or Iraq would be forced to look for alternative delivery methods to attack the United States. Without outside technical or financial help, it would be unlikely that these small states could build or launch enough warheads and countermeasures to penetrate this system. Similarly, Chinese leaders would face significant technical and quantitative challenges in any effort to create a secure second-strike force directed against the United States.

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The enhanced capability of the C3 Plus system would come at a significant price in terms of arms control. In addition to the changes made to accommodate a Threshold C1 deployment, the ABM Treaty would have to be amended to allow for construction of two ground-based interceptor sites and to allow air-based and sea-based NMD.

A C3 Plus system would have its greatest impact by challenging China's quest to modernize its strategic nuclear forces, eliminating China's free ride on Russian-American cooperation in limiting missile defenses. A vigorous Chinese response to these deployments could set off a chain reaction in Asia affecting Indian, Pakistani, Japanese, and Taiwanese defensive doctrines and deployments. Chinese efforts to complicate the defense problems faced by American policymakers by providing advanced missile or weapon technologies to America's adversaries also could destroy the nonproliferation regime.

C3 Plus would strain the international arms control regime because it would be difficult to construct a treaty that would curb the break-out potential inherent in such a robust defense deployment. If Russian and American offensive forces continue to decline in numbers, a C3 Plus system might be expanded rapidly to deny Russians the ability to hold U.S. targets at risk. Moreover, Chinese officials would have an interest in the details of a renegotiated treaty because they would want to discern exactly how a new treaty might interact with their plans for modernizing their strategic forces. An ABM Treaty that accommodated a C3 Plus system might have to become multilateral. But it would be difficult to construct a multilateral arms control treaty of sufficient issue depth to restrict missile defenses in a meaningful way. Russian officials might cooperate in renegotiating the ABM Treaty under these circumstances, but the negotiations could be a source of acrimony unless a political agreement to integrate defenses into the Russian-American strategic relationship existed.

Revising the ABM Treaty to permit a C3 Plus deployment probably would strain Russian-American cooperation in arms control to the breaking point. Although it would still be in Russias interest to constrain U.S. missile defense deployments in an arms control agreement, critics might correctly charge that a C3 Plus system would provide the United States with a break-out capability. In other words, by quickly adding interceptors to an existing defense architecture, U.S. forces could greatly reduce Russian second-strike capabilities against the United States. No matter what the final outcome, Russian-American treaty negotiations to allow a C3 Plus deployment would be highly acrimonious. Even if an agreement about the Treaty were finally reached, Russian leaders might believe that they had been strong-armed by their American counterparts.

Supporters of robust missile deployments would object to this pessimistic picture of the diplomatic consequences of an U.S. decision to deploy a C3 Plus system. Bush administration officials might suggest that robust missile defenses could eliminate deterrence as the cornerstone of Russian-American strategic relations. C3 Plus could serve as the basis of a cooperative transition to a world where defense is dominant and offensive systems are reduced in number and capability. Robust defenses could help Russians and Americans alike finally put the Cold War behind them. For NMD advocates, C3 Plus is a logical response to the emerging threats facing the United States.

Scenario III: Unlimited Defenses, Unconstrained by Treaty
The third scenario assumes U.S. withdrawal from the ABM Treaty. Defense deployments would no longer be constrained by an arms control regime. The opportunity to increase Russian-American cooperation by creating a revised arms control regime is unlikely to emerge under these circumstances.

American officials would be free to deploy whatever weapons or sensors they considered necessary or technologically feasible. In all probability, they would attempt to deploy robust defenses as soon as possible--otherwise why would they be eager to eliminate the ABM Treaty? But given the long lead times involved, it might be nearly two decades before revolutionary kinds of systems, for example the space-based laser, can be deployed. It is difficult to say, however, how effective advanced defenses might be given the performance uncertainties about even limited defenses based on relatively proven technologies.

The end of the ABM Treaty would signify that American policymakers, or Russian leaders for that matter, had decided that unilateral measures offered a path preferable to cooperation as a means of guaranteeing their national security. Alternatively, an abrupt end to the ABM Treaty might be caused by some diplomatic failure produced by domestic political pressures or miscalculation. But a U.S. decision to withdraw from or abrogate the Treaty also could be a response to an abrupt change in the strategic environment. In this case, an end to the ABM Treaty would constitute a consequence

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rather than a primary cause of changes in the international system.

Arms race and crisis instability could become commonplace in a world of strategic defenses left unconstrained by any treaty, or in the absence of a new consensus among the Great Powers about the role of defenses in national security. Russia might decide that the effort to run an arms race with the United States was not worth the cost and find some new basis for Russian-American strategic relations. Equally likely, however, would be a Russian decision to join with China in a diplomatic campaign to resist American unilateralism. Sentiments among America's NATO allies probably would swing between the traditional fears of abandonment and entrapment. America's Asian allies might work quickly to integrate their defenses into an emerging American defense architecture to protect themselves against an increasingly suspicious China. Small states such as Pakistan, Iraq, North Korea, Israel, and Iran might try to improve their offensive and defensive missile capabilities by capitalizing on a resulting breakdown in the Missile Technology Control Regime or the Nuclear Nonproliferation Treaty. In sum, the United States could find its real security actually diminished despite the deployment of robust defenses.

Recurring Themes in the Debate about NMD and Treaty Revision

Our analysis identified several unexpected observations about the strategic situation facing national governments at the dawn of the twenty-first century. First, unintended consequences would follow not only in the wake of efforts to modify the ABM Treaty, but also by continuing to abide by a Treaty that no longer reflects strategic or technical realities. For example, theater ballistic missiles have grown more capable in the thirty years since the Treaty was signed, but the restrictions placed by the ABM Treaty on national missile defenses are beginning to impede the effort to develop theater missile defenses. While many hoped that the ABM Treaty would be a living document that could be adapted to changing technical and strategic circumstances, that hope has not been realized. The proliferation of theater offensive capability, defensive responses to meet that capability, and the technological advances that made such responses possible, all combine to raise treaty conflicts. Today the United States is prevented from responding to threats that did not exist when the Treaty was signed, but it is difficult to imagine that the ABM bargain with the Soviets really was intended to leave Americans vulnerable to a North Korean missile threat. The key questions are whether the objectives that the Treaty was intended to meet are still valid as we enter the twenty-first century, and whether the Treaty can be modified to meet legitimate security concerns now that the Cold War is over.

Second, while most observers agree that national missile defenses will enhance U.S. power projection capabilities, they disagree about the political and strategic consequences that will flow from this new capability. Would the deployment of missile defenses enhance isolationist tendencies within the United States, as the European allies fear, or allow America to intervene more readily in international disputes, as China and many other states believe? Limited NMD capabilities would increase the ability of the United States to project power into regional trouble spots with less fear of retaliation, but many debate it is uncertain whether this would have a positive or negative affect on the course of international relations.[10] Moreover, the impact of defense deployments will vary depending on the amount of offensive missile capability possessed by potential U.S. opponents. Ultimately, the diplomatic path to deployment, reflected in efforts to renegotiate the ABM Treaty, may have a greater impact on crisis and arms race stability than the specific capabilities of American missile defenses.

Third, modifying the ABM Treaty and deploying theater and national missile defenses eventually will be viewed primarily as an Asian issue. Reactions in China to the possibility that Chinese strategic force modernization might no longer be able to capitalize on Russian-American security cooperation raise the possibility that U.S. NMD deployments could lead to a cascading effect in the Asia-Pacific region as China's neighbors react to Beijing's security decisions. NMD proponents and opponents both neglect the serious ramifications of their decisions in far-away parts of the globe. South Asia is the region most likely to experience a cascading effect following a U.S. decision to deploy NMD. Japan and Taiwan also would have to adjust their defense policies to reflect any American decision. For better or worse, U.S. NMD deployments and changes to the arms control regime governing strategic defenses are likely to clarify Chinese national security objectives in the years ahead. These decisions may not be to Washington's liking. China, after all, sees a dark side to U.S. plans to deploy NMD, one that includes American desires for global hegemony and an overt U.S. campaign to stem China's emergence as a great power. The United States needs to decide

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whether it considers China a Little Russia or a Big Rogue. If the former, then the United States should accept China's effort to develop a secure retaliatory capability for reasons of stability along the classic deterrence model.[11] If the latter, however, then NMD should be directed at the potential Chinese threat.

Recommendation: Deploy and Negotiate

The United States finds itself on the horns of a dilemma. On the one hand, it can seek to increase its security through largely unilateral action, but at the risk of a harsh international response. The arms race and crisis instability unleashed by highly capable defenses deployed in the absence of a revised ABM Treaty probably would undermine America's strategic position over the long term. Given the likely international ramifications, are deploying missile defenses and modifying the ABM Treaty worth the modest protection NMD will provide? On the other hand, can the United States avoid defense deployments given the proliferation of ballistic missile threats and domestic demands for protection? No matter how American policymakers attempt to resolve this missile defense dilemma, real choices will have to be made concerning strategic interests that consider the long-term international consequences of U.S. decisions.

Although Bush administration officials suggest that missile defenses can be used to help transform strategic relationships, what is missing from today's debate about NMD is a vision of how U.S. policymakers will use arms control and national missile defense to shape the future international security environment. NMD supporters are correct to claim that the missile threat is growing and that the bargain at the heart of the ABM Treaty is nearly obsolete. But this changing threat environment does not justify abandoning formal and unilateral arms control initiatives that can pave the way for the strategic transformation envisioned by the Bush administration. The fact that today's proponents of NMD are often yesterdays arms control critics is regrettable, because old biases can blind officials when it comes to the important role arms control can play in legitimizing missile defense deployments. Arms control negotiations can provide a forum to communicate military concerns and to explain changes in force structure and doctrine that will inevitably occur in the future. It can help concerned states repeatedly adjust not only their forces, but strategic concepts and plans as missile defenses become increasingly robust. By contrast, a prompt U.S. withdrawal from the ABM Treaty would send a shock wave throughout the international community, causing unforeseen and negative consequences in the decades ahead.

The United States should deploy missile defenses that provide modest protection of the American homeland, deployed forces, and possibly allies. Exactly what sort of system will be deployed, a few dozen ground based interceptors, a sea-based system, or even the airborne laser remains a matter of conjecture. But limited defenses make strategic and diplomatic sense. A modest missile defense system would stretch the current technological limits without breaking them, can remain fiscally viable, and would allow the United States to approach Russia with a proposal to renegotiate the ABM Treaty to allow for theater and limited national missile defenses in a cooperative defensive regime. This negotiation process might even be broadened beyond a bilateral arrangement to include other key states in a multilateral forum, one that could lead to a successful transition to a world in which missile defenses have a role to play in maintaining international stability.

NMD highlights the danger of making shortsighted policy decisions without considering immediate international reactions or longer-term systemic consequences. The NMD debate focuses on current threats and technical challenges. But deployment decisions and Treaty negotiations have to take into account the strategic setting twenty years from now, when robust defense systems become fully operational. Too often, both critics and supporters treat the decision to deploy missile defenses as an end in itself, not part of a transition to a new, more cooperative security framework. If it fails to foster this transition, the United States will find itself either wedded to an increasingly irrelevant arms control treaty or saddled with potentially ineffective and provocative missile defenses.

Foot Notes

[1] James J. Wirtz is Chairman of the Department of National Security Affairs at the Naval Postgraduate School, Monterey, CA. Jeffrey A. Larsen is a senior policy analyst with Science Applications International Corporation in Colorado Springs, CO. This article reflects the analysis in James J. Wirtz and Jeffrey A. Larsen (eds.), *Rockets Red Glare: Missile Defenses and the Future of World Politics* (Boulder, CO: Westview Press, 2001). A version of this article will be published by the *National Security Studies Quarterly*. The views expressed in this article are the author's own and do not necessarily reflect the official positions of the United States Navy or SAIC.

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[2] For a concise description of the Clinton administration's plans for national missile defense, see Remarks of the Honorable Walter B. Slocombe, Under Secretary of Defense for Policy, to the Center for Strategic and International Studies Statesmens Forum, November 1999, published in *Comparative Strategy*, Vol. 19, No. 2 (April/June 2000), pp. 167-174.

[3] Stephen W. Young, for example, sees only a downside to national missile defense: by building national missile defenses, the U.S. may stimulate new threats, unraveling the entire post-Cold War structure for controlling nuclear and missile technology and weapons. U.S. withdrawal from the ABM Treaty would jeopardize four non-proliferation and disarmament treaties--the NPT, the CTBT, and START I and II--as well as the potential for START III, for even deeper cuts, and for the ban on fissile material production. Russian officials have even hinted that the Intermediate-range Nuclear Force (INF) Treaty, which completely eliminated nuclear-tipped missiles with a range of 500-5,500 kilometers, could come into question. Prospects for mutual, cooperative steps to reduce nuclear dangers outside the treaty process would also diminish sharply. Stephen W. Young, "Pushing the Limits: The Decision on National Missile Defense" (Washington, D.C.: Coalition to Reduce Nuclear Danger, April 2000), p. 25.

[4] Robert Jervis, *System Effects: Complexity in Political and Social Life* (Princeton, NJ: Princeton University Press, 1997).

[5] Samuel P. Huntington, "The Lonely Superpower," *Foreign Affairs*, Vol. 78, No. 2 (March/April 1999), pp. 35-49; and Gary Wills, "Bully of the Free World," *Foreign Affairs*, Vol. 78, No. 2 (March/April 1999), pp. 50-59; and William Pfaff, "The Question of Hegemony," *Foreign Affairs*, Vol. 80, No. 1 (January/February 2001), pp. 221-234

[6] "New Leadership on National Security," speech by George W. Bush to the National Press Club, Washington, DC, 23 May 2000, on the Internet at http://www.georgewbush.com.

[7] Speech by President George Bush on national missile defense at National Defense University, Washington, DC, 1 May 2001, on the internet at http://washingtonpost.com/wp-srv/onpolitics/transcripts/bushtext050101.htm.

[8] For a discussion of how various NMD systems would require changes in the existing ABM Treaty regime, see Dean A. Wilkening, "Amending the ABM Treaty," *Survival*, Vol. 42, No. 1 (Spring 2000), pp. 29-45. For the Treaty text, see the U.S. Department of State at http://www.state.gov/www/global/arms/treaties/abm/abm2.html.

[9] For general guidelines on the Bush missile defense plans, see the President's two speeches on 23 May 2000 and 1 May 2001 and John Isaacs, "Pebbles and All," *Bulletin of the Atomic Scientists* (September/October 2001), pp. 22-23.

[10] For more on this concept, see Richard J. Harknett, "Global Stability in a Changing Defense Environment," Chapter 5 in Wirtz and Larsen, eds., *Rockets Red Glare*.

[11] This construct regarding China was developed by Brad Roberts for his chapter in *Rockets Red Glare*.

ELECTRONIC MANEUVERING BOARD DECISION AID, *continued from page 13*

making tool, while increasing ease of data exchange and reducing current redundancies and manning-inefficient practices. This system will significantly enhance Safe Navigation at Sea while maintaining the age old, time tested ways of avoiding other vessels at sea (Figure 5).

Our software design is implemented via using GtkAda, which allows the development of a GUI-based program that is neither operating system nor hardware dependent. Gtk-Ada is supported on a wide range of platforms, and its use can ultimately allow the U.S. Navy to develop operational tools and programs without being limited to any specific hardware or operating system. The flexibility that this tool affords can reduce development and maintenance cost significantly as the amount of rework due to a paradigm shift in any operating system vendor will be greatly reduced or eliminated. Additionally, Ada's ability to interoperate with other programming languages makes it an excellent candidate for integrating with current stove-piped systems.

Our system provides the basis for a robust fusion analysis plot that, due to its modular design, can interact with virtually any other system (Figure 6).

GtkAda and GNAT

There are several reasons we chose to use GtkAda and GNAT compilers. First off, as students with no funding, both of these compilers are free, a very attractive quality. Secondly, part of our research was to design a computer program that was hardware and software (Operating System) independent, thus portable. GtkAda is a high level portable graphical toolkit based on the gtk+

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ELECTRONIC MANEUVERING BOARD DECISION AID, *continued from page 47*

toolkit and one of the official GNU toolkits. Additionally, GtkAda uses Ada95 features and supports Object Orientation. Another attractive feature of GtkAda is that it supports OpenGL.

There is no guarantee that the DoD will be using Windows NT or Linux, or any other operating system five years from now. Our program is designed to be and is hardware and software independent. This is an attractive feature that gives the DoD flexibility in operating system procurement, as well as, makes our code more maintainable and robust. Our code can be run on all of the following platforms:

- Linux/x86
- Linux/sparc
- Linux/ppc
- Solaris/sparc
- Solaris/x86
- Dec Unix
- SGI IRIX 6.5
- HP/UX
- NT 4.0
- Windows 2000
- Aix 4.3.2
- SCO UnixWare 7.1
- FreeBSD 3.2

Future Work

Future work will include a set of additional views (an extensibility of our design). Additionally, our program will contain the functionality to alert the OOD and CO when a contact will be within the set distance based upon the Commanding Officer's Standing Orders. An alert will be generated signaling the OOD and/or CO that the designated contact will be within minimum distances set. The program will include functionality that gives the OOD recommendations based upon rules of the Road library. This library will alert the OOD/CO of important Rules of the Road and give recommended course and speed changes based upon those rules and the Captain's Standing Orders. The default being, maneuver the ship to maintain minimum set Closets Point of Approach (CPA). The computer program will also alert the OOD/CO if a course and speed change will affect the CPA of other contacts adversely or affect the safe navigation of the ship. These enhancements will be a guide/aid to the OOD/CO designed to promote safe navigation at sea and prevent collisions and human-errors that result in collisions at sea.

Figure 5. Contact Management Today.

We also expect the project will evolve to incorporate the following technologies:

- Touch screen displays
- Wireless LAN connectivity
- Voice recognition technology
- Mobile headset/communications
- Automated Deck Log
- Palm Pilot/CE devices providing information on demand
- Integrated multiple views (FalconView, Heads-up displays, etc.)
- Ada-enabled Applets for browser exchange of information

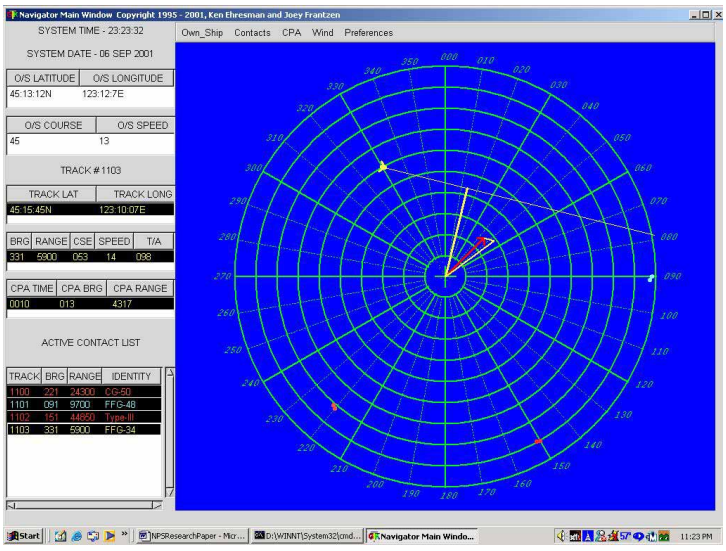

Figure 6. Screenshot of the Digital Moboard.

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DSP BASED CHAOTIC COMMUNICATIONS SYSTEM, *continued from page 19*

conducive to the research process.

Chaotic systems are a class of deterministic systems that are sensitive to slight variations of initial conditions as well as aperiodic. A systems sensitive dependence to initial conditions results in the problem that the behavior of a system cannot be predicted for a significant time into the future. The state of a system for the next instant is completely deterministic, but in the long run it cannot be calculated with any degree of accuracy. These systems produce random-like behavior. I will be looking at both the frequency-domain and time-domain properties of chaotic systems and expect to find that using them for a message carrier will offer several advantages over traditional modulation schemes.

Initially, it seems useless to attempt communication using a chaotic carrier since the state of a chaotic system cannot be well predicted. On the other hand, if it could be done, the natural properties of chaotic systems would be very beneficial for covert communication. Fortunately, a number of chaotic communication schemes are possible based on the property of synchronization.

A picture captured from the oscilloscope on Mr. Reddell's desk visually shows his current efforts to emulate the Lorenz system on DSP hardware.

Some chaotic systems can be synchronized with an identical system by allowing for some influence between the two. Both systems will remain chaotic, but one mirrors the other. Once synchronization is achieved, information can be sent. A transmitter's output is modified by a message. Since the receiver follows what the transmitter's state should be, it can detect the change caused by a message and thus extract the information from the chaotic signal. Meanwhile, the transmission continues to look like noise to an outside observer.

This project involves several investigations into the feasibility and performance of chaotic communication schemes. At first, all of my work will be done with a baseband transmitter and receiver, later more study will be done by up-shifting the frequency of the system to an intermediate stage suitable for radio transmission.

I am using two Texas Instruments Digital Signal Processors (DSPs) to numerically emulate a chaotic transmitter and receiver. I have started out with the classic Lorenz system, but expect to try others as well. For the base-band system, a wire from one DSP board to the other carries the transmission. I will spend a good deal of time analyzing the frequency domain properties of this signal. This is how I will determine the effectiveness of camouflaging the transmission among background noise. Artificial noise will also be incrementally added to construct bit error rate (BER) curves.

Upon completion of this project, I will have completed investigations in at least two new areas. One is the utilization of digital signal processing methods in the transmitter and receiver instead of analog circuitry. The second is performance analysis of the system from a communications perspective.

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CHARACTERIZATION OF NONLINEAR OPTICAL LIMITERS HOUSED WITHIN CAPILLARY WAVEGUIDES

Jeremiah J. Wathen (Physics major)
Advisors: Assistant Professor James J. Butler, Physics Department, and Dr. James S. Shirk, Naval Research Laboratory

Many applications - especially commercial fiber optical systems - demand practical optical limiters. These devices can protect optical sensors that can't handle the intense light many optical systems carry. Optical limiters can be constructed from chemical compounds that display a nonlinear response to incident light. That is, they allow nearly full transmission of low-intensity light but deny the transmission of high-intensity light. The more intense incident light becomes, the less light a limiting compound will transmit. We hope to build fast-response limiters compatible with modern fiber optics systems.

Midshipman Jeremiah J. Wathen with Advisor Assistant Professor James J. Butler.

We propose to construct optical limiters by filling tiny glass tubes, called capillaries, with nonlinear compounds. Through total internal reflection, these filled capillary tubes will act as optical waveguides. The glass capillary method offers important advantages. First, within such a capillary waveguide, the light/limiter interaction length can be extended indefinitely, increasing the limiting ability of nonlinear materials. Second, capillary waveguides will easily integrate into standard single-mode fiber optical applications. Third, these capillaries can have extremely small diameters. Thus, we can invoke a limiting response even against low intensity light by focusing the light into an intense beam inside a capillary waveguide.

The study will attempt to discover how untested limiting compounds respond to light. Nonlinear compounds limit due to a number of mechanisms. Molecular photon absorptions and refractive index changes both cause a nonlinear limiting response. While many different types of photon absorptions can occur, this study will focus specifically on two-photon absorption (TPA) and reverse saturable absorption (RSA). These two nonlinear mechanisms limit very quickly, providing limiting against very short-pulsed laser sources. Negative refractive index change, caused by increased kinetic activity of the limiting compound, is a slower acting phenomenon that can limit longer laser pulses.

Experiments will investigate two separate classes of nonlinear compounds. First, we will characterize the response of numerous lead and thallium phthalocyanines engineered by chemists at the Naval Research Laboratory and at the U.S. Naval Academy. These molecules have previously demonstrated excellent TPA and RSA responses. Other tests will characterize the responses of various gold cluster/alkanethiol solutions. Such solutions should demonstrate limiting due to negative refractive index change.

Experiments will test these molecules responses against laser light over broad range of wavelengths, intensities and pulse widths. Tests will place specific interest in the limiting response observed against near-infrared wavelengths, as most fiber optics systems operate in this range.

We intend to accomplish a number of objectives. We intend first to engineer a single-mode capillary housing to incorporate into fiber optics systems. Once we achieve such a design, experiments will characterize the responses of a number of the compounds within these single-mode housings. We will measure the raw limiting effect of the nonlinear materials and attempt to determine by which mechanism each different limiter acts. By mixing the different limiters we study, we hope to engineer a viable limiter that can limit against a broad range of wavelengths and pulse widths. Finally, if time allows, we may investigate limiting responses from compounds housed within an array of coupled waveguides.

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were designed to be along the primary acoustic transmission paths. Two sound sources operating at 224 and 400 Hz were deployed on the 350 m isobath (Figure 3, sites A5 and A6) and sources operating at 300, 400, and 500 Hz were deployed on the 120 m isobath (sites A1-A4). The signals were all received at the WHOI/NPS L-array (Figure 3) also moored on the 120 m isobath (site A7). An array of 18 WHOI Low-Cost (LOCO) moorings were deployed along and near the main across-shelf line to form an internal wave antenna to characterize the very strong nonlinear solitons in the region. An array of four Pop-up Ambient Noise Data Acquisition (PANDA) moorings, provided by National University of Singapore, were also deployed.

The middle OR1 cruise conducted a small-scale survey focused on the acoustics region and a large-scale survey to describe the surrounding mesoscale circulation and Kuroshio intrusions into the South China Sea. This required having two SEASOAR instruments on board, one rigged for shallow operation (WHOI) and one for deep (NTU). These surveys had considerable 3-D spatial scale and were not limited to being along the primary transmission paths. To be sure these paths were adequately sampled, the NRL/National University of Singapore group on OR3 sampled dedicated cruise tracks exclusively along the acoustic transmission paths. The data collected by OR3 included towed CTD, hull mounted ADCP, and high frequency acoustic backscatter at 200 and 350 kHz.

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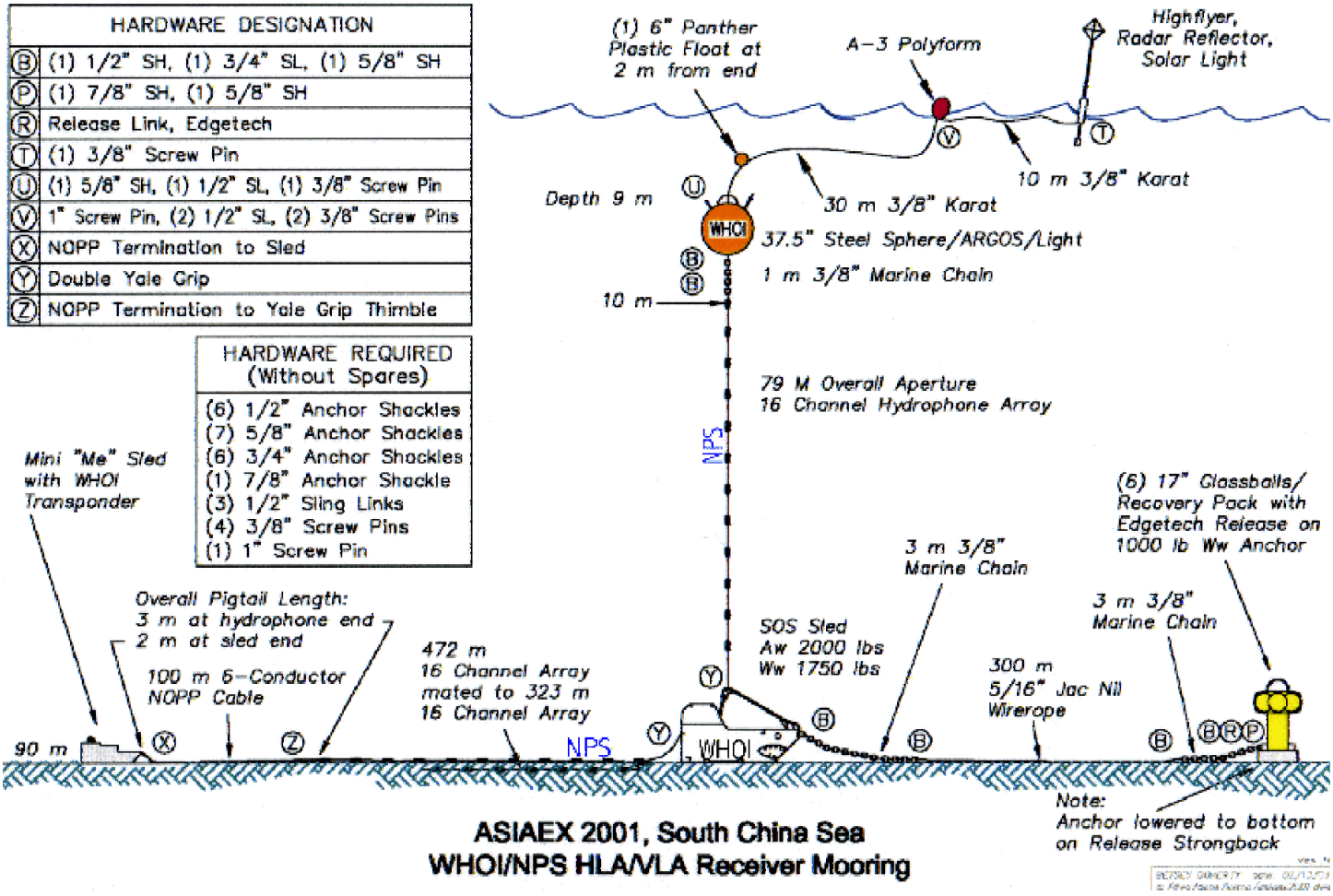

Figure 3. Schematic drawing of the WHOI/NPS L-shaped hydrophone array deployed in the South China Sea for studying both the vertical and horizontal properties of the sound field associated with both across and along-shelf signal transmissions. (Mooring design and figure provided by Keith von der Heydt and John Kemp, Woods Hole Oceanographic Institution.)

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East China Sea Operations

Meanwhile, over in the East China Sea, the *MELVILLE* got underway from Naha on May 28 to rendezvous with the Chinese ships in the study region bounded by 28-30°N, 126.5 to 128°E. The reverb studies require a very accurate characterization of the sub-bottom structure. Much of this was done by the UNC and FAU groups the previous year during the pilot study on the *REVELLE*. These groups carried out chirp sonar and sub-bottom profiling operations along several closely spaced transects in the study region, and collected a few bottom gravity cores as well. During the main field program in 2001, the *MELVILLE* first deployed a surface wave buoy to characterize the surface boundary and the In-situ Measurement of Porosity (IMP-2) instrument to sample the bottom porosity and roughness. Finally, a third cruise during August 6-13 2001 successfully collected many deeper piston cores in the region. This cruise was a joint Taiwan/U.S./Korea operation conducted from the Taiwanese research vessel *OCEAN RESEARCHER 2* (sister ship of the OR3), home ported in Keelung, Taiwan.

Following the boundary layer characterizations, the acoustics observations on board the *MELVILLE* began in earnest. The MPL/SIO group made low and mid-frequency towed-source observations, received with a 16 element VLA, followed by some direct path bottom reverberation experiments in the 3.5 kHz and 850 Hz range. The APL/UW group conducted surface and seabed forward scattering experiments in the 2-20 kHz range, using the broadband acoustic source system (BASS) to transmit and the moored receiving array (MORAY) to receive. Ambient noise in the 0.5-20 kHz band was also measured using the MORAY by itself.

During the period June 3-5, operations from the *MELVILLE* were coordinated with those from the *SHI YAN 2* and *SHI YAN 3*. A broadband propagation experiment was conducted in about 24 h during which the *SHI YAN 2* deployed broadband sources at a depth of 50 m and at ranges from 0.5 to 30 km. A Broadband reverberation experiment was conducted on June 3rd, and again on June 5th, using broadband sources deployed this time from the *SHI YAN 3*. In both experiments, data were recorded on arrays deployed from the *SHI YAN 3* (by IOA), and on a VLA (URI and APL/UW) deployed from the *MELVILLE*.

Coping with Fishing

Fishing effort over both the ECS and SCS continental shelves was very heavy, and considerable effort was expended to be sure that valuable equipment and data were not lost to fishing. A guard boat was hired in the SCS to stand over the acoustic receiving arrays and protect them from trawlers and long-liners. In the ECS, the *MELVILLE* and *SHI YAN 3* took care to always be near the moored gear to fend off the fishermen. Despite these efforts, the Chinese suffered the unfortunate loss of their HLA deployed along the surface, which was run over by a fishing boat passing too close to the stern of the *SHI YAN 3*. The recovery rate in the SCS was better than expected: All the acoustics moorings were recovered, plus seven of eight environmental moorings, with one still adrift at this writing. The LOCOs took a bit more of a beating, with 11 of 18 being successfully recovered. Just one of four PANDAs was recovered, the rest presumably lost to trawling activity.

Preliminary NPS Results

Most of the data from this large international experiment are still being processed. We regret we cannot fully represent the scientific results of all our colleagues in this short article and still publish it in a timely fashion. NPS Professors Steve Ramp and Ching-Sang Chiu had administrative oversight for both the SCS and ECS programs, but their personal scientific involvement, and that of NPS staffers Chris Miller, Marla Stone, and Fred Bahr, was limited to the South China Sea volume interaction experiment. A few scientific observations, to illustrate the nature of the experiment, are provided here.

The mooring locator plot (Figure 2) shows the impressive size of the moored array. The oceanographic moorings S1-S8 were all traditional heavy-duty, subsurface moorings using conventional current meters, temperature sensors, and acoustic Doppler current profilers (ADCPs). The moorings sampled very fast, typically 1-minute averages, during the three-week experiment to capture all scales of variability including a very energetic internal wave field. These large-amplitude, nonlinear internal waves, also known as solitons, turned out to be the most energetic feature in the data set. The temperature record from mooring S7 on the 350 m isobath (Figure 4) shows that the thermocline was depressed all the way to the bottom when a strong wave passed by. The temperature at 100 m changed by 10°C from 18°C to over 28°C near 0800 on May 9. Several smaller waves followed behind the primary depression, in keeping with theoretical expectations. The largest solitons traveled west-northwest

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through the ASIAEX region with phase speeds of about 1-m s-1 (2 knots). Evidence from the space-borne synthetic aperture radar (SAR) suggests these waves were generated in the Luzon Strait between Taiwan and the Philippines, at approximately tidal frequencies. Other smaller waves were generated locally at the continental shelf break. The fate of these waves, that is, how their energy is dissipated on the continental shelf, is not well understood and is a topic of continuing investigation. The dense array of WHOI LOCO moorings spanning 50-100 m depth should help understand these processes. The impact of the internal waves on the acoustic transmissions is also an important topic to be addressed with the ASIAEX data.

The WHOI/NPS L-array consisted of 32 hydrophones spanning 472 m along the bottom and 16 hydrophones moored vertically in the water column (Figure 3). These hydrophones sampled at 3.2 kHz for nearly three

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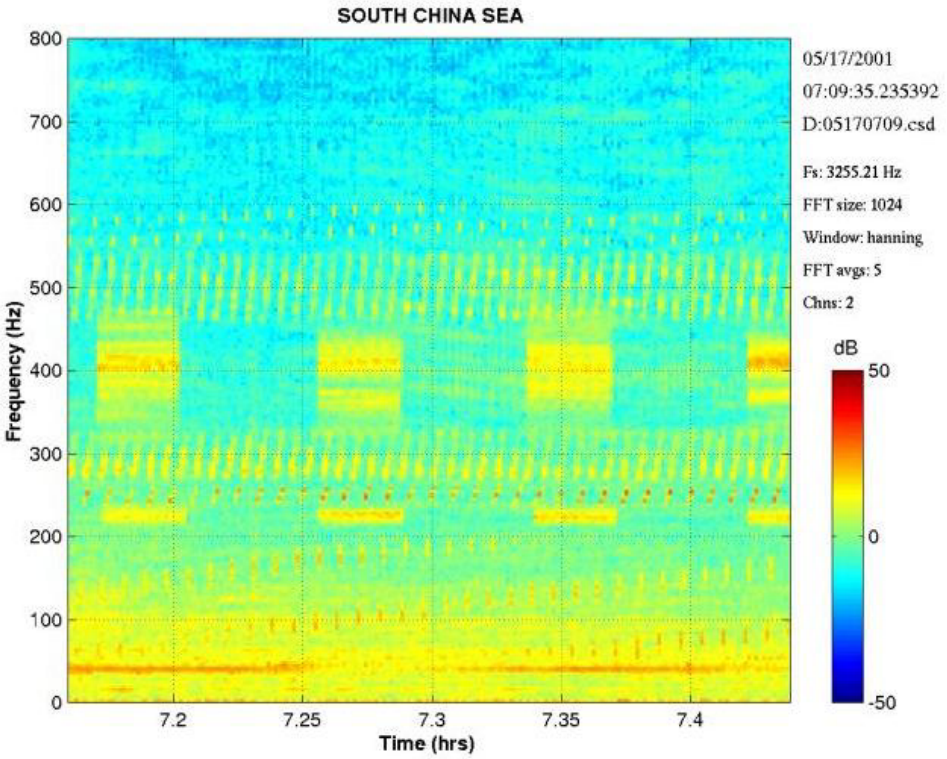

Figure 5 (above). A spectrogram of the South China Sea acoustic signals received by an element on the horizontal segment of the L-array toward the end of the equipment. The band-passed signals centered at 225, 300, 4300 and 500 NHz were either phase or frequency-modulated signals transmitted from a number of fixed sources moored on the shelf and slope. The other signals containing Doppler frequency shifts were transmitted from a towed source aboard the OR3. [Figure courtesy of Arthur Newhall, WHOI]

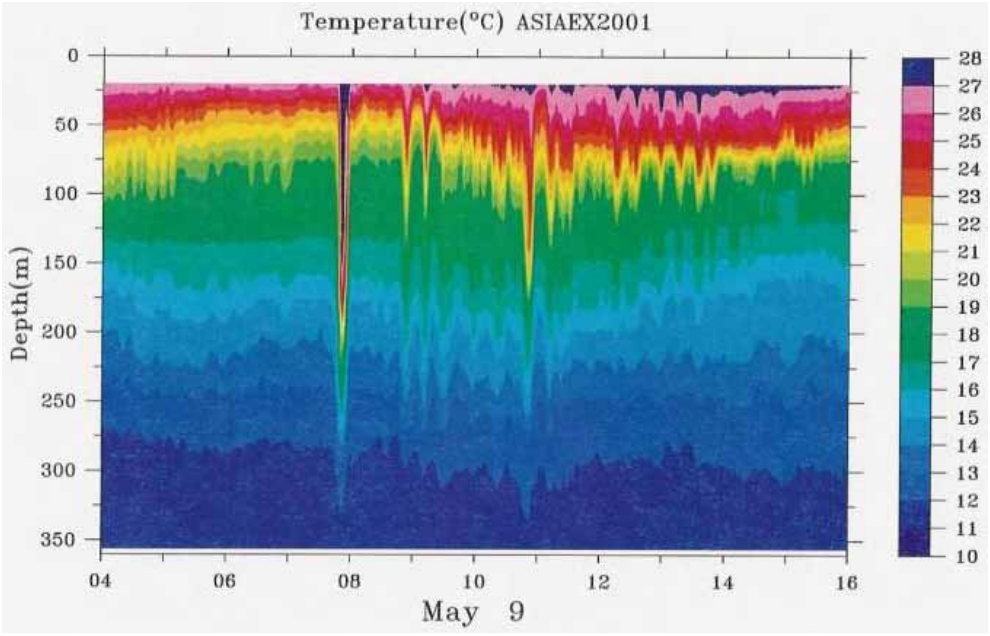

Figure 4. Temperature plot from ASIAEX mooring S7 (see Fig. 2) from 0400 to 1600 hours on 9 May 2001. The plot was constructed using data from several different kinds of instruments including microCATS, mini-starmons, and Aanderaa current meters contributed to the experiment by NPS, WHOI, and NTU. This frame isolates one of the strongest nonlinear internal wave (soliton) events observed during the experiment, which occurred just prior to 0800 ours. Weaker, approximately rank-ordered waves follow along behind.

ASIAEX PROGRAM, *continued from page 53*

weeks and collected 600 gigabytes of data. These data are still being processed, quality controlled, backed up and distributed to the participating institutions. A single spectrogram from one of the bottom hydrophones shows how well the array functioned (Figure 5). The arrivals from both the along- and across-shore sources at 225, 300, 400, and 500 Hz are clearly seen as are the arrivals from the towed source aboard the OR3. The processing and analysis of the entire acoustic data set, in conjunction with the oceanographic data, is currently underway with goal to understand the influences of inherent ocean variability on acoustic propagation, coherence, and predictability.

Summary

Altogether, the ASIAEX field program was a great success. The volume interaction group collected a factor of 10 more data than the New England Shelfbreak PRIMER Experiment, which was previously the largest experiment of this type. Likewise the ECS boundary interaction group far exceeded the results of the 1996 Yellow Sea Experiment, the last joint U.S./China cooperation in the area. A workshop has been scheduled for October 31 to November 2 in Maui, Hawaii, to allow everyone a chance to present a first-look at their data. The entire program is looking forward to hearing these results.

Acknowledgements

The ASIAEX Program was sponsored primarily by the Office of Naval Research Ocean Acoustics Program, with additional contributions from the ONR Physical Oceanography Program and the Navy International Cooperation (NICOP) Program. The skill, leadership, and determination of Dr. Jeffrey Simmen, ONR Team Leader for Ocean Acoustics, in executing the program are particularly appreciated.

Left: Scenes from the East China Sea boundary interaction cruise. Clockwise from top left: The Chief Scientist, Peter Dahl, with his new toy; Dick Harris and Bill Hodgkiss share a laugh; the return of Jim Miller; Russ Light never left his computer chair for two weeks; and D. J. Tang pulls his weight. The group shot at center left shows some of our Asian collaborators on the deck of the *MELVILLE* in Shanghai. From left to right, they are: Zhongkang Wang, Kunde Yang, Feng Ding, and Lixin Wu (all PRC), Hee Chun Song (Korea), and Jin Yan (PRC). [Photos courtesy of Peter Dahl, APL/UW]

CONFERENCE CALENDAR

UPCOMING CONFERENCES/SHORT COURSES/MEETINGS AT NPS

Date	Title	Sponsor
12-19 Oct 01	Leader Development and Education for Sustained Peace	Naval Postgraduate School, Center for Civil-Military Relations
24-26 Oct 01	PACJET Workshop	Naval Postgraduate School
5-8 Nov 01	Aircraft Survivability 2001; Integrating Survivability into 21st Century Designs	Air Force Research Laboratory
7-9 Nov 01	Waterside Security Wargames	U.S. Pacific Fleet
17-18 Nov 01	Naval Sea Systems Command Reserve Policy Steering Group (RPSG) Meeting	Naval Sea Systems Command
15-16 Jan 02	XML Technical Exchange Meeting	Program Executive Office (C3S)
29-31 Jan 02	AIAA Strategic and Tactical Missile Systems Conference	American Institute of Aeronautics and Astronautics
5-7 Mar 02	N-912 OPNAV Navy Simulator Validation Working Group	Office of the Chief of Naval Operations, Office of Naval Research
10-15 Mar 02	Hardened Electronics and Radiation Technology Conference	Defense Threat Reduction Agency, Sandia National Laboratories, U.S. Army Space and Missile Defense Command, Navy Strategic Systems Program Office
8-11 Apr 02	13th Annual U.S. Army Tank-Automotive and Armaments Command (TACOM) Ground Vehicle Survivability Symposium (GVSS)	U.S. Army Tank-Automotive and Armaments Command
18-22 Apr 02	18th Annual Review of Progress in Applied Computational Electromagnetics	Naval Postgraduate School, Applied Computational Electromagnetics Society
22-25 Apr 02	5th International Technology and the Mine Problem Symposium	Naval Postgraduate School, Defense Advanced Research Projects Agency
22-26 Apr 02	19th Annual Technology Review and Update	Naval Postgraduate School
6-9 May 02	Live Fire Test and Evaluation Conference	National Defense Industrial Association, Defense Advanced Research Projects Agency
5-7 Nov 02	AIAA Missile Sciences Conference	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. 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, Karen Flaherty, at 831-656-2426 or by e-mail, flaherty@nps.navy.mil.

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