Naval Postgraduate School
Monterey, California 93943-5138

NPS-09-05-004

Summary of Research

2003

Office of the Associate Provost and Dean of Research
Naval Postgraduate School

Summary of

Research

2003

NAVAL POSTGRADUATE SCHOOL
Monterey, California

RADM PATRICK W. DUNNE, USN   **RICHARD ELSTER**

Superintendent   Provost

Reviewed by: Released by:

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13. ABSTRACT (Maximum 200 words.)

This report contains project summaries of the research undertaken at the Naval Postgraduate School. A list of recent publications is also included which consists of conference presentations, books, contributions to books, published journal papers, and technical reports. The research was conducted in the areas of National Security Affairs, Computer Science, Defense Analysis, Information Science, Operations Research, Aeronautics and Astronautics, Electrical and Computer Engineering, Mathematics, Mechanical Engineering, Meteorology, Oceanography, Physics and Business and Public Policy. This also includes research by the Space Systems Academic Group, the Cebrowski Institute, (formerly the Institute for Information Innovation and Superiority, I2SI), the Wayne Meyer Institute (formerly the Institute for Defense Systems Engineering and Analysis, IDSEA), The Modeling, Virtual Environments, and Simulation (MOVES) Institute, School of Aviation Safety and Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS).

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THE NAVAL POSTGRADUATE SCHOOL MISSION

Enhance the combat effectiveness of the Navy and Marine Corps by conducting and directing advanced education of commissioned officers, and providing such other technical and professional instruction as may be prescribed to meet the needs of the Naval service. In support of the foregoing, and to sustain academic excellence, foster and encourage a program of relevant and meritorious research.

PREFACE

Research at the Naval Postgraduate School is carried out by faculty in the four Graduate Schools, Research and Education Institutes, Research Centers, and the School of Aviation Safety. This volume contains research summaries for the projects undertaken by faculty during 2003. The summaries are grouped by School and Institute and include an overview, faculty listing, and a compilation of publications/presentations.

Questions about particular projects may be directed to the faculty Principal Investigator listed, the Department/Group Chair, or the Associate Chair for Research. Questions may also be directed to the Office of the Associate Provost and Dean of Research. General questions about the Naval Postgraduate School Research Program should be directed to the Office of the Associate Provost and Dean of Research at (831) 656-2099 (voice) or research@nps.edu (e-mail). Additional information is also available at the RESEARCH AT NPS website, http://www.nps.edu/Research/index.html

Additional published information on the Naval Postgraduate School Research Program can be found in:

- *Compilation of Theses Abstracts:* A quarterly publication containing the abstracts of all unclassified theses by Naval Postgraduate School students.

- *Naval Postgraduate School Research*: A tri-annual (February, June, October) newsletter highlighting Naval Postgraduate School faculty and student research.

> This publication and those mentioned above can be found on-line at:
> http://www.nps.edu/Research/Publications/SummaryRes.html

INTRODUCTION

The research program at the Naval Postgraduate School exists to support the graduate education of our students. It does so by providing military relevant thesis topics that address issues from the current needs of the Fleet and Joint Forces to the science and technology that is required to sustain the long-term superiority of the Navy/Department of Defense (DoD). It keeps our faculty current on Navy/DoD issues, and maintains the content of the upper division courses at the cutting edge of their disciplines. At the same time, the students and faculty together provide a very unique capability within the DoD for addressing warfighting problems. Our officers must be able to think innovatively and have the knowledge and skills that will let them apply technologies that are being rapidly developed in both the commercial and military sectors. Their unique knowledge of the operational Navy, when combined with a challenging thesis project that requires them to apply their focused graduate education, is one of the most effective methods for both solving Fleet problems and instilling the life-long capability for applying basic principles to the creative solution of complex problems.

The research program at the Naval Postgraduate School consists of both reimbursable (sponsored) and institutionally funded research. The research varies from very fundamental to very applied, from unclassified to all levels of classification.

- Reimbursable (Sponsored) Program: This program includes those projects externally funded on the basis of proposals submitted to outside sponsors by the School's faculty. These funds allow the faculty to interact closely with RDT&E program managers and high-level policymakers throughout the Navy, DoD, and other government agencies as well as with the private sector in defense-related technologies. The sponsored program utilizes Cooperative Research and Development Agreements (CRADAs) with private industry, participates in consortia with government laboratories and universities, provides off-campus courses either on-site at the recipient command, by VTC, or web-based, and provides short courses for technology updates.

- Naval Postgraduate School Institutionally Funded Research (NIFR) Program: The institutionally funded research program has several purposes: (1) to provide the initial support required for new faculty to establish a Navy/DoD relevant research area, (2) to provide support for major new initiatives that address near-term Fleet and OPNAV needs, (3) to enhance productive research that is reimbursably sponsored, and (4) to cost-share the support of a strong post-doctoral program.

In 2003, the level of research effort overall at the Naval Postgraduate School was 198 faculty work years and exceeded $71 million. The reimbursable program has grown steadily to provide the faculty and staff support that is required to sustain a strong and viable graduate school in times of reduced budgets. In FY2003, over 94% of the research program was externally supported. A profile of the sponsorship of the Naval Postgraduate School Research Program in FY2003 is provided in Figure 1.
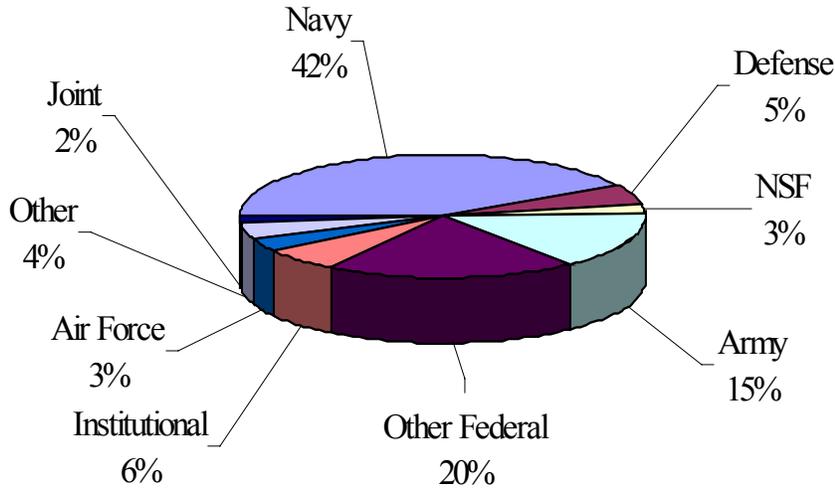
**Figure 1. Profile of NPS Research and Sponsored Programs
($71M)**

The Office of Naval Research is the largest Navy external sponsor. The Naval Postgraduate School also supports the Systems Commands, Warfare Centers, Navy Labs and other Navy agencies. A profile of external Navy sponsorship for FY2003 is provided in Figure 2.
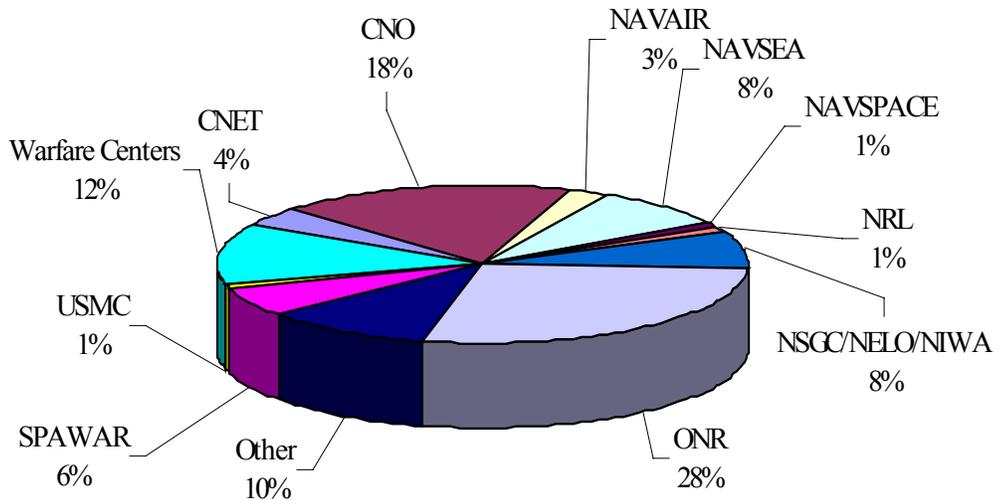

**Figure 2. Navy External Sponsors of NPS Research
and Sponsored Programs ($29M)**

These are both challenging and exciting times at the Naval Postgraduate School and the research program exists to help ensure that we remain unique in our ability to provide education for the warfighter.

Leonard A. Ferrari
Associate Provost and Dean of Research

August 2005

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SCHOOL OF INTERNATIONAL GRADUATE STUDIES

PAUL STOCKTON
DEAN

DEPARTMENT OF NATIONAL SECURITY AFFAIRS

JAMES WIRTZ
CHAIR

OVERVIEW:

The world around continues to evolve at an ever-increasing pace. The tempo of global events demands military officers who can analyze complex issues and think originally. The Department of National Security Affairs (NSA) is uniquely capable of providing an education that encourages these qualities in the officers who study here. The NSA Department brings together distinguished faculty and a highly motivated student body who share a focus on U. S. foreign and defense policies. The Department also tailors its programs to meet sponsor needs through a variety of means, including close ties to Service sponsors, access to classified information, and an intensive program of quality instruction and research.

CURRICULA SERVED:

- Strategic Studies
- Regional Security Studies
- Resource Planning
- Management for International Defense
- Civil-Military Relations and International Security

DEGREE GRANTED:

- Master of Arts in National Security Affairs

RESEARCH THRUSTS:

- Strategic Studies
- Joint Intelligence
- Regional Security Studies
- Civil-Military Relations and International Security
- Resource Planning and Management for International Defense (RePMID)

RESEARCH CENTERS:

- Center for Contemporary Conflict

RESEARCH PROGRAM (Research and Academic)-FY2003:

The Naval Postgraduate School's sponsored program exceeded $71 million in FY2003. Sponsored programs included both research and educational activities funded from an external source. A profile of the sponsored program for the Department of National Security Affairs is provided below:

Army 1%
Defense 6%
Navy 3%
Other Federal 90%
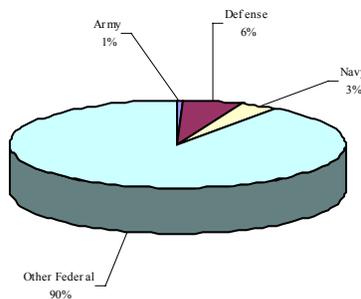
Size of Program: $5,998K

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INTELLIGENCE AND DEMOCRACY PROJECT
Thomas C. Bruneau, Professor
Department of National Security Affairs
Sponsor: Naval Engineering Logistics Office

OBJECTIVE: Naval Postgraduate School and outside scholars prepared and delivered a series of papers culminating in a final written report that developed an analytic framework for understanding issues involving foreign intelligence service reforms in emerging democracies.

A paper was delivered on the issue of intelligence reform and democratization and an initial assessment regarding the policy implications for the U.S. government, including the war on terrorism. Area experts delivered four additional papers on intelligence service reforms in Brazil, the Philippines, Romania, and South Africa.

KEYWORDS: Foreign Intelligence Service Reform, Brazil, Philippines, Romania, South Africa

DETERRENCE AFTER SEPTEMBER 11
Jeffrey W. Knopf, Visiting Associate Professor
Department of National Security Affairs
Sponsor: U.S. Department of Justice

SUMMARY: Many government officials and commentators have stated that September 11 shows that deterrence is no longer applicable to the security threats of the 21st century. This product evaluated the claim that deterrence is no longer useful and assessed how alternative conceptions of deterrence might be employed to the main post-9/11 threats. It considered two terrorist attacks on the U.S. homeland and weapons-of-mass-destruction (WMD) attacks by rogue states. The project assessed the similarities and differences in these two threats, and it identified concepts of deterrence that might be useful in addressing these threats. The starting assumption of the project was that deterrence is not dead, but the perceptions regarding how deterrence works need to change in the new threat environment.

KEYWORDS: Deterence, 9/11, WMD, Homeland Security

BIOLOGICAL WEAPONS AND HOMELAND SECURITY
Peter R. Lavoy, Assistant Professor
Department of National Security Affairs
Sponsor: U.S. Department of Justice

SUMMARY: The goal of this project was to produce a state-of-the-art course on biological weapons threats to the homeland and planned and potential U.S. responses.

Because this was such a dynamic new field, two small workshops were held to bring together leading governmental and non-governmental experts to analyze the problem, identify informative readings and other course materials, and produce new course materials on subjects where none exist. Governmental and non-governmental experts participated in the course, which was taught during the funded period.

KEYWORDS: Biological Weapons, Homeland Security

POLITICAL-MILITARY ANALYSIS
Peter R. Lavoy, Assistant Professor
Department of National Security Affairs
Sponsor: Defense Intelligence Agency

SUMMARY: The aim of this multi-author research project was to analyze the lessons learned in Indian and Pakistani political and military circles from the 1999 Indian–Pakistani Kargil conflict. Particular emphasis was placed on examining the lessons that affect the likelihood and character of war in Asia today.

STRATEGIC STABILITY IN SOUTH ASIA
Peter R. Lavoy, Assistant Professor
Department of National Security Affairs
Sponsor: Defense Threat Reduction Agency

SUMMARY: The objective of this research project was to support a visiting threat reduction fellow at the Naval Postgraduate School. The threat reduction fellow and the point of contact analyzed the elements required to model strategic stability, especially in the context of the dynamic Indian–Pakistani strategic rivalry; identified possible U.S. defense policy initiatives that could enhance strategic stability in south Asia; and provided other support to the research sponsor.

RESEARCH ACCOUNT (2003)
Theodore G. Lewis, Professor
Center for Homeland Defense and Security
Paul Stockton, Dean
Department of National Security Affairs
Sponsor: U.S. Department of Justice

GLOBAL STRIKE WARFARE AND NATIONAL DEFENSE STRATEGY: A PRELIMINARY ASSESSMENT
Daniel Moran, Associate Professor
Department of National Security Affairs
Sponsor: Defense Threat Reduction Agency

SUMMARY: This project sought to identify and analyze the significance of new and emerging forms of strike warfare at the level of U.S. national strategy and considered the strategic implications of the proliferation of advanced strike capabilities among potential adversaries. This project served as an initial assessment and laid the foundation for a follow-on multi-author project.

A HISTORY OF THE POSSE COMITATUS
Douglas Porch, Professor
Department of National Security Affairs
Sponsor: U.S. Department of Justice

SUMMARY: It is inevitable that in a mass-casualty event, such as an outbreak of smallpox in Los Angles caused by a terrorist attack, the American military will be mobilized to quarantine and assure public order over a large area. This task will place the military in the unaccustomed role of enforcing civil order within the United States, and have extensive legal implications for the distribution of authority between federal, state, and local officials. It will also pose significant challenges for civil–military relations in a country that traditionally has resisted using the military in a law enforcement role within the Unites States. Americans have resisted the use of the military to enforce order at least since the Whiskey Rebellion in the early years of the Republic. However, it was the employment of the Army in the ex-Confederacy to police polling stations, ensure that no former Confederate soldiers voted, protect judges, and corral the Ku Klux Klan that raised deep resentment in the South. Rough justice dispensed by Army commanders on the otherwise lawless frontier also raised the ire of civilians. The Posse Comitatus Statute of 1878 was passed at the end

of Reconstruction. It forbids the employment of the Army "for the purpose of executing laws," unless authorized by the Constitution or by an Act of Congress. This Act has not always been popular with federal officials in need of muscle, and was violated in 1919 when the Army was mobilized to control rioting in Chicago, in 1932 to flush the bonus marchers out of the capital, and to control striking railway workers during the Truman Administration. The National Security Act of 1947 extended to prohibition of "search, seizure, arrest, or other similar activity," to all services. The National Guard, which is not constrained by Posse Comitatus, was placed under federal control to contain civil rights unrest in the 1950s and 60s and to control rioting during the Democratic Convention and in Los Angeles in 1992. This use of the military to control civilian disturbances is justified by the fact that the President is responsible for enforcing public order, and so may set aside Posse Comitatus. Nevertheless, these events reveal a deep popular ambivalence, not to mention hostility, to the use of the military to enforce public order, as was apparent in 1997, when a Marine patrol pressed into duty as border guards shot and killed a teenaged boy near the border. This ambivalence is reflected in the confused legal status of a statute that was originally passed as a rider to an appropriations bill.

With the War on Terror and the creation of the Department of Homeland Security, there will be increasing pressure to employ the military in a law-enforcement role within the country. This proposal helped define and anticipate present and future problems by exploring the issues and debates of the past. The goal was to propose a set of policy recommendations and organizational responsibilities that might be applied in a future crisis.

KEYWORDS: Posse Comitatus, Civil Order, National Guard, Army

MODELING TARGET ACQUISITION, TRACKING, AND LOSS IN MILITARY OPERATIONS IN URBAN TERRAIN (MOUT) USING GRAPHS
C. W. Rasmussen, Associate Professor
Department of National Security Affairs
Sponsor: TRADOC Analysis Command

OBJECTIVE: The objective of this project was to model target detection, tracking, and loss in urban areas using graphs so that analytic methods associated with graph theory and random graphs can be applied to the models to provide insights to support objective force/future combat systems and to suggest aggregate models for future simulation and analysis. The scope of the research was limited to developing graph models and exploring analytic techniques that might provide insights using these models.

KEYWORDS: Target Detection, MOUT, Graph Theory, Modeling Targets

SUPPORT OF INTELLIGENCE CURRICULUM
Robert Simeral, Senior Intelligence Officer
Department of National Security Affairs
Sponsor: Office of Naval Intelligence

HOMELAND SECURITY RESEARCH INITIATION PROPOSAL – FISCAL YEAR 2002
Paul Stockton, Dean
Department of National Security Affairs
Sponsor: U.S. Department of Justice

SUPPORT FOR PROJECT 30976
Harold Trinkunas, Assistant Professor
Department of National Security Affairs
Sponsor: Naval Engineering Logistics Office

CONFERENCE: RUSSIAN SECURITY POLICY AND CONTINUING WAR ON TERROR
Mikhail Tsypkin, Associate Professor
Department of National Security Affairs
Sponsor: Combined Arms Center

SUMMARY: Conducted a conference on Russian security policy and the continuing War on Terror, with participation by Russian, U.S., and European experts.

KEYWORDS: Russia, War on Terror

MILITARY POLICIES OF POST-SOVIET STATES
Mikhail Tsypkin, Associate Professor
Department of National Security Affairs
Sponsor: Naval Engineering Logistics Office

MILITARY POLICIES OF POST-SOVIET STATES: SOURCES AND CONDUCT
Mikhail Tsypkin, Associate Professor
Department of National Security Affairs
Sponsor: Defense Threat Reduction Agency

SUMMARY: U.S.–Russian workshop on confidence-building measures in strategic command and control resulted in a proposal for future negotiations between the two nations.

KEYWORDS: Russia, Post-Soviet, Negotiation

MILITARY POLICIES OF POST-SOVIET STATES: SOURCES AND CONDUCT
Mikhail Tsypkin, Associate Professor
Department of National Security Affairs
Sponsor: Naval Information Warfare Activity

OBJECTIVE: This project was a study of military policies of post-Soviet states. The study focused on the decision-making mechanisms for formulation and implementation of military policies, the impact of revolution in military affairs, and the process of military reform.

DoD KEY TECHNOLOGY AREA: Other

KEYWORDS: Russia, Ukraine, Eurasia, Military, Security, Doctrine, Decision-making

U.S.-RUSSIAN CONFERENCE ON CONFIDENCE BUILDING MEASURES FOR STRATEGIC WEAPONS
Mikhail Tsypkin, Associate Professor
Department of National Security Affairs
Sponsor: Defense Threat Reduction Agency

SUMMARY: Conducted a U.S.-Russian conference on confidence building measures for strategic weapons.

KEYWORDS: Russia, Confidence Building, Strategic Weapons

ARMS CONTROL COMPLIANCE: FUTURE ISSUES
James Wirtz, Professor
Department of National Security Affairs
Sponsor: Strategic Systems Program

SUMMARY: The purpose of this project was to provide support to the Naval Treaty Implementation Program (SP2025) by responding to a series of research questions related to arms control compliance, the changing strategic environment, and the future of strategic deterrence.

KEYWORDS: Naval Treaty Implementation Program, Arms Control, Deterrence

CBRN JPM-IS (CHEMICAL, BIOLOGICAL, RADIOLOGICAL, AND NUCLEAR JOINT-PROJECT MANAGER, INFORMATION SYSTEMS) RESEARCH PROJECT
James Wirtz, Professor
Department of National Security Affairs
Sponsor: Space and Naval Warfare Command

NAVAL POSTGRADUATE SCHOOL OUTREACH FOR NUCLEAR STRATEGY
James Wirtz, Professor
Department of National Security Affairs
Sponsor: Defense Threat Reduction Agency

SUMMARY: This project supported the Defense Threat Reduction Agency program "Outreach 21" by supporting research efforts and outreach initiatives that foster greater awareness of issues related to nuclear strategy, policy, and threat reduction.

KEYWORDS: Defense Threat Reduction Agency, Outreach 21

ALLIANCE RELATIONS AND CONCEPTS OF ASSURANCE, DETERRENCE, AND DISSUASION
David S. Yost, Professor
Department of National Security Affairs
Sponsor: Defense Threat Reduction Agency

SUMMARY: The deliverables for this project consisted of written reports regarding research findings. Two reports were envisaged: the first in the form of a presentation at the Fifth Nuclear Stability Roundtable, "Strategic Stability in a Turbulent World," 28-29 April 2003, in McLean, Virginia; and the second in the form of a more extensive analysis submitted in 2003. This approach enabled the principle investigator to make "mid-course corrections" at the sponsor's direction regarding the themes and focus of the research effort.

KEYWORDS: Strategic Stability, Assurance, Deterrence, Nuclear Stability

ANALYZING DETERRENCE AND DISSUASION
David S. Yost, Professor
Department of National Security Affairs
Sponsor: U.S. Department of Justice

SUMMARY: The purpose of this research was to deepen understanding of the concepts of dissuasion and deterrence articulated in the 2001 Quadrennial Defense Review, the 2001 Nuclear Posture Review, and the 2002 National Security Strategy of the United States. How can the general principles articulated in these documents be most effectively translated into specific actionable tasks to protect the U.S. homeland?

EUROPEAN SECURITY AND NATO NUCLEAR POLICY
David S. Yost, Professor
Department of National Security Affairs
Sponsor: Office of the Secretary of Defense

SUMMARY: Provided written reports regarding research findings, as requested by the International Security Policy (ISP) staff in the Office of the Secretary of Defense. This approach enabled the principal investigator to make "mid-course corrections" at the sponsor's direction regarding the themes and focus of the research effort.

Work performed pertained to issues regarding U.S. nuclear and missile defense policy in the NATO context. Professor Yost conducted research on public statements and written material from European government officials. He also conducted personal interviews with leading European experts. In addition, he investigated issues including: the role of U.S. nuclear forces in Europe in fulfilling the defense goal of "assurance" identified in the Quadrennial Defense Review and the Nuclear Posture Review; means to promote furtherance of NATO's November 2002 Prague Summit goal of defense against the full spectrum of missile threats, given the various challenges in developing, fielding, and operating missile defenses; and methods to cultivate political consensus and resolve command and control questions in missile defense. Professor Yost submitted written reports on the results of this research to the ISP staff in the Office of the Secretary of Defense.

GRADUATE SCHOOL OF OPERATIONAL AND INFORMATION SCIENCES

WAYNE HUGHES
DEAN

DEPARTMENT OF COMPUTER SCIENCE

LCDR CHRIS EAGLE, USN
ACTING CHAIR

COMPUTER SCIENCE

<u>OVERVIEW:</u>

The Department of Computer Science provides graduate training and education in major areas of computer science. Both basic and advanced graduate courses are offered. Course work and research lead to either the degree of Master of Science or Doctor of Philosophy. The requirements to complete either program are rigorous and comparable to those of other major universities.

<u>CURRICULA SERVED:</u>

- Computer Science
- Software Engineering
- Modeling, Virtual Environments, and Simulation

<u>DEGREES GRANTED:</u>

- Master of Science in Computer Science
- Master of Science in Software Engineering
- Master of Science in Modeling, Virtual Environments, and Simulation
- Doctor of Philosophy in Computer Science
- Doctor of Philosophy in Software Engineering
- Doctor of Philosophy in Modeling, Virtual Environments, and Simulation

<u>RESEARCH THRUSTS AND FACULTY EXPERTISE</u>:

- Software Engineering:
  Professor Luqi, Professor Valdis Berzins, Professor Ted Lewis, Associate Professor Man-Tak Shing, Military Instructor CDR Deborah Kern, and Military Instructor LCDR Chris Eagle
- Databases:
  Associate Professor Thomas Wu, Research Assistant Professor Wolfgang Baer, and Professor Robert McGhee
- Information Security:
  Associate Professor Cynthia Irvine, Lecturer Daniel Warren, and Lecturer Paul Clark
- Artificial Intelligence:
  Professor Robert McGhee, Professor Neil Rowe, and Assistant Professor Chris Darken
- MOVES Institute (Modeling, Virtual Environments, and Simulation)/Computer Graphics:
  Professor Michael Zyda, Assistant Professor Rudy Darken, Lecturer Eric Bachmann, Research Professor John Hiles, and Research Professor Michael Capps
- Networks:
  Associate Professor G. M. Lundy, Assistant Professor Geoffrey Xie, and Associate Professor Bret Michael
- Programming Languages:
  Associate Professor Dennis Volpano

<u>RESEARCH FACILITIES:</u>

- Computer Science Academic Laboratory
- Artificial Intelligence and Robotics Laboratory
- Computer Systems and Security Laboratory
- Computer Graphics and Video Laboratory
- Microcomputer Systems Laboratory
- Modeling, Virtual Environments, and Simulation Institute
- Software Engineering Laboratory

- Visual Database and Interface Laboratory

RESEARCH CENTERS:

- Center for Information Security (INFOSEC) Studies and Research (CISR)
- Software Engineering Center

RESEARCH PROGRAM (Research and Academic)-FY2003:

The Naval Postgraduate School's sponsored program exceeded $71 million in FY2003. Sponsored programs included both research and educational activities funded from an external source. A profile of the sponsored program for the Department of Computer Science is provided below:

National Science Foundation 2%
Other 4%
Navy 45%
Other Federal 20%
Army 20%
Industry 3%
Defense 4%
Joint 2%
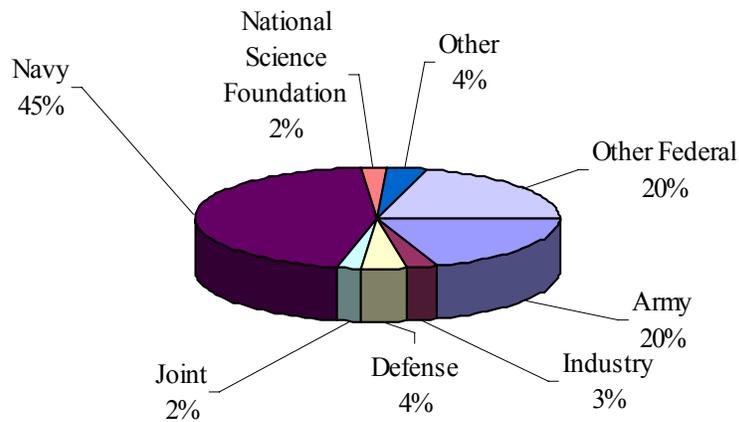
Size of Program: $3,817K

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COMPUTER SCIENCE

APPLICATION-LAYER IMPLEMENTATION OF SELF-CONFIGURING, AD-HOC, WIRELESS NETWORKS ON SELF-ROUTING, HANDHELD MOBILE CLIENTS USING OPEN STANDARD
Major Thomas E. Arnold, Jr., USMC
Department of Computer Science
Sponsor: Space and Naval Warfare Systems Command-San Diego

SUMMARY: Tactical data communications systems fielded to the United States Marine Corps support few users below the battalion headquarters level. In most cases "light forces," such as Marine Infantry, must rely on only voice communication via radio; access to networked data requires cumbersome equipment with heavy infrastructure requirements. However, technical and fiscal obstacles keeping timely information out of the hands of Marine squad leaders and company commanders can be overcome by applying focused research to hardware and software available today.

KEYWORDS: Wireless Networks, USMC, Handheld, Self-Routing, Mobile Clients, Open Standard

FRAMEWORK FOR SEAMLESS INTEROPERATION OF HETEROGENEOUS DISTRIBUTED SOFTWARE COMPONENTS
Mikhail Auguston, Associate Professor
Department of Computer Science
Sponsor: Office of Naval Research

SUMMARY: The objectives of this research were to develop generative component-based meta-model, to develop methods and tools for automatic generation of glue and wrapper software for communication between components, and to develop methods and tools for quality of service control.

KEYWORDS: Heterogeneous, Distributed, Software, Glue, Wrapper

PROTOTYPE MICRO-TERRAIN DATABASE GENERATION SYSTEM
Wolfgang Baer, Research Assistant Professor
Department of Computer Science
Sponsor: U.S. Army TRADOC Analysis Command

SUMMARY: This proposal requested funding for a system design and prototype implementation experiments leading to one-meter resolution intrinsic earth surface descriptor terrain database utilizing image feedback technology.

KEYWORDS: Micro-Terrain, Database, Earth Surface, Descriptor

TERRAIN DATABASE TOOLKIT
Wolfgang Baer, Research Assistant Professor
Department of Computer Science
Sponsor: U.S. Army TRADOC Analysis Command

OBJECTIVE: The goal of this research was to test, document, and support a one-meter battlefield terrain generation system known as PVNT. Tasks included documenting prototype systems and software capable of displaying the high-resolution one-meter resolution terrain, and enhancement of after action review capabilities using such products on low-cost PC-based workstations. Support was also provided for the initialization and construction of sample databases, and the porting and testing of existing tools to low-cost networked commodity based computer systems.

DoD KEY TECHNOLOGY AREA: Human-systems Interfaces

KEYWORDS: Simulation, Battlefield Visualization, High Resolution Terrain, 3-D Imaging

COMPUTER SCIENCE

ANALYSIS OF SAFETY REQUIREMENTS FOR AUTOMATED BATTLE MANAGEMENT

Michael L. Brown, Visiting Professor
James Bret Michael, Associate Professor
Department of Computer Science
Sponsor: Missile Defense Agency, Washington, D.C.

OBJECTIVES: The goal of this research was to develop a model of the safety executive for the battle management kernel (BMK). An additional objective was to model the dependencies among components of the ballistic-missile defense system (BMDS) in order to define safety requirements for the system in a system-of-systems acquisition environment.

SUMMARY: Traditional system safety techniques rely on the identification of hazards and hazard causal factors, which allow the safety professional to develop design requirements and recommendations that either mitigate the causal factors or reduce the impact of the hazards. This requires detailed knowledge of the system components and their interactions at all levels, and the operational environment for the system, which defines the system context. In the BMDS, detailed knowledge was lacking, due in part to the dynamic nature of the BMDS and the integration of legacy weapon and sensor systems, some of which were not designed for a C2-type system interface. Normally, system safety reevaluates the safety attributes of the individual systems in the new system context; however, reevaluating the safety attributes of the individual systems in the BMDS context is impractical, requiring extensive resources and time. Therefore, alternative means of risk mitigation were needed.

Although not widely used in weapon or C2 systems, a safety kernel (i.e., safety executive) is an alternative to traditional techniques of risk mitigation. Making a safety kernel effective, particularly in a SoS environment, requires developing the SoS architecture around the concept of a safety kernel. However, the safety kernel provides only part of the overall risk reduction. The full BMDS must use a hybrid architecture that includes wrappers to the interfacing weapon and sensor systems to ensure adequate risk mitigation. The wrappers provide interoperability assurance with the interfacing systems, reducing the safety-related risk associated with those interfaces (e.g., data integrity). This reduces the risk associated with one aspect of the interaction between system components. The wrappers improve the plug-and-play and open systems architecture features of the system. They also relieve the safety kernel of having to incorporate specific risk mitigation features for the system interfaces.

The safety kernel, coupled with the wrappers, must ensure that the BMK, at a minimum, provides the same level of safety assurance across the weapon and sensor system interfaces as previous C2 interfaces. That assurance requirement affects the dependencies between components of the BMDS as well as the interfaces to the weapon and sensor systems. The fundamental changes in the operational context of both the weapon and the sensor systems requires identification of the new mishaps associated with the BMDS and development of safety constraints to mitigate the risk. Integrating these constraints into the safety kernel and the wrappers in the form of safety design requirements requires a detailed understanding of the interaction of the weapon and sensor systems with their host C2 systems (if applicable) and any safety-related assumptions relevant to that interaction. This in turn requires developing domain knowledge and related safety constraints for the BMDS that dynamically configure the system for the required risk reduction, while maintaining an acceptable level of system performance.

TECHNICAL REPORTS:

Caffall, D.S. and Michael, J.B., "Developing Highly Predictable System Behavior in Real-Time Battle-Management Software," Naval Postgraduate School Technical Report, NPS-CS-03-006, 29 September 2003.

Michael, J.B., Pace, P.E., Shing, M.-T., Tummala, M., Babbitt, J., and Miklaski, M., "Test and Evaluation of the Ballistic Missile Defense System: FY03 Progress Report," Naval Postgraduate School Technical Report, NPS-CS-03-007, September 2003.

THESES DIRECTED:

Caffall, D.S., "Conceptual Framework Approach for System-of-Systems Software Developments," Master's Thesis, Naval Postgraduate School, March 2003.

Miklaski, M.H. and Babbitt, J.D., "A Methodology for Developing Timing Constraints for the Ballistic Missile Defense System," Master's Thesis, Naval Postgraduate School, December 2003.

KEYWORDS: Automated Battle Management, BMDS, BMK

AUTONOMOUS AGENT-BASED ASSESSMENT OF SIMULATION TO PROVIDE REALISTIC STIMULATION OF C4ISR SYSTEMS
LTC Rene G. Burgess, USA
Department of Computer Science
Sponsor: Space and Naval Warfare Systems Command-San Diego

SUMMARY: The goal of this research was to develop an autonomous agent-based artificial intelligence which is capable of assessing entity-level information from a joint simulation and providing a human-like representation of the situation to a tactical training audience equipped with C4ISR (command, control, communications, computers, intelligence, surveillance, and reconnaissance) devices.

KEYWORDS: C4ISR, Artificial Intelligence, Agent-Based AI

AUTONOMOUS AGENT-BASED SIMULATION OF AN AEGIS CRUISER COMBAT INFORMATION CENTER PERFORMING BATTLE GROUP AIR DEFENSE COMMANDER OPERATIONS
LT Sharif H. Calfee, USN
Department of Computer Science
Sponsor: Space and Naval Warfare Systems Command-San Diego

SUMMARY: The goal of this research was to develop an autonomous agent-based artificial intelligence simulation of an Aegis cruiser performing Battle Group air defense commander duties. The resultant simulation was utilized to gain insight and understanding into numerous factors that influence (positively or negatively) the effective performance of both the Combat Information Center (CIC) Air Defense Commander (ADC) team collectively and watch-station personnel individually. Additionally, the simulation allowed for the exploration of CIC team and individual watch-station performance during abnormal or high intensity/stress situations to determine the role of skill proficiency levels in the effective execution of ADC duties. The development of this simulation provides battle group staffs, air defense training commands, and ADC units with valuable information on focusing, improving, and refining their training programs.

KEYWORDS: Artificial Intelligence, Agent-Based AI, Aegis, Air Defense, Combat Information Center

EMERGENCY RESPONSE FOR CYBER INFRASTRUCTURE MANAGEMENT/PROTECTING PACKET-SWITCHED COMMUNICATIONS NETWORKS
George W. Dinolt, Associate Professor
Department of Computer Science
Sponsor: U.S. Department of Justice

SUMMARY: The objective of this research was to investigate architectural mechanisms to provide emergency response capability for cyber infrastructure management through the use of distributed, highly secure, protected domains. Instead of creating a costly physically separate domain, logical separation was used. This work developed an architecture and prototype demonstration in the context of an open source

operating system. First, this research provided satisfactory (non-simulation) mathematical models of the behavior of packet-switched communications networks, with initial focus on the Navy–Marine Corps Intranet (NMCI). Second, the research provided optimization-based methods for the attack and defense of such networks.

KEYWORDS: Cyber Infrastructure Management, Logical Separation, NMCI, Packet-Switched

PROVIDING ASSURANCE OF IMPLEMENTATIONS OF SECURITY
George W. Dinolt, Associate Professor
Department of Computer Science

OBJECTIVE: The goal of this research was to develop mathematical models and a common "specification framework" that can describe a number of different kinds security policies. The process will show the similarities of the models and provide assistance in developing high assurance implementations.

SUMMARY: Building high assurance, secure systems requires technology that not only constructs the system but also provides very strong evidence that the systems will meet their security goals. There is a well-known process for doing this that starts with a mathematical model of the desired security properties and continues with a formal (mathematical) chain of reasoning that the developed system satisfies the mathematical model. There are a number of apparently different models of security. In this work, researchers showed that many of the models share a common, underlying, mathematical framework. Given this framework, one may be able to develop a common computer system architecture that will implement this framework.

CONFERENCE PUBLICATION:

Ubhayakar, S., Bibighaus, D., Dinolt, G., and Levin, T., "Evaluation of Program Specification and Verification Tools for High Assurance Development," *Proceedings of the International Workshop on Requirements for High Assurance Systems*, IEEE International Requirements Engineering Conference, Monterey, CA, 9 September 2003.

THESIS DIRECTED:

Clark, J.L, "High Assurance Project Evidence Presentation Using Semantic Graphs in XML," Master's Thesis, Naval Postgraduate School, March 2004.

Ubhayakar, S., "Evaluation of Program Specification and Verification Systems," Master's Thesis, Naval Postgraduate School, June 2003.

Ziegenhagen, L., "Evaluating Configuration Management Tools for High Assurance Software Development Projects," Master's Thesis, Naval Postgraduate School, June 2003.

KEYWORDS: Computer Security, High Assurance, Security Models

COMPUTER SCIENCE

REAL-TIME, ON-LINE, LOW IMPACT, TEMPORAL PATTERN DETECTION FOR EXTENSIONS OF AUTOMATED TRANSPORTATION (AIRLINE) SECURITY PROFILING

Doron Drusinsky, Associate Professor
Mikhail Auguston, Associate Professor
J. L. Fobes, Transportation Security Chair
Department of Computer Science
Sponsor: U.S. Department of Justice

OBJECTIVE: The goal of this research was to investigate architecture, methods, and logic required for effective application of run-time monitoring specification and verification techniques to automated transportation security profiling.

SUMMARY: In this project, researchers showed the benefits of applying run-time monitoring specification and verification techniques to automated transportation security profiling systems such as CAPPS II. The following benefits were shown:

- Temporal Pattern Detection: the suggested technique provided a language for specifying complex temporal patterns (pertaining to airline security profiling).
- Low Impact: the suggested method reduced the impact of the profiling system on constituent systems. Consider, for example, a constituent banking database system. With the existing techniques, the profiling system queries the banking database in an open-ended manner, i.e., whenever it decided to do so and for almost any information cross section it desires to see. With the new approach, the profiling system and the bank database communicate using a narrowly defined, mutually accepted vocabulary and they do so on the banks' terms and schedule.
- On-line: the suggested method was efficient as it did not require storage and querying of large history traces.
- Real-time: the suggested method was able to provide answers to queries that involve real-time, and do so in (soft) real-time.

Researchers investigated the architecture required to achieve such real-time on-line profiling and necessary improvements needed for the specification language- augmenting temporal logic with time series capabilities.

PUBLICATIONS:

Auguston, M., "Building Program Behavior Models," *Progress in Computer Science Research*, New York; Nova Science Publishers, (to appear).

Drusinsky, D. and Fobes, J., "Executable Specifications: Language and Applications," *Department of Defense (DoD) Crosstalk Magazine*, (accepted for publication).

Drusinsky, D. and Shing, M., "Monitoring Temporal Logic Specifications Combined with Time Series Constraints," *Journal of Universal Computer Science (JUCS)*, Vol. 9, No. 11, 1261-1276, 2003.

CONFERENCE PUBLICATIONS:

Auguston, M., Jeffery, C., and Underwood, S., "A Monitoring Language for Run Time and Post-Mortem Behavior Analysis and Visualization," *Proceedings of 5th International Workshop on Algorithmic and Automatic Debugging AADEBUG 2003*, Ghent, Belgium, pp. 41-54, 8-10 September 2003, (see CoRR web site at http://arxiv.org/abs/cs/0310025).

Drusinsky, D., "Monitoring Temporal Rules Combined with Time Series," *Proceedings of the 2003 Computer Aided Verification Conference (CAV),* pp. 114-117.

Drusinsky, D. and Fobes, J., "Real-Time, On-Line, Low Impact, Temporal Pattern Matching," *7th World Multiconference on Systemics, Cybernetics, and Informatics*, Orlando, FL, p. 345-348, 2003.

Jeffery, C. and Auguston, M., "Some Axioms and Issues in the UFO Dynamic Analysis Framework," *Proceedings of Workshop on Dynamic Analysis, ICSE'03, 25th International Conference on Software Engineering*, Portland, OR, pp.45-48, 3-11 May 2003.

PRESENTATIONS:

Auguston, M., "Workshop on Dynamic Analysis," 25th International Conference on Software Engineering ICSE'03, Portland, OR, 3-11 May 2003.

Auguston, M., 5th International Workshop on Algorithmic and Automatic Debugging AADEBUG 2003, Ghent, Belgium, 8-10 September 2003.

Drusinsky, D. and Fobes, J., "Real-Time, On-Line, Low Impact, Temporal Pattern Matching," 7th World Multiconference on Systemics, Cybernetics, and Informatics, Orlando, FL, 2003.

CONTRIBUTION TO BOOK:

Auguston, M., "Building Program Behavior Models," *Progress in Computer Science Research*, New York: Nova Science Publishers, (to appear).

KEYWORDS: Logic, Specification, Monitoring, Temporal, Patterns, Security, Transportation, CAPPS

ADVANCED TOPICS IN INFORMATION ASSURANCE: MULTILEVEL SECURITY, ASSURANCE, AND CERTIFICATION
Cynthia E. Irvine, Professor
Timothy E. Levin, Research Associate Professor
Department of Computer Science
Sponsor: Space and Naval Warfare Systems Command

SUMMARY: Ongoing and emerging within the Navy require an appreciation of the concepts associated with multilevel security, assurance, and certification. The objective of this effort was to provide selected members of the Navy community with a survey of the foundational concepts and design techniques associated with the design and implementation of high assurance multilevel systems and issues of concern in their certification and accreditation.

KEYWORDS: Information Assurance, IA, Multilevel, Security, Certification

AUTHENTICATION STUDIES: PUBLIC KEY INFRASTRUCTURE AND HIGH ASSURANCE TRUSTED PATH
Cynthia E. Irvine, Professor
Department of Computer Science
Sponsor: Office of Naval Research

SUMMARY: The objective of this research was to conduct research primarily focused on authentication in distributed systems. The work entailed preliminary research toward the development of a high assurance network authentication device, studies related to the Department of Navy/Department of Defense public key infrastructure, and a draft certification of a high assurance component for transferring information from low to high sensitivity networks with minimized covert channels.

KEYWORDS: Authentication, High Assurance

CENTER FOR INFORMATION SECURITY STUDIES AND RESEARCH (CISR) INFORMATION ASSURANCE SCHOLARSHIP PROGRAM, SUMMER 2002 INCREMENT
Cynthia E. Irvine, Professor
Department of Computer Science
Sponsor: National Security Agency

CRITICAL INFRASTRUCTURE PROTECTION ANALYSIS LABORATORY
Cynthia E. Irvine, Professor
Department of Computer Science
Sponsor: Department of the Navy Chief Information Officer

SUMMARY: The laboratory supported two courses in critical infrastructure protection. The Department of the Navy Chief Information Officer (CIO) funded the development of these courses.

KEYWORDS: Critical Infrastructure, CISR

CRITICAL INFRASTRUCTURE PROTECTION: AN INTERDISCIPLINARY COURSE
Cynthia E. Irvine, Professor
Department of Computer Science
Sponsor: Department of the Navy Chief Information Officer

SUMMARY: This research developed a class in critical infrastructure protection to be taught at the Naval Postgraduate School and an Institute for Information Superiority and Innovation course. The objective was to create an interdisciplinary class that permits students from a variety of curricula to participate in an effort to solve challenges in critical infrastructure protection by addressing real problems and hypothetical incidents.

KEYWORDS: Critical Infrastructure, Information Superiority and Innovation

CRITICAL INFRASTRUCTURE PROTECTION: AN INTERDISCIPLINARY SECRET LEVEL COURSE
Cynthia E. Irvine, Professor
Department of Computer Science
Sponsor: Department of the Navy Chief Information Officer

SUMMARY: This research developed a class in critical infrastructure protection to be taught at the Naval Postgraduate School. The objective was to create a secret level interdisciplinary class that permits students from a variety of curricula to participate in an effort to solve challenges in critical infrastructure protection by addressing real problems and hypothetical incidents. This course built on existing material developed in the spring and summer.

KEYWORDS: Critical Infrastructure, Interdisciplinary

FEDERAL AVIATION ADMINISTRATION (FAA) ANALYSES: BIOMETRICS, ANALYSIS OF TRUSTWORTHY SYSTEMS, AND DIGITAL INTEGRITY
Cynthia E. Irvine, Professor
Department of Computer Science
Sponsor: Federal Aviation Administration

SUMMARY: The objective of this research was to investigate three areas: biometrics as they might be applied to the continuous authentication of pilots, analysis of the composition of trustworthy systems from untrustworthy components, and digital integrity.

COMPUTER SCIENCE

KEYWORDS: Biometrics, FAA, Trustworthy Systems, Digital Integrity

MONTEREY SECURITY ENHANCED ARCHITECTURE (MYSEA)
Cynthia E. Irvine, Professor
Department of Computer Science
Sponsor: Defense Advanced Research Projects Agency

SUMMARY: The objective of this research was to develop high assurance security services and integrated operating system mechanisms that will protect distributed multi-domain computing environments from malicious code and other attacks. These security services and mechanisms will extend and interoperate with existing applications and open source operating systems, providing new capabilities for composing secure distributed systems using commercial, off-the-shelf components.

KEYWORDS: High Assurance, Distributed, Multi-Domain Computing, Malicious Code

NAVAL POSTGRADUATE SCHOOL SCHOLARSHIP FOR SERVICE: SCHOLARSHIP TRACK
Cynthia E. Irvine, Professor
Department of Computer Science
Sponsor: National Science Foundation

OBJECTIVE: The objective of this project was to provide master's level education in the science and practice of Information Assurance to selected students who would subsequently be available and obligated to perform two years of federal service in the same field.

SUMMARY: Students with undergraduate computer science degrees were placed into a specially designed, two-year, computer security track within the Center for Information System Security Studies and Research at the Naval Postgraduate School. This four-year Scholarship for Service program initiated a stream of ten students per year for the first three years, and will graduate the final set of ten students at the end of the fourth year.

Through courses involving extensive laboratory exercises and projects, student will learn how to design, build, configure, and manage systems and networks securely. During their two years of study, the program will provide students with a firm grounding in the foundations of computer science and the concepts and techniques for understanding modern information assurance.

The program is intended to have a significant effect toward filling the current personnel gap in Information Assurance for the national information infrastructure.

The first group of thirteen students matriculated in January 2002, a second group of eight students started classes in October 2002, and a third group of students matriculated in April 2003.

Of the first group of students, all have graduated and all have been employed or have firm job offers in the federal sector.

PUBLICATION:

Fulp, J.D., "Training the Cyber-Warrior. Security Education and Critical Infrastructures," C. Irvine and H. Armstrong (Eds.), Norwell, MA: Kluwer Academic Publishers, pp. 261-273, 2003.

THESIS DIRECTED:

(Note these students were supported by the scholarship program. The theses listed below may also appear in reports related to other funded research projects.)

Bailey, C.F., "Analysis of Security Solutions in Large Enterprises," Master's Thesis, Naval Postgraduate School, June 2003.

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Carrillo, C.M., "Continuous Biometric Authentication for Authorized Aircraft Personnel: A Proposed Design," Master's Thesis, Naval Postgraduate School, June 2003.

Galante, V.J., "Feasibility of Automating FIWC Website Noncompliance Monitoring and Enforcement Activities," Master's Thesis, Naval Postgraduate School, June 2003.

Lack, L., "Using the Bootstrap Concept to Build an Adaptable and Compact Subversion Artifice," Master's Thesis, Naval Postgraduate School, June 2003.

Murray, J., "An Exfiltration Subversion Demonstration," Master's Thesis, Naval Postgraduate School, June 2003.

Nafaratte, L. and Valverde, L., "Secure Wireless Handoff," Master's Thesis, Naval Postgraduate School, June 2003.

Schoberg, P., "Secure Ground-Based Remote Recording and Archiving of Aircraft 'Black Box' Data," Master's Thesis, Naval Postgraduate School, June 2003.

Stauffer, N., "An Introduction to Certification and Accreditation for New Accreditors," Master's Thesis, Naval Postgraduate School, June 2003.

Stewart, D., "NetTop Configuration," Master's Thesis, Naval Postgraduate School, June 2003.

Ubyakhar, S., "Evaluation of Program Specification and Verification Systems," Master's Thesis, Naval Postgraduate School, June 2003.

Ziegenhagen, L., "Evaluating Configuration Management Tools for High Assurance Software Development Projects," Master's Thesis, Naval Postgraduate School, June 2003.

KEYWORDS: Computer Security, Information Assurance, Critical Infrastructure Protection

NAVY SYSTEM CERTIFIER PROGRAM – PHASE II
Cynthia E. Irvine, Professor
Department of Computer Science
Sponsor: Space and Naval Warfare Systems Command

SUMMARY: The objective of this research was to develop material to support a program to enhance the ability of individuals required to carry out the certification of Navy systems. This effort was a continuation of research started in fiscal year 2002 that resulted in introductory materials for the education of Navy certifiers. This work was intended to develop a series of modules to create a tiered Navy system certifier program that was in compliance with the requirements of National Training Standard for System Certifiers (NSTISSI) Number 4015, and addressed recent developments and standards associated with the certification.

KEYWORDS: NSTISSI 4015, Navy System, Certification

PROJECT CHALLENGE PROBLEMS
Cynthia E. Irvine, Professor
Department of Computer Science
Sponsor: Pacific Northwest National Lab

SUMMARY: The Center for Information Systems Security Studies and Research (CISR) undertook a collaborative project with Pacific Northwest National Laboratories through an intergovernmental service agreement. The project was of a classified nature and required both staff and facilities cleared at the

appropriate level.

KEYWORDS: CISR, Pacific Northwest National Lab

SECURITY-ENHANCED WINDOWS CE
Cynthia E. Irvine, Professor
Department of Computer Science
Sponsor: Microsoft

SEPARATION KERNEL PROTECTION PROFILE
Cynthia E. Irvine, Professor
Department of Computer Science
Sponsor: National Security Agency

SUMMARY: The objective of this research was to develop a high robustness common criteria protection profile for a target of evaluation (TOE) intended to enforce a separation policy at the evaluation-assurance level seven (EAL7). The analysis of the separation policy and the requirements for this category of TOEs provided the guidance required for the development of a high robustness separation kernel protection profile at EAL7.

KEYWORDS: EAL7, High Robustness, Common Criteria Protection

SIM SECURITY
Cynthia E. Irvine, Professor
Department of Computer Science
Sponsor: Center for Naval Education and Training

SUMMARY: The purpose of this research was to create a distance-learning lab to support hands-on learning, working with or without distance learning modules, focused on the subject of information assurance (IA).

KEYWORDS: SIM Security, IA

SIMSECURITY PROJECT ENHANCEMENTS
Cynthia E. Irvine, Professor
Department of Computer Science
Sponsor: National Security Agency

SUMMARY: The purpose of this research was to enhance the creation of an education, training, and awareness tool using a resource management game as the vehicle. The tool constituted a virtual laboratory for experimentation with security mechanisms. A range of threats to computer and network security allowed users to understand the strengths and limitations of various approaches and fostered an appreciation of the difference between ad hoc mechanisms and those included as part of a prior design. Student participation in this project ensured its suitability for use in the Department of the Navy and the Department of Defense.

KEYWORDS: SIM Security, IA, Virtual Laboratory

COMPUTER SCIENCE

TRUSTED COMPUTING EXEMPLAR: DESIGN AND IMPLEMENTATION FOR HIGH ASSURANCE CONFIGURATION MANAGEMENT SYSTEM AND DEVELOPMENT TOOLS FRAMEWORK
Cynthia E. Irvine, Professor
Department of Computer Science
Sponsor: Office of Naval Research

SUMMARY: The Center for Information Security Studies and Research (CISR) in Monterey, California, was engaged in a novel approach to strengthen the national information infrastructure and reinvigorate the national capability to produce trustworthy computing systems.

KEYWORDS: CISR, Trusted Computing Exemplar

WIRELESS DATA COMMUNICATION NETWORK SECURITY ASSESSMENT METHODOLOGY
Major William C. James, USMC
Department of Computer Science
Sponsor: Space and Naval Warfare Systems Command - San Diego

SUMMARY: The objective of this research was to develop a methodology for conducting security assessments on Department of the Navy wireless data communication networks (WDCN).

KEYWORDS: Wireless Network, Security

FEDERATION SESSION MANAGEMENT PROTOCOL (FSMP)
LT George M. Lawler, USN
Department of Computer Science
Sponsor: Space and Naval Warfare Systems Command-San Diego

SUMMARY: Developed a session-layer network protocol that allowed CAPT Paul Young's fiomide to function as a distributed network application on top of the existing TCP/IP and internet hardware.

KEYWORDS: FSMP, Session-Layer Network Protocol

ENGINEERING AUTOMATION FOR RELIABLE SOFTWARE
Luqi, Professor
Department of Computer Science
Sponsor: U.S. Army Research Office

SUMMARY: This proposal addressed the problem of how to produce reliable software that is also flexible and cost effective for the Department of Defense distributed-software domain. Current and future DoD software systems fall into two categories: information systems and war fighter systems. Both can be distributed, heterogeneous, and network-based, consisting of a set of components running on different platforms and working together via multiple communication links and protocols. Researchers proposed tackling the problem with a "wrap and glue" technology that is based in a domain specific distributed prototype model. The key to making this approach reliable, flexible, and cost effective was the automatic generation of glue and wrappers based on the designer's specification. Glue and wrappers are the software that bridges the interoperability gap approach, including prototyping, automatic program generation, inference for design checking, reliability assessment, and reliability improvement.

KEYWORDS: Engineering Automation, Glue, Wrap, Domain-Specific Distributed

COMPUTER SCIENCE

ANALYSIS OF COMMAND STRUCTURES FOR AUTOMATED BATTLE MANAGEMENT

James Bret Michael, Associate Professor
Department of Computer Science
Dan C. Boger, Professor
Department of Information Sciences
Sponsor: Missile Defense Agency, Washington, D.C.

OBJECTIVE: The objective of this research was to develop a model of the command structure for global ballistic missile defense in order to derive requirements for automated battle management. An additional objective was to develop a class of decision processes that support the adaptation of war fighting doctrine, without requiring modification of the underlying architecture of the battle manager.

SUMMARY: Automated battle management for global missile defense is a new kind of warfare: it differs in many ways from that of theater and regional missile defense. As the threat missile speed and range have increased, there has been a corresponding need for quicker defensive decisions; that is, the time budgets for making such decisions have decreased. Current command and control (C2) for conventional forces is designed for large-scale movements of forces and large unit tactics and campaigns. Global missile defense, on the other hand, will have few movements, but require almost instantaneous decisions to allow the threat missile to be engaged on favorable terms. Using the time constraints established for missile defense in the joint thesis authored by CDR Michael H. Miklaski, USN, and CPT Joel D. Babbitt, USA, researchers tentatively concluded that C2 for missile defense needs to be "flattened" to accomplish its mission. This flattening requires a centralized C2 command that has partial operational control (OPCON) for missile defense units.

This work centered on the following:
- determining the decisions the battle managers are responsible for making, along with the time-budgets for these decisions
- investigating what information needs to be passed between battle managers at the strategic (i.e., global commander and its backups) level, tactical (i.e., AOR) level, and between levels
- determining how deliberate planning and consequence management can be integrated into missile defense—into the decision rules embodied in the battle management kernels.

Researchers treated everything outside of deliberate planning as execution (e.g., react by shooting); unlike conventional types of warfare, time was not available to complete crisis action planning during a missile attack due to little or no advance warning and the speed of engagement.

Researchers also planned to investigate the new requirement for C2 and real-time battle management across the combatant command's (COCOM) areas of responsibility (AORs). Previously, the battle space was confined to a single COCOM AOR. The ballistic missile defense problem is global and involves planning and execution with multiple COCOMs. In addition, researchers considered the impact of asynchronous threats from potential adversaries.

KEYWORDS: Command Structures, Automated Battle Management, OPCON

ARCHITECTURAL MODELING FOR DEPENDABILITY AND ADAPTABILITY REQUIREMENTS

James Bret Michael, Associate Professor
Valdis Berzins, Professor
Department of Computer Science
Sponsor: Missile Defense Agency, Washington, D.C.

OBJECTIVE: The goal of this research was to architect the automated battle manager so that the architecture will both "outlive" the peripheral components (e.g., weapons, C2, sensor systems) that interface with the battle manager and be flexible enough to support a wide spectrum of distributed control and fault-tolerance regimes. An additional objective was to investigate how to design the system to be verification-ready, that is, so that assurance arguments can be readily derived from the system requirements and their refinements in order to create dependability cases (similar to safety cases) for review by system certification and accreditation boards.

SUMMARY: Researchers developed an initial list of the desired capabilities and properties for battle managers. These were derived from the vision document and high-level Unified Modeling Language (UML) Use Cases for the Command, Control, Battle Management, and Communications (C2BMC) as specified in the thesis authored by Mr. Dale S. Caffall of the Missile Defense Agency (MDA). This work focused on the dependable and reconfigurable (to adapt to new or modified requirements) characteristics of the system.

Some key challenges were identified. The environment in which the C2BMC will operate is unpredictable, and thus difficult to model. This made it hard to obtain a sufficient set of system requirements from which to define, for instance, the safety properties and hazards for the system. System safety relies on predictability: there is a need to know what the system must guard against, so how does one handle emergent hazards? Adaptive systems can have many configurations that are hard to characterize. Each instance of a component has a different view of the system. Thus, the set of things in the environment is neither closed nor stable. It might be possible to create a sufficiently large closed world model to represent all of the system hazards, but even so, there will still be a challenge to specify the upper bound on the hazard probability, and to gain confidence that all relevant hazards have been identified.

Another class of challenges was directly related to the system architecture. The lifetime of the architecture must be longer than that of the components, due to changes in such things as the threat space, technology, and geopolitical alignments for defense purposes. Economic considerations were an integral factor too, as it is too costly for the U.S. and its allies in missile defense to repeatedly redevelop the Ballistic Missile Defense System (BMDS) from scratch. Dependability was of utmost importance because the configurable battle managers will be fully automated—this is counter to the traditional human-in-the-loop paradigm for executing a battle over the entire kill chain. In addition to the aforementioned issues, researchers investigated real-time liveness and interconnection (composition) properties of the system-of-systems (i.e., battle managers and peripheral components—the components that interface with the battle managers). The aim was to institutionalize the invariant part of the principles of operation of the battle manager (treated as an abstract component that was made concrete—as part of the configuration process—through generative techniques) and specification of contracts at component-interfaces to provide for hooking-up new components (variants) to the battle manager so that predicates on the behavior of the composed system can be checked.

KEYWORDS: Architectural Modeling, BMDS, UML, C2BMC

COMPUTATIONAL SUPPORT FOR TESTING AND EVALUATING COMPOSED HETEROGENEOUS DISTRIBUTED MISSILE SYSTEMS
James Bret Michael, Associate Professor
Department of Computer Science
Sponsor: Missile Defense Agency

SUMMARY: Supported the Missile Defense Agency (MDA) in identifying and evaluating alternative ways forward in both testing and evaluating the Ballistic Missile Defense System (BMDS).

KEYWORDS: Heterogeneous, Distributed, Missile, Computational Support

INFORMATION OPERATIONS: VULNERABILITY, TECHNICAL, AND RISK ASSESSMENTS TO ADVANCED ACTIVE NETWORK INTRUSION DETECTION TECHNOLOGIES AND SYSTEMS
James Bret Michael, Associate Professor
Department of Computer Science
Sponsor: Joint Information Operation Center

SUMMARY: Supported the Joint Information Operation Center by conducting information warfare vulnerability, technical, and risk assessments for the Active Network Intrusion Detection (ANID) program Advanced Concept Technology Demonstrations (ACTD).

INTELLIGENT SOFTWARE DECOYS
James Bret Michael, Associate Professor
Department of Computer Science
Sponsor: U.S. Department of Justice

SUMMARY: Some information systems are more critical to defend against malicious attack than others. Yet they often rely on the same countermeasures—firewalls, authentication, intrusion-detection systems, and encryption—even though politically motivated attackers may be far more determined than hackers to bring them down. Researchers should also look to ideas from military defensive tactics to defend critical information systems. In particular, researchers proposed to explore automatic embedding of deception in the form of intelligent software decoys to defend against attacks in information systems. Decoys will deceive attackers that do break into overestimating the effectiveness of their attacks, while at the same time protecting key assets, at least temporarily, and dissuading attackers from more vulnerable systems.

INTELLIGENT SOFTWARE DECOY TOOLS FOR CYBER COUNTERINTELLIGENCE AND SECURITY COUNTERMEASURES
James Bret Michael, Associate Professor
Department of Computer Science
Sponsor: U.S. Department of Justice

SUMMARY: The objective was to explore the use of deception, psychological operations, and other aspects of information operations as a means to conduct cyber counterintelligence and security countermeasures against technically savvy information warriors, with particular emphasis on attackers who are sponsored by nation-states, terrorist organizations, and criminal syndicates.

The first phase of research was funded by the Homeland Security (HLS) Research and Technology portion of the Naval Postgraduate School's HLS Leadership Program. In this phase, research began in the design of intelligent software decoys, including an integrated suite of software tools for creating and managing the decoys. The first prototype of intelligent software decoys for counterintelligence and countermeasures was completed and tested against a real-world attack program that is used to compromise FTP servers. Researchers reported some of the key results in a formal technical report to the sponsor, two Master's theses, and two papers submitted to the International Federation for Information Processing (IFIP) International Conference on Information Security. The next phase of research focused on completion of a representative set of case studies of intrusions and countermeasures. Researchers intended to complete the first draft of the high-level language for specifying intrusions and countermeasures and implement the first complete prototype of the tool that will automatically compile these specifications into executable code.

TEST AND EVALUATION OF THE BALLISTIC MISSILE DEFENSE SYSTEM
James Bret Michael, Associate Professor
Department of Computer Science
Center for Joint Services Electronic Warfare
Sponsor: Missile Defense Agency

OBJECTIVE: The objective was to propose and evaluate candidate architectures for the Command, Control, Battle Management, and Communications (C2BMC) component of the global Ballistic Missile Defense System (BMDS).

KEYWORDS: C2BMC, BMDS, Architecture

TESTING OF LARGE-SCALE SOFTWARE-INTENSIVE SYSTEMS
James Bret Michael, Associate Professor
Department of Computer Science
Sponsor: Space and Naval Warfare Systems Command

SUMMARY: Supported Space and Naval Warfare Systems Command in its oversight of the National Institute for Systems Test and Productivity (NISTP), researched topics related to the testing of large-scale software-intensive systems, and provided educational experiences to improve Space and Naval Warfare Systems Command's ability to oversee the NISTP.

KEYWORDS: NISTP, Large Scale Systems

DEVELOPING A VIRTUAL NETWORKING LABORATORY TO COMPLEMENT CLASSROOM INSTRUCTION OF COMPUTER NETWORK SECURITY AND VULNERABILITY ASSESSMENT TECHNIQUES
Major Joseph J. Petto, USMC
Department of Computer Science
Sponsor: Space and Naval Warfare Systems Command-San Diego

SUMMARY: This research scaled and improved upon a virtual networking laboratory prototype. The principal investigator worked with personnel from SPAWAR Systems Center (SSC SD) to develop and teach network defense training material for SSC SD assist visits. Instructing this material has highlighted the need for future work to provide students with the ability to practice the tools and techniques demonstrated in a safe environment. This would extend their learning experience beyond the one-week course and greatly increase the value of the coursework. This research and finished laboratory would ultimately become an integral part of a larger project: developing a service-wide distributed vulnerability assessment capability. Effective practical application is missing from all on-line coursework and this research attempted to provide this missing and critical piece.

DoD KEY TECHNOLOGY AREAS: Computing Software, Other (Information Operations)

KEYWORDS: Distance Learning, Network Security, Vulnerability Assessment, NMCI, Threat Assessment, Training, Information Assurance

EMBEDDING QUALITY FUNCTION DEPLOYMENT WITHIN THE COMPUTER-AIDED SOFTWARE-EVOLUTION MODEL
LTC Joseph Puett, USN
Department of Computer Science
Sponsor: Space and Naval Warfare Systems Command-San Diego

SUMMARY: Extended and improved the computer aided software evolution model by combining it with the quality function deployment process. Software developed with the new model was of higher quality, more reliable, and safer than software developed using the existing evolution model.

KEYWORDS: Computer-Aided Software, Software Evolution Model

COMPUTER SCIENCE

DEFENSE COLLABORATION TOOLS SUITE (DCTS) ASSESSMENT FOR CINC-21 (COMMMANDER-IN-CHIEF, 21ST CENTURY)
William J. Ray, Professor
Department of Computer Science
Sponsor: Joint Information Operation Center

SUMMARY: The Naval Postgraduate School installed the Defense Collaboration Tools Suite (DCTS) in the Software Engineering Automation Center to support distance-learning students. These students resided at multiple Department of Defense locations, including Space and Naval Warfare Systems Command Systems Center and the Tank-Automotive and Armaments Command (TACOM). Research was performed into security issues related to operating the DCTS across firewall configuration and virtual private network (VPN) implementations.

KEYWORDS: DCTS, Distance Learning, Security, Virtual Private Network, VPN

ESTABLISH AND MAINTAIN SOFTWARE ENGINEERING TEST LAB (SETL)
William J. Ray, Professor
Department of Computer Science
Sponsor: Joint Information Operation Center

SUMMARY: Established a lab for the purpose of stress testing real Department of Defense (DoD) systems with an emphasis on a holistic approach. The systems were made available through a separate internet service provider (ISP) than the Naval Postgraduate School's . The separate ISP enabled the testing of different access configurations and allowed for outside entities to red team the systems. This lab will be used to evaluate multiple different DoD systems over the years. Four full-time NPS students will work in the lab over the next three years. NPS will install systems selected by the Joint Information Operation Center (JIOC) in the Software Engineering Test Lab (SETL), install test hardware/software, maintain systems, evaluate systems capability and usability in different deployment paradigms, and evaluate security and safety vulnerabilities. NPS will provide lab space, lab manager, and network connectivity. The funding for the proposal will come in increments.

KEYWORDS: SETL, JOIC, System Stress, Evaluate Systems

FIRE PLAN SKETCH MANAGER FOR C2PC (COMMAND AND CONTROL PERSONAL COMPUTER) SOFTWARE PROJECT PLAN
Richard Riehle, Visiting Professor
Department of Computer Science
Sponsor: U.S. Marine Corps–Marine Corps Systems Command

BEHAVIORAL MODELING FOR BATTLE MANAGEMENT TIMING REQUIREMENTS
Man-Tak Shing, Associate Professor
Doron Drusinsky, Associate Professor
Department of Computer Science

OBJECTIVES: The goal of this research was to develop behavioral, structural, and simulation models of battle management, sensor netting, and weapons netting functions in order to analyze the timing constraints and derive system requirements for conducting automated battle management throughout the kill chain. An additional objective was to demonstrate "armor plating" Unified Modeling Language (UML) (State chart and UML-RT) models of Command, Control, Battle Management, and Communications (C2BMC) with temporal logic assertions that can be checked by some combination of internal and external verification mechanisms.

COMPUTER SCIENCE

SUMMARY: This modeling effort was challenging because the Ballistic Missile Defense System (BMDS) is a system-of-systems and must be highly dependable: very little is known about how to model and reasoning about such systems. In addition, feasible requirements for large dynamic systems are difficult to formulate, understand, and meet without extensive prototyping. Modeling and simulation holds the key to the rapid construction and evaluation of prototypes early in the development process. Researchers adopted an iterative process for studying the timing constraints of the missile defense system using models expressed in UML for Real-Time extension (UML-RT), which were then translated into coarse-grained simulation models that were exercised using the OMNeT++ simulation engine. The process started with Use Case analysis to identify user needs along the kill chain—defined as high-level system capabilities. Based on the use cases, an object-oriented distributed architecture of the system was developed using UML-RT. The internal structures of the component systems were refined, using the hierarchy plus input, process, output (HIPO) technique until components were readily mapped to modules of the target simulation written in OMNeT++. The architecture model was then translated into an OMNeT++ simulation model for test and evaluation. The integration of the UML-RT models with simulation models provided a seam less process for rapidly constructing executable prototypes for the purpose of analyzing timing constraints and deriving system requirements from those constraints. Through the Use Case-Model-Simulation feedback cycle, researchers identified potential bottlenecks in the architecture design, which led to redesign of some of its components.

In addition, techniques were studied to improve the dependability of C2BMC by armor-plating the specification using temporal logic and TLChart. TLChart is a hybrid visual specification language that combines the visual and intuitive appeal of non-deterministic Harel Statecharts with formal specifications written in Linear-time (Metric) Temporal Logic. Harel Statecharts are commonly used in the design analysis phase of an object-oriented UML-based design methodology to specify the dynamic behavior of complex reactive systems. While Harel Statecharts can effectively specify what a system should do (positive information), they tend to be less effective for the specification of safety requirements (i.e., negative information about what a system must not do). TLCharts offer an opportunity for armor-plating specifications using over-specification, namely by adding temporal conditions to an otherwise fully specified design. The inclusion of safety requirements in design specifications helped highlight what the system must not do, which if overlooked, will lead to unsafe operation of the software. Armor plating was investigated on three levels: i) armor-plating of Statecharts with temporal logic assertions, ii) armor plating using TLCharts, and iii) armor plating of interfaces in the OMNeT++ simulation model with temporal logic assertions pertaining to temporal rules for component interfaces. Note that the third item was directly linked to the reconfigurable nature of the overall research because assertions on component interfaces were key to a correct and predictable operation of the envisioned reconfigurable system.

KEYWORDS: Sensor Netting, Weapons Netting, BMDS, TLChart, Harel Statechart, Linear-time Temporal Logic, OMNeT++

BORDER GATEWAY PROTOCOL (BGP) ANOMALY DETECTION AND STRESS TESTING

Geoffrey G. Xie, Assistant Professor
Department of Computer Science
Sponsor: National Security Agency

SUMMARY: The internet BGP-4 inter-domain routing infrastructure is essential to the correct and efficient operation of the internet and the hosts attached to it. However, the understanding of BGP lags far behind that of the intra-domain routing protocols such as RIP or OSPF. To address this problem, the National Security Agency (NSA) requested further study of BGP. Two topics were emphasized. The first was anomaly detection, whose objective is to determine how efficient the current statistical and heuristic methods are for detecting malicious BGP route injection or route-based denial of service attacks. The results must be based on an evaluation of the accuracy of these methods' underlying mathematical models for predicting the overall "health" of the internet BGP routing infrastructure. The second was stress testing, where the objective is to develop robust and effective test suites than can exercise large code coverage of current commercial and experimental BGP-4 implementations. This proposal described a research agenda that achieved both objectives.

KEYWORDS: BGP-4, Anomaly Detection, Stress Testing

FACULTY SUPPORT FOR RESEARCH ON NETWORK TRAFFIC ENGINEERING
Geoffrey G. Xie, Assistant Professor
Department of Computer Science
Sponsor: Space and Naval Warfare Systems Command-San Diego

OBJECTIVE: Support of supervision of Ph.D. student in San Diego for distance learning in software engineering, traffic engineering.

KEYWORDS: Traffic Engineering, Network Management

A NETWORKING PROTOCOL FOR UNDERWATER ACOUSTIC NETWORKS
Geoffrey G. Xie, Assistant Professor
Department of Computer Science
Sponsor: National Science Foundation

OBJECTIVE: Focus on protocol for mitigating the negative factor of large propagation delays in underwater environments.

KEYWORDS: Autonomous Control, Performance Evaluation, Protocol Analysis

DEPARTMENT OF COMPUTER SCIENCE

**2003
Faculty Publications
and Presentations**

COMPUTER SCIENCE

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Irvine, C. E., Levin, T., Nguyen, T., and Dinolt, G., "Trusted Computing Exemplar Project," *IEEE Symposium on Security and Privacy*, Oakland, CA, May 2003.

Kapolka, A., "The Extensible Run-Time Infrastructure (XRTI): An Emerging Middleware Platform for Interoperable Networked Virtual Environments," *Proceedings of the Lake Tahoe Workshop on Collaborative Virtual Reality and Visualization*, October 2003.

Zyda, M., "This Year in the MOVES Institute," *Proceedings of the 7th International Conference on Telecommunications ConTel 2003*, Zagreb, Croatia, pp. 37-38, 11-13 June 2003.

CONFERENCE PRESENTATIONS
(WITHOUT PAPER)

Brown, M., "Safety Certification Process," NOSSA Software Safety Summit, Dam Neck, VA, 1–3 April 2003.

Irvine, C., "Considering Lifecycle Subversion," Office of the Secretary of Defense Workshop on Multilevel Security, Alexandria, VA, 24 September 2003, (invited).

Irvine, C., "Current Research Supporting the FAA," Federal Aviation Administration (FAA) Information Technology (IT) Information Systems Security (ISS) R&D Workshop, 6 May 2003, (invited).

Irvine, C., "An Editor for Adaptive XML-Based Policy Management of IPsec," 19th Computer Security Applications Conference, Las Vegas, NV, 11 December 2003.

Irvine, C., "Monterey Security Architecture (MYSEA)," Office of the Secretary of Defense Workshop on Multilevel Security, Alexandria, VA, 25 September 2003, (invited).

Irvine, C., "NPS Information Assurance Research and Development," Department of Defense Information Assurance Research and Development Symposium, Alexandria, VA, 4 December 2003, (invited).

Irvine, C., "Subversion," National Security Agency, Fort Meade, MD, 17 June 2003, (invited).

Irvine, C., "Trusted Computing Exemplar," Information Assurance Task Force Forum, Columbia, MD, 20 March 2003, (invited).

Irvine, C. E. and Thompson, M., "Teaching Objectives of a Simulation Game for Computer Security," Informing Science and Information Technology Joint Conference, Pori, Finland, June 2003.

Loecher, M. and Darken, C., "Concurrent Estimation of Time-to-Failure and Effective Wear," 2003 Maintenance and Reliability Conference (MARCON).

McDowell, P., Kapolka, A., Capps, M., and Zyda, M., "Game Engines for Use in Context Aware Research," 2003 UBICOMP Conference, Gothenburg, Sweden, 29 September - 1 October 2003.

Ubhayaka, S., Bibighaus, D., Dinolt, G., and Levin, T., "Evaluation of Program Specification and Verification Tools for High Assurance Development," International Workshop on Requirements for High Assurance Systems, IEEE International Requirements Engineering Conference, Monterey, CA, 9 September 2003.

CONTRIBUTION TO BOOKS

Davis, M., Shilling, R., Mayberry, A., McCree, J., Bossant, P., Dossett, S., et al., "Researching America's Army," *Design Research: Methods and Perspectives,* B. Laurel (Ed.), MIT Press, pp. 268-275, 1 October 2003, (ISBN 0262122634).

Denning, D. E., "Cyber Security as an Emergent Infrastructure," *Bombs and Bandwidth: The Emerging Relationship between IT and Security*, R. Latham (Ed.), The New Press, 2003.

Denning, D. E., "Information Technology and Security," *Grave New World: Global Dangers in the 21st Century,* M. Brown (Ed.), Georgetown Press, 2003.

Denning, P. J., "The Somatic Engineer," *Being Human at Work*, Chapter 12, R. S. Heckler (Ed.), North Atlantic Books, 2003.

Michael, J. B., Fragkos, G., and Auguston, M., "An Experiment in Software Decoy Design: Intrusion Detection and Countermeasures via System Call Instrumentation," *Security and Privacy in the Age of Uncertainty*, D. Gritzalis, S.D.C. di Vimercati, P. Samarati, and S. Katsikas (Eds.), Norwell, MA: Kluwer Academic Publishers, pp. 253-264, 2003.

Michael, J. B. and Wingfield, T. C, "Lawful Cyber Decoy Policy," *Security and Privacy in the Age of Uncertainty*, D. Gritzalis, S.D.C. di Vimercati, P. Samarati, and S. Katsikas (Eds.), Norwell, MA: Kluwer Academic Publishers, pp. 483-488, 2003.

Rasmussen, C., Irvine, C.E., Dinolt, G., Levin, T., and Burke, K., "A Program for Education in Certification and Accreditation," *Security Education and Critical Infrastructures*, C. Irvine and H. Armstrong (Eds.), Norwell, MA: Kluwer Academic Publishers, pp. 131-149, 2003.

Zyda, M., et al., "An Assessment of NASA's Pioneering Revolutionary Technology Program," *Committee for the Review of NASA's Pioneering Revolutionary Technology (PRT) Program, Aeronautics and Space Engineering Board, Division on Engineering and Physical Sciences, National Research Council*, Washington, D.C.: National Academy Press, 189 pages, October 2003, (ISBN 0-309-09080-6).

TECHNICAL REPORTS

Caffall, D. S. and Michael, J. B., "Developing Highly Predictable System Behavior in Real-Time Battle-Management Software," Naval Postgraduate School Technical Report, NPS-CS-03-006, 29 September 2003.

Clark, P., Levin, T., and Irvine, C., "Execution Policies Research and Implementation," Naval Postgraduate School Technical Report, NPS-CS-03-003, February 2003.

Luqi, "Engineering Automation for Reliable Software, Final Progress Report (10/01/1999- 09/30/2003)," Naval Postgraduate School Technical Report, NPS-SW-03-002, September 2003.

Luqi, "Impacts of ARO/NPS Software Engineering Research," Naval Postgraduate School Technical Report, NPS-SW-02-001, July 2003.

Michael, J. B., Bossuyt, B. J., and Snyder, B. B., "Testing, Verifying, and Validating Critical Real-Time Vehicle Control Software," Report 2003-C1, California PATH Program, University of California, Berkeley, CA, March 2003.

Michael, J., Pace, P., Shing, M.-T., Tummala, M., Babbitt, J., Miklaski, M., et al., "Test and Evaluation of the Ballistic Missile Defense System: FY03 Progress Report," Naval Postgraduate School Technical Report, NPS-CS-03-007, 30 September 2003.

Nguyen, T. D. and Levin, T.E., "Policy Enforced Remote Login," Naval Postgraduate School Technical Report, NPS-CS-03-004, February 2003.

BOOKS

Irvine, C. and Armstrong, H. (Eds.), *Security Education and Critical Infrastructures*, Norwell, MA: Kluwer Academic Publishers, 2003.

Otani, T. W., *Introduction to Object-Oriented Programming with Java, 3rd edition*, New York: McGraw-Hill, 2003.

PATENT

Wyse, L. and Singh, G., "Method for Text-Labeling Sound Effects," U.S. Patent PCT/SG 99/00010, 31 October 2003.

DEPARTMENT OF DEFENSE ANALYSIS

GORDON MCCORMICK
CHAIR

DEFENSE ANALYSIS

OVERVIEW:

The Department of Defense Analysis is an interdisciplinary program, drawing on a wide range of academic specialties. The program provides a focused course of instruction on the dynamics of asymmetric warfare, sub-state conflict, terrorism, information operations, and other "high leverage" operations in U.S. defense and foreign policy. The core program also provides every student with a strong background in strategic analysis, international relations and comparative politics, organization theory, and formal analytical methods.

CURRICULUM SERVED:

- Special Operations

DEGREE GRANTED:

- Master of Science in Defense Analysis

RESEARCH THRUSTS:

- Special Operations
- Asymmetric Warfare
- Sub-State Conflict
- Terrorism
- Information Operations
- Defense and Foreign Policy

RESEARCH CENTERS:

- Center on Terrorism and Irregular Warfare

SPONSORED PROGRAM (Research and Academic)-FY2003:

The Naval Postgraduate School's sponsored program exceeded $71 million in FY2003. Sponsored programs include both research and educational activities funded from an external source. A profile of the sponsored program of the Department of Defense Analysis is provided below:
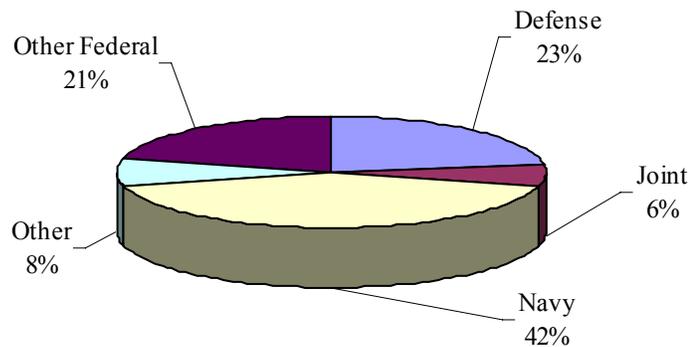
Size of Program: **$630K**

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CONCEPTS FOR DECISION SUPPORT TO AID THE DEVELOPMENT AND ADAPTATION OF COUNTERTERRORIST STRATEGIES
John Arquilla, Associate Professor
Department of Defense Analysis
Sponsor: Rand Corporation

SUMMARY: Developed concepts and methods for characterizing adversaries in such a way that alternative characterizations (qualitative models) could be used to stimulate high-level dialog that would inform development and later adaptation of U.S. counter-terrorism strategies. The purpose of this subcontract was to provide material assistance to that effort.

KEYWORDS: Counterterrorism, Strategy, Decision Support

DECEIVING TERRORISTS
John Arquilla, Associate Professor
Department of Defense Analysis
Sponsor: Office of the Secretary of Defense

SUMMARY: Identified and analyzed historical cases where deception was used against terrorists. Selected options suggested by these cases that were applicable to the current terror war.

KEYWORDS: Deception, Counterterrorism

RESEARCH AND ANALYSIS OF TERRORIST INFORMATION OPERATIONS (RATIO): PHASE
John Arquilla, Associate Professor
Department of Defense Analysis
Sponsor: Joint Special Operations Command

SUMMARY: The information revolution has already had profound effects on commerce and military affairs, and may transform or energize terrorism in the coming years. It is thus necessary that those who must defend against or counter acts of terror begin a process of assessing trends in terrorist usage of advanced information technologies, and identifying the ways in which terrorists might employ information operations and computer network attack tools.

KEYWORDS: RATIO, Terrorist Information Operations

LITHUANIA 5TH QUARTER PHASE I/II
LCDR Kimberley A. Marshall, USN
Defense Health Management
Sponsor: Defense Security Cooperation Agency

PORTUGAL PHASE II CONTINENTAL UNITED STATES
MOBILE EDUCATION TEAM (MET)
LCDR Kimberley A. Marshall, USN
Defense Health Management
Sponsor: Defense Security Cooperation Agency

DEFENSE ANALYSIS

UKRAINE PHASE II (FMS) MET
LCDR Kimberley A. Marshall, USN
Defense Health Management
Sponsor: Defense Security Cooperation Agency

THE CHALLENGE OF UNCONVENTIONAL WARFARE
Hy S. Rothstein, Senior Lecturer
Department of Defense Analysis
Sponsor: Assistant Secretary of Defense / Special Operations-Low Intensity Conflict

OBJECTIVE: The study sought to determine why the United States seems to be unable to conduct unconventional warfare.

SUMMARY: The research report was divided into five parts.

Part 1 highlighted the period immediately after the 9/11 attacks and the president's decision on how to respond. The report explored why the Department of Defense (DoD), with all its capabilities, was unable to present a satisfactory course of action to the defense secretary and president, while the CIA, with significantly less capabilities than the DoD, was able to rapidly generate a plan and get operatives on the ground. Most interesting was that the CIA's plan could only work with DoD resources.

Part 2 addressed the historical development of Special-Operations forces (SOF) capabilities and why this development has adversely affected unconventional thinking within the DoD. This historical journey showed how SOF has developed into a hyper-conventional force at the expense of maintaining a sophisticated unconventional warfare capability.

Part 3 identified the conditions necessary to wage successful unconventional warfare. These conditions were derived from two theoretical frameworks—organizational theory (contingency theory in particular) and processes of innovation.

Part 4 explained the conditions outlined in Part Three, above, and related these conditions to the war in Afghanistan. Data on Afghanistan was obtained from open sources; personal observations from two, three-week research trips to Afghanistan and Qatar; detailed interviews with senior commanders, both SOF and conventional; and interviews with Special Forces Operational Detachment (SFOD)-A/B/C members. Classified data was reviewed but not included in the report.

Part 5 drew conclusions based on the study findings. It also offered recommendations to better exploit the unconventional potential of SOF.

PRESENTATION:

Results presented to the office of the Assistant Secretary of Defense / Special Operations-Low Intensity Conflict on 24 February 2004.

KEYWORDS: Unconventional Warfare, Lithuania, Portugal Ukraine, SOF

THE MILITARY OFFICER IN 2030
Anna Simons, Associate Professor
Department of Defense Analysis
Sponsors: Office of the Secretary of Defense, Office of Net Assessment

OBJECTIVE: The objective of this research was to explore what might change the desired or required characteristics of the future officer corps in 20 to 30 years.

SUMMARY: In order to prepare for a 2003 Summer Study project to be held at the Naval War College (Newport, Rhode Island, July 13-23), Anna Simons organized and held a one-day meeting with the principle members of the study group. The group convened in Washington, D.C., to discuss the summer

study. The research funding covered transportation costs, per diems, and honoraria for the participants at this session. The Summer Study itself was completed as scheduled.

PUBLICATION:

Final report summarizing the study's findings, bound and distributed by the Office of Net Assessment, 105 pages.

PRESENTATION:

"Summer Study," Newport, Rhode Island, 23 July 2003, and Washington, D.C., 17 October 2003.

KEYWORDS: Officers, Leadership, Adaptability

CASE STUDIES FOR THE FUTURE
David Tucker, Associate Professor
Hy S. Rothstein, Senior Lecturer
Department of Defense Analysis
Sponsor: Joint Special Operations Command

SUMMARY: Assisted in the development of operational concepts for special operations forces that can be tested in exercises.

KEYWORDS: Special Operations, Operational Concepts

SOFTWARE TO SUPPORT ONLINE LEARNING: VIRTUAL CHARACTERS FOR SCENARIO-BASED SIMULATIONS
David Tucker, Associate Professor
Department of Defense Analysis
Sponsor: U.S. Department of Justice

SUMMARY: This effort developed a virtual character that motivates students to learn and increase their mastery of course content. Online education is critical to the success of any educational program in homeland security since the key audience for this education is employed full-time and can only undertake education if a significant portion of it is done online. Experience shows, however, that keeping students engaged with online education is difficult and a serious obstacle to the success of these programs.

The purpose of the research was two-fold. First, it produced a virtual character for students to interact with during a homeland security (HLS) online course. The purpose of using the character was to make time online interesting enough to motivate students to do the coursework and challenging enough to increase their mastery of the subject matter. Second, this research produced a report that compares the students' online experience during this HLS course with other comparable online courses that do not use a virtual character to see of the virtual character helped motivate students to do their online work and master the course material. Assessment data included student evaluations and data gathered by the software that runs the virtual character and the online environment. The report also included suggestions for improving the online virtual character and its use in the students' educational experience, as well as suggestions for additional use for virtual characters in the Homeland Security program (e.g., specialized training, simulations, and exercises).

KEYWORDS: Online Learning, HLS, Scenario-Based Simulation

DEPARTMENT OF INFORMATION SCIENCE

DAN BOGER
CHAIR

INFORMATION SCIENCE

OVERVIEW:

The Information Science (IS) Department is an interdisciplinary association of faculty interested in problems associated with defense information systems, command, control and communications, and information warfare/operations.

CURRICULA SERVED:

- Information Systems Technology
- Information Systems and Operations
- Joint Command, Control, Communications, Computers and Intelligence Systems
- Information Systems Technology
- Information Warfare
- Electronic Warfare Systems International

DEGREES GRANTED:

- Master of Science in Information Systems and Operations
- Master of Science in Information Technology Management
- Master of Science in Systems Engineering
- Master of Science in Systems Technology

RESEARCH THRUSTS:

- Software Metrics and Maintenance
- IT Architectures
- Computer Networks
- Decision Support Systems
- Knowledge Management
- Information Warfare
- Information Superiority
- Information Operations
- Command and Control
- Modeling and Analysis of Military Systems
- Combat Identification
- Human Systems Interface
- Threat Analysis

RESEARCH FACILITIES:

Systems Technology Laboratories (STL): The Naval Postgraduate School Systems Technology Laboratories provide centrally managed, supported, and funded facilities where students and faculty can conduct research and instruction using tomorrow's C4I systems technologies today. The facilities provide for classified and unclassified capabilities for students and faculty to use for immediate classroom reinforcement, student projects, and theses and for faculty and students to conduct leading edge research in their fields. The labs, through advanced telecommunications and networking, allow local platforms of various types to communicate at very high data rates with each other over the Naval Postgraduate School backbone and with other national laboratories and research facilities worldwide using Internet, SIPRNET, and ATM networks, such as the Defense Advanced Research Projects Agency (DARPA) Leading Edge Services ATM network, the California Research and Education Net (CALREN), Defense Research and Evaluation Net (DREN), and other wideband wide area networks that define the nation's information

infrastructure. Using these capabilities, researchers can collaborate with leading researchers and can participate in systems technology research efforts of national prominence.

The Naval Postgraduate School Systems Technology Laboratories contain (or have distributed access to) actual command and control systems for exercises and experiments. The prime example of this is a fully functional CINC version of the Global Command and Control Systems (GCCS) with SECRET interconnectivity to all CINCs and supporting sites. GCCS permits CINCs to complete crisis action plans including assessment, evaluation, and development of options, as well as selection, dissemination and monitoring of execution. The STL routinely conducts experiments with humans in the loop. Operational teams of officer-students can be trained/tested-using wargames as stimuli and using data collection techniques to evaluate performance under varied, but controlled, conditions. Insights into requirements for new doctrine, training and other aspects of the joint environment may be identified that will speed the acceptance of new approaches to decision-making and training.

RESEARCH PROGRAM (Research and Academic)-FY2003:

The Naval Postgraduate School's sponsored program exceeded $71 million in FY2003. Sponsored programs include both research and educational activities funded from an external source. A profile of the sponsored program for the Department of Information Science is provided below.
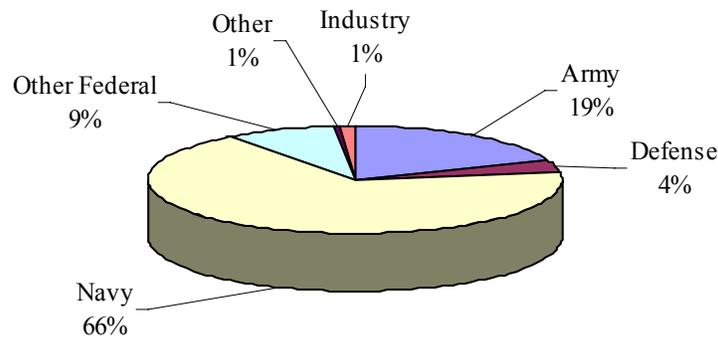
Size of Program: $2,988K

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INFORMATION SCIENCE

TERRAIN DATABASE GENERATION PRODUCT PUBLICATION
Wolfgang Baer, Research Associate Professor
Department of Information Science
Sponsor: U.S. Army TRADOC Analysis Command

SUMMARY: This proposal requested funding for the testing, documentation, and user delivery packaging of the Perspective View Nascent Technologies (PVNT) perspective view and database generation system. The effort moved the PVNT package from prototype research tool to an operational capability available for general use within the Department of Defense (DoD) and capable of being modified and/or maintained outside the academic research environment in which it was developed.

KEYWORDS: PVNT, Nascent Technologies, Database Generation

NETWORK DESIGN FOR QUANTUM KEY DISTRIBUTION IN A NAVY BATTLE GROUP
LT Tracy Black-Howell, USNR
Department of Information Science
Sponsor: Space and Naval Warfare Systems Command-San Diego

SUMMARY: Assuming quantum repeaters and all other necessary equipment were available today, a network would be required to implement quantum key distribution. The goal of this research was to determine how that network could be implemented in a battle group.

KEYWORDS: Quantum Key Distribution

CLASSIFIED SUPPORT OF NAVY FORCENET AND SEAPOWER 21 – COMBAT SATELLITE CONNECTIVITY
Dan C. Boger, Professor
Department of Information Science
Sponsor: Naval Security Group Command

E-SPACE PROGRAM STUDY
Dan C. Boger, Professor
Department of Information Science
Sponsor: National Security Agency

OBJECTIVE: The Electronic-Space (E-Space) program was a new information warfare initiative within the Department of Defense (DoD). The program manager requested Naval Postgraduate School thesis support to investigate desired follow-on capabilities in a post-Initial Operational Capability (IOC) for the E-Space architecture.

SUMMARY: This project identified critical factors required to fuse disparate databases in a multiple level security environment, using the E-Space project as a case study. Data fusion and data integration questions were addressed, specifically the combination, corroboration, deconfliction, and validation of information brought together for the purpose of providing a more accurate basis for decision making focused on electromagnetic warfare databases, broadly defined. Issues that are most problematic when developing a systems architecture that supports data or information fusion were identified and prioritized. Examples of problematic issues included data compatibility, data access, data validity, etc. Special emphases were given to identification and prioritization of issues peculiar to a multiple level security environment.

THESIS DIRECTED:

Overton, D. F. and Johnson, B. F., "Selection of a Conceptual Framework for Enterprise Information Integration (EII) in a Multiple Level Security Environment (Electromagnetic Space Analysis Center),"

Master's Thesis, Naval Postgraduate School, September 2003 (classified SCI).

KEYWORDS: E-Space, Data Fusion, Data Integration, Muliple-Layer Security

INTELLIGENCE VISUALIZATION AND ACTIVITY DATABASE SOFTWARE
Dan C. Boger, Professor
Department of Information Science
Sponsor: Orincon Defense

OBJECTIVE: The Naval Postgraduate School and Orincon Defense worked together to demonstrate the capabilities and advantages of intelligence visualization and activity database software.

SUMMARY: Orincon Defense provided the TIBCO BusinessFactor software application package for NPS evaluation and use. NPS researched how this commercial information system could be tailored to provide more relevant information for the user, specifically to allow a military intelligence professional the ability to conduct quality analysis (i.e., data mining) of operational intelligence (OPINTEL) data, culminating in the fusion of intelligence products and raw intelligence data. This commercial system will aid the user by reducing the amount of time required to collect, catalog, interpret, and fuse data from multiple sources. The proposed title of the thesis was "Advanced Database Visualization in Support of OPINTEL Research – ADVISOR. The intelligence application was to the Maritime Domain Awareness problem. Thesis students attended familiarization training on the TIBCO BusinessFactor software during 2003. This is a continuing project.

THESIS DIRECTED:

A thesis is in process and will be completed by June 2004.

KEYWORDS: Orincon Defense, BusinessFactor, OPINTEL, Data Mining

ADAPTIVE MANAGEMENT OF WIRELESS C4ISR NETWORKS
Alexander B. Bordetsky, Associate Professor
Department of Information Science
Sponsor: Aprisma Technologies

OBJECTIVE: The objective of this agreement was to determine the feasibility of implementing Aprisma technology to provide adaptive Quality of Service (QOS) and intrusion detection capabilities.

SUMMARY: Research efforts supported the command, control, communications, computers, and intelligence (C4I) research mission of the Naval Postgraduate School. Researchers knowledgeable in the development of C4ISR wireless networks were involved in this project. Tasks included evaluating the functionality of Aprisma's developed Spectrum and SpectroWatch to monitor and implement the rules of intrusion detection in the management of C4ISR networks as a potential commercial application of their contributing technologies.

KEYWORDS: Aprisma, Intrusion Detection, QOS

INFORMATION SCIENCE

EMERGENCY AND SURVEILLANCE NETWORK-CENTRIC HABITATS FOR HOMELAND DEFENSE

Alexander B. Bordetsky, Associate Professor
Department of Information Science
Sponsor: U.S. Department of Justice

OBJECTIVE: The objective of this research was to provide studies critical to Homeland Security (HLS) on how to integrate, deploy, and monitor collaborative networks designed for maintaining emergency site situational awareness and ubiquitous surveillance.

SUMMARY: The project addressed the challenges of civil-military situational awareness and interagency data fusion. This recognized and required cooperation between agencies is in the context of deploying a human-intelligent, agent-sensors habitat and a collaborative network capable of organizing surveillance, civil-military logistics, and tactical level requirements between agencies monitoring the emergency site events.

The approach was based on the capabilities of the emerging Global Information Grid, the Defense Advanced Research Projects Agency (DARPA) concept of Network-Centric habitats, collaborative technology tools recently adopted by HLS Office and Complex Humanitarian Emergency (CHE) Experimentation teams and, recently released DARPA Control of Agent-Based Systems (CoABS) multi-agent middleware.

The main results included a unique test bed environment and training scenarios that would allow military and civilian units to gain knowledge regarding:

1. How to establish the emergency site mobile network.
2. How to set up the biometric sensors and facial recognition surveillance environment.
3. How to set up collaboration across the ubiquitous surveillance network.
4. How to enable peer-to-peer collaboration, collaborative data mining and information fusion environments in a civil-military setting.
5. How to enable situational awareness and data sharing capabilities for the emergency site logistics, medical support, and Weapons of Mass Destruction (WMD) contamination effects monitoring.
6. How to provide ad hoc communication with legacy systems and HLS agencies via agent wrappers, facilitators, and other elements of the intelligent agent grid.

CONFERENCE PUBLICATION:

Bordetsky, A. B., Hutchins, S., Kemple, B., and Bourakov, E., "Network Awareness for Wireless Peer-to-Peer Collaborative Environments," *Proceedings of 37th Hawaii International Conference in Systems Sciences,* Big Island, HI, 2003.

THESES DIRECTED:

Barge, H., Davis, M., and Schwent, J., Jr., "Field Level Information Collaboration During Complex Humanitarian Emergencies and Peace Operations," Master's Thesis, Naval Postgraduate School, June 2003.

Bridges, D. M., Jr. and Mason, A. R., "Exploring of Wireless Technology to Provide Information Sharing Among Military, United Nations and Civilian Organizations During Complex Humanitarian Emergencies and Peacekeeping Operations," Master's Thesis, Naval Postgraduate School, March 2003.

Dennis, L. P., III and Ford, M., "The Wireless Ubiquitous Surveillance Testbed," Master's Thesis, Naval Postgraduate School, March 2003.

KEYWORDS: Network-Centric, Emergency Mobile Network, GIG, Ubiquitous Surveillance, Situational Awareness, Data Sharing, Biometric Sensor, Facial Recognition

FEEDBACK MECHANISMS FOR AGENT-BASED QUALITY OF SERVICE (QOS) ADAPTIVE MANAGEMENT OF NETWORKING RESOURCES
Alexander B. Bordetsky, Associate Professor
Department of Information Science
Sponsor: SBC

GIGA LAB TESTBED FOR COLLABORATION AND KNOWLEDGE MANAGEMENT PROGRAM
Alexander B. Bordetsky, Associate Professor
Department of Information Science
Sponsor: Office of Naval Research

OBJECTIVE: The objective of this research was to develop a distributed testbed environment for proof-of-concept experimentation with Collaboration and Knowledge Management projects.

SUMMARY: The project was performed jointly with the Naval Air Systems Command and the Massachusetts Institute of Technology (MIT). The testbed demonstrated the benefit of CKM collaboration products, derived from each project's empirical research, within the context of operational mission scenarios. The communication infrastructure of proposed distributed testbed should allow the CKM team to explore the collaborative aspects of operation:

- Focus on improved Team Communication/Problem Solving/SA Attainment/Decision Making
- Focus on the visualization of knowledge
- Use MIT EWALL for knowledge object manipulation and processing
- Focus on key aspects of team collaboration: knowledge base construction, interoperability of knowledge, individual situational understanding development, team situational awareness development, and consensus development
- Planned use of expanded NEO mission scenario for team collaboration exercises

THESIS DIRECTED:

Barge, H., Davis, M., and Schwent, J., Jr., "Field Level Information Collaboration During Complex Humanitarian Emergencies and Peace Operations," Master's Thesis, Naval Postgraduate School, June 2003.

KEYWORDS: Giga Lab, CKM Collaboration, Team Communication, SA Attainment, Decision Making, MIT EWALL

NAVAL POSTGRADUATE SCHOOL INTERNET 2 TESTBED
Alexander B. Bordetsky, Associate Professor
Department of Information Science
Sponsor: Foundry Networks, Inc.

OBJECTIVE: The goal of this research was to design and implement an Internet 2 Access and Experimentation testbed at the Naval Postgraduate School that will be able to support distributed agent-based simulations for Homeland Security, end-to-end IPv6 network performance, and broad range of multimedia-loaded distance learning activities.

SUMMARY: The required design and analysis tasks involved the implementation of the NPS Internet 2 testbed. More specifically, the NPS Giga Lab was connected with the NPS MOVES Institute (Modeling, Virtual Environments, and Simulation) lab and the combined network was connected to the Internet 2 backbone. Locally, the two labs participated in a variety of activities such as 3D situation awareness modeling and simulation tasks. Externally, the two labs accommodated distributed agent based simulations

for Homeland Security (simulated urban chemical-biological attack dispersion by using agents that simulate individual behavior) and distance learning activities.

The implementation of the network was based on specific building blocks (Foundry's switch/ routers) and it must support IPv6 activity. Moreover, the labs were involved in end-to-end IPv6 performance studies, so the network's management system must support such applications.

PUBLICATION: *NPS IT Strategic Plan*

KEYWORDS: Internet 2, Giga Lab, MOVES, agent-based simulation, IPv6

SURVEILLANCE TARGETING AND ACQUISITION NETWORK
Alexander B. Bordetsky, Associate Professor
Department of Information Science
Sponsor: JSOCOM, Center for Defense Technology and Education

OBJECTIVE: Explored the UAV-based multipath satellite-802.11 wireless networking system for collecting reconnaissance video data, monitoring the network behavior, and maintaining the shared situational awareness interface.

SUMMARY: The specific research tasks included:

1. Prototype the UAV-based data collection network on the floor of Giga Lab
2. Set up and tested the network management environment
3. Integrated the actual 802.11-Satellite wireless networking prototype using the UAV, mobile PDAs, and Network Management station on the ground
4. Set up distributed network operation and situational awareness (SA) control station
5. Programmed the data collection monitoring process in the situational awareness
6. Provided ubiquitous global positioning system (GPS) data posting to the Tactical Operations Center (TOC) Situational Awareness environment via integrated 802.11 and satellite link
7. Integrated the control screens for multiple video streams monitoring process
8. Captured the video streams and synchronized the observed networking events for analyzing the experimental results

THESES DIRECTED:

Corderovila, M., "Voice Over Internet Protocol (VOIP) Technology Migration to DSN in Support of Information and Decision Pre-Eminence to Network Centric Warfare," Master's Thesis, Naval Postgraduate School, March 2004.

Hagenston, M.G. and Chance, S.G., "Using a Semantic Web Application Employing Mobile Software Agents to Improve Military Operations," Master's Thesis, Naval Postgraduate School, June 2003.

Harp, B., "Shared Situational Awareness and METOC Data Collection via the Iridium Satellite System," Master's Thesis, Naval Postgraduate School, (to be completed in 2004).

Manuel, C., "Surveillance Target Acquisition Network for SOF Missions," Master's Thesis, Naval Postgraduate School, (to be completed in 2004).

Yu, Y.S., "OPNET/STK Integrated Environment for Modeling an UAV Network," Master's Thesis, Naval Postgraduate School, September 2003.

KEYWORDS: VOIP, UAV, 802.11, Multipath Satellite, Giga Lab, Data Collection

VIRTUAL AND PHYSICAL COMMAND CENTER PROJECT
Alexander B. Bordetsky, Associate Professor
Department of Information Science
Sponsor: Space and Naval Warfare Systems Command-San Diego

OBJECTIVE: The Virtual and Physical Command Center project (VPCC) is an Office of Naval Research (ONR)-sponsored effort managed by the Space and Naval Warfare Systems Center, San Diego (Space and Naval Warfare Systems Command SYSCEN, San Diego) Code 24121. The objective of this research was to explore the use of emerging peer-to-peer technology infrastructures in order to discover how they can significantly improve the collaborative planning and execution effectiveness of Navy personnel distributed among physical and virtual command centers. In the near future, war fighters will be distributed among traditional land-based (physical or geo-located) command centers, mobile (e.g., ship/submarine-board, or vehicle-based) command centers, and, more importantly, virtual command centers, which may have *no physical* counterpart.

SUMMARY: How these distributed war fighters interact and inform each other of mission planning progress and situation assessment, how they establish their battle rhythm, is open to conjecture. The current pressure to use software systems developed for business purposes (particularly collaboration software developed for the commercial community) in warfare settings may hamper the effective use of these evolving technologies. Understanding the promises and limitations of peer-to-peer computing and its impact on war fighter effectiveness in a heterogeneous command center environment is imperative.

VPCC will provide a system that will support the war fighter's knowledge requirements for a truly 21st century distributed, command and control environment that spans physical and virtual command centers, using knowledge-centric concepts to define the knowledge management processes that must be supported. Given a more efficient computing model, such as a peer-to-peer paradigm, the Navy after next will be able to exploit the right mix of physical (geo-located) and virtual command centers such that they are supported in their knowledge-centric war fighting activities. The Navy can then begin to exploit this unique asymmetrical advantage to attack the enemy in ways against which he cannot effectively defend. The scientific knowledge and technology developed in this project will support knowledge-centric operations, given effects-based mission objectives. With a network-centric force (collaborative, not hierarchical; interdependent, not stove-piped), participation in seamless collaboration for planning and execution across geographic, temporal, operational, and organizational boundaries can begin. In the first quarter of fiscal year 2003, initial research was completed on VPCC. The program plan was to continue to research and document battle rhythm management. As part of the FY03 research and development process, automated software agents in a peer-to-peer computing environment were developed, as was designed in the early FY03 research.

PUBLICATION:

Bordetsky, A.B., Bach, E., et al., "An Analysis of the Impact of Modern Collaborative Technology on Battle Rhythm at the Tactical Level," Final Report to Space and Naval Warfare Systems Command, 2003.

CONFERENCE PUBLICATION:

Bordetsky, A.B. and Statnikov, R., "Multiple Criteria Fan-Out Mechanism for Peer-to-Peer Collaborative Networking," *Proceedings of 11th International Conference in Telecommunication Systems*, Monterey, California, 2003.

THESIS DIRECTED:

Brzostowski, S. and Smith, L., "Transition of Naval Expeditionary Force's Tactical Mission Planning System to a Global Collaborative Capability," Master's Thesis, Naval Postgraduate School, September 2003.

KEYWORDS: VPCC, Virtual and Physical Command Center, Distributed War Fighter

WIRELESS MOBILE WEARABLE COMPUTING BASED COLLABORATION
Alexander B. Bordetsky, Associate Professor
Department of Information Science
Sponsor: Center for Defense Technology and Education

OBJECTIVE: The objective of this project was to develop software architectures to support wireless mobile collaboration among members of wearable computing group to enhance their effectiveness, productivity, and coordination.

SUMMARY: The study focused on the following tasks:

- Coordination mechanisms for wearable computing multipoint conferencing and data sharing tasks,
- Adaptation of the collaborative tools interface to the limitations of wearable computing mobile monitors,
- Client-server communication challenges between the command center and individual members of wearable computing geographically dispersed group,
- Peer-to-peer communication challenges among the members of geographically distributed wearable computing group,
- Interface models for viewing the multipoint decision support environments via the wearable gear,
- Productivity and speed-of-command implications of integrating wearable computing collaboration in civil-military operations.

THESES DIRECTED:

Fay, J., "Fleet Network Operations with Decision Support and Augmented Reality Technologies," Master's Thesis, Naval Postgraduate School., March 2004

Nasman, J., "Fusion of Augmented Reality and Collaborative Technologies to Support Fleet Aviation Maintenance," Master's Thesis, Naval Postgraduate School, March 2004.

KEYWORDS: Wireless Mobile Collaboration, Wearable Computing

TRANSITION OF NAVAL EXPEDITIONARY FORCES MISSION PLANNING SYSTEMS TOT GLOBAL COLLABORATIVE CAPABILITY
Major Stephen C. Brzostowski, USMC
Department of Information Science
Sponsor: Space and Naval Warfare Systems Command-San Diego

SUMMARY: This joint research project recommended the general design for low cost, interim, commercial, off-the-shelf, geographically dispersed, real-time collaborative mission-planning system. It also proposed the implementation process for this system to aide in the transformation of current Naval Expeditionary Force mission planning into a joint global real-time collaborative mission planning.

KEYWORDS: Collaborative Mission Planning, Naval Expeditionary Forces

ANALYSIS OF NAVY MUOS (MOBILE USER OBJECTIVE SYSTEM) NETWORKING REQUIREMENTS, PROTOCOLS, AND TECHNOLOGY
Rex A. Buddenberg, Senior Lecturer
Department of Information Science
Sponsor: Space and Naval Warfare Systems Command

SUMMARY: Evaluated and tested for internetworkability of MUOS segment within IT-21. Evaluated intra-network protocols for suitability to Navy use. Supported thesis research.

INFORMATION SCIENCE

DEVELOPMENT OF HIGH-FREQUENCY RADIO-WAN
Rex A. Buddenberg, Senior Lecturer
Department of Information Science
Sponsor: Office of Naval Research

SUMMARY: Developed extended line-of-sight radio-frequency (RF) communications system for maritime purposes. The RF aspects of this project were the primary area for Mr. Bob Rogers, Applied Research Laboratory, University of Texas (ARL:UT). Naval Postgraduate School issues were date framing, media access control, and interoperability with other IP networks.

KEYWORDS: High-Frequency Radio, WAN

SIGNALS INTELLIGENCE (SIGINT) SOFTWARE ARCHITECTURE STUDY
Rex A. Buddenberg, Senior Lecturer
Department of Information Science
Sponsor: National Security Agency

SUMMARY: Evaluated existing Signals Intelligence (SIGINT) software, analyzed portability issues. Supported thesis research.

KEYWORDS: SIGINT, Signals Intelligence

INFORMATION OPERATIONS SUPPORT FOR THE JOINT INFORMATION OPERATION CENTER (JIOC)
LCDR Raymond Buettner, USN, Military Faculty
Department of Information Science
Sponsor: Joint Information Operation Center

SUMMARY: Provided analysis and advice regarding Joint Information Operation Center (JIOC) support to the war fighter in the information operations domain.

KEYWORDS: JIOC, Information Operations

MODELING AND SIMULATION SUPPORT STUDY
Alexander J. Callahan, Jr., Research Assistant Professor
Department of Information Science
Sponsor: Naval Surface Warfare Center-Crane Division

SUMMARY: Provided analytical support for modeling and simulation study of U.S. Marine Corps organic artillery requirements.

KEYWORDS: Modeling and Simulation, M&S, Organic Artillery

INFORMATION SCIENCE

MULTI-MISSION MARITIME AIRCRAFT PROGRAM (MMA) MODELING AND SIMULATION SUPPORT

Alexander J. Callahan, Jr., Research Assistant Professor
Department of Information Science
Sponsor: Naval Air Warfare Center - Aircraft Division

SUMMARY: The research provided the Maritime Aircraft Program (MMA) Program Office an analysis environment to evaluate MMA alternatives. The work included developing changes and verification of Naval Simulation System and mission level scenarios. The study included operational and technical research involving model engine and database module effectiveness, verification of algorithm fidelity, and configuration management of the Naval Simulation System.

KEYWORDS: Maritime Aircraft, MMA Alternatives, Model Engine, Database Module, Configuration Managment

SEMANTICALLY ENABLED HABITAT FOR RAPID KNOWLEDGE CAPTURE, STORAGE, AND TRANSFER

LT Samuel G. Chance, USN
Department of Information Science
Sponsor: Space and Naval Warfare Systems Command-San Diego

SUMMARY: Established a semantically enabled environment to facilitate rapid knowledge capture, storage, transfer, and generation process using the Defense Advanced Research Projects Agency (DARPA) Agent Markup Language (DAML). The end-state was an ontology-governed domain that set the conditions for autonomous software agents to represent contextual information to the computer to operate.

KEYWORDS: Semantically Enabled Environment, DARPA, Agent Markup Language, DAML, Autonomous Software Agent

AN AGENT-BASED SIMULATION WAR GAME FOR BIO-TERRORIST ATTACKS

Daniel R. Dolk, Professor
Department of Information Science
Sponsor: U.S. Department of Justice

SUMMARY: The high-level objective of this research proposal was to implement an initial adaptation of measured response (MR) developed at Purdue University for use in the homeland security curriculum at the Naval Postgraduate School. This required that the current MR be scaled down from synchronous war game use to standalone use by individual players who were able to access the system via the web. The main features which the scaled down version of MR must support were as follows: 1) the effects of various times-to-intervention in terms of infection rates and fatality rates, 2) comparison of the effects of mass vaccination (MV) versus trace vaccination (TV) treatments, and 3) comparison of different epidemiological strategies.

KEYWORDS: Measured Response, MR, Purdue, Homeland Security, Synchronous War Game

EFFECTIVE VISUALIZATION FOR NAVAL CAREER INFORMATION SUMMARY AND EVALUATION

Daniel R. Dolk, Professor
Department of Information Science
Sponsors: NPC (PERS-3), Bureau of Navy Personnel

OBJECTIVE: The objectives of this project were to re-engineer the visual displays currently used by selection boards, detailers, and others career planners to determine the future promotion, advancement, and

assignment of Navy personnel, and to determine the relative effectiveness of these displays vis-à-vis the current presentations. This was accomplished largely by studying current visualization techniques for multi-criteria decision making models in concert with well established principles for the display of visual information as articulated by Professor Edward Tufte in his classic works in this area.

SUMMARY: The current Navy selection board voting process uses tabular forms displayed across five screens in a small theater-like setting. The forms are displayed very quickly, allowing board members very little time to mentally assimilate the quantitative data dispersed over a wide area. In this model, researchers distilled the source data into a single graphical display, thus reducing the cognitive computing requirements of the board members. The Knowledge Value Added methodology was used to determine the proposal's relative effectiveness and a prototype as a proof of concept was developed. With this study and follow on recommendations, researchers envisioned the potential for considerable improvement in the Navy's promotion board procedures and outcomes.

THESIS:

Grose, J. and Rogers, G., "Design of an Effective Visualization for Naval Career Information Summary and Evaluation," Master's Thesis, Naval Postgraduate School, September 2003.

DoD KEY TECHNOLOGY AREAS: Manpower, Human-Machine Interface

KEYWORDS: Visualization, Return on Information Investment

UNITED STATES ARMY ACCESSIONS COMMAND / UNITED STATES ARMY RECRUITING COMMAND STRATEGIC SIMULATION LEADERSHIP EXERCISE: PARALLEL WORLDS FOR ARMY RECRUITING
Daniel R. Dolk, Professor
Department of Information Science
Sponsor: U.S. Army Recruiting Command (via TRAC Monterey)

OBJECTIVE: The objectives of this phase of the project were the following:

(1) Refine and enhance the existing simulation system for use in a second Strategic Simulation Leadership Exercise (SSLE) to be held during the fourth quarter of 2003, and to include a full beta test run with USAREC as the major players during the second or third quarter of 2003. Additional features to be included in the SSLE are the ability to drill down to the company level of granularity, and to refine the mental categories of recruits to embrace three subcategories of Alpha level recruits as a way of addressing in a preliminary fashion the mission of recruiting the Objective Force soldier;
(2) Further integrate the operational-decision-support system (ODSS) with the USAREC data warehouse as the warehouse is expanded to store more information, and fielding of the ODSS;
(3) Delineate preliminary requirements for an ODSS to be used by USAAC.

SUMMARY: Two SSLE exercises were held at USAREC: a Management Staff Training exercise in March 2003 and a USAREC-wide SSLE in September 2003. The former exercise spurred a requirement for a scaled down version of the agent-based simulation to be used just for Staff Management purposes. The September SSLE is now a major component in USAREC's strategic planning process. This version of the exercise helped verify and validate the agent-based model at the Brigade levels. This exercise generated requirements for enhancement of the simulation, such as the addition of recruiter agents and the need to push the game down to the Brigade and Battalion levels, so that it can be played remotely as well as in a synchronous setting.

USAREC RECRUITING STRATEGIC VISION PROGRAM (RSVP) WARGAME: AN OPERATIONAL DECISION MAKING AGENT-BASED SIMULATION SYSTEM
Daniel R. Dolk, Professor
Department of Information Science
Sponsor: U.S. Army Recruiting Command (via TRAC-Monterey)

OBJECTIVE: This was the wrap-up of the third phase of the Recruiting Strategic Vision Program (RSVP) project for implementing strategic business war-gaming at the U.S. Army Recruiting Command (USAREC). The objective of this phase was to refine and enhance the existing recruiting market simulation so that it can be used by USAREC as an operational decision making tool to test the virtual effectiveness of various recruiting policies. The simulation system was able to support synchronous, multiplayer war games, one of which was played in FY2002, as well as asynchronous, single or multi player games via the web. The asynchronous version of the game will allow Recruiting Brigade Commanders and other players to access the game via the web and test drive various policies for meeting recruit mission for the year.

SUMMARY: Although a second full scale war game was scheduled for summer 2002, USAREC was not able to decide upon a date, and so this event was postponed until March 2003. At that time, a Management Staff Exercise was held for USAREC staff using the SEAS simulation. Results from this exercise drove the requirements for the overall command exercise in September 2003.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Agent-based Simulation, Business War Game

COMPUTER NETWORK ATTACK (CNA) METRICS OR BATTLE DAMAGE ASSESSMENT METHODOLOGY FOR COMPUTER NETWORK ATTACK
CPT William Eger, USA
Department of Information Science
Sponsor: Space and Naval Warfare Systems Command-San Diego

SUMMARY: The ability to provide Computer Network Attack (CNA) Battle Damage Assessment (BDA) will help reduce uncertainty and result in better decision making by the war fighters. This research sought to provide a foundation for the development and integration of effective CNA BDA information-warfare operations.

KEYWORDS: Agent-based Simulation, Business War Game, Information Warfare, Computer Network Attack

INFORMATION SCIENCE

**TRANSFORMING NETWORK OPERATIONS THROUGH COLLABORATIVE DECISION
SUPPORT AND AUGMENTED REALITY TECHNOLOGIES**

LT John F. Fay, USN
Department of Information Science
Sponsor: Space and Naval Warfare Systems Command-San Diego

SUMMARY: The objective of this research was to support ForceNet by creating an improved network operations model using collaborative decision support and augmented reality technologies. This model provided a method to improve network management through automated system recommendations, collaborative tools, and improved visualization of network performance.

KEYWORDS: ForceNet, Augmented Reality, Network Management

**FORCENET ANALYSIS SUPPORT FOR FORCENET INNOVATION AND RESEARCH
ENGINE (FIRE)**

Shelley P. Gallup, Research Associate Professor
Meyer Institute of Systems Engineering
Randy W. Maule, Research Associate Professor
Department of Information Science
Sponsor: Naval Network Warfare Command

SUMMARY: The Naval Postgraduate School's Meyer Institute of Systems Engineering (MI) proposed to populate an existing data warehouse with ForceNet data from the integrated prototype demonstration (IPD) for data mining, knowledge-based content management, and comprehensive IPD analysis and assessment. The technology built upon the current knowledge management system (KMS) hosted at NPS, which contains information from Fleet Battle Experiments, Limited Objective Experiments, USJFCOM experimentation, and other relevant network-centric warfare experimentation. This web-based data warehouse and initiative analysis system was an evolution and expansion of the current NPS KMS system and served as a gateway providing expanded warfare analysis and knowledge management capabilities for Naval Network Warfare Command (NETWARCOM).

KEYWORDS: NETWARCOM, Meyer Institute, ForceNet

STANDING JOINT FORCE HEADQUARTERS PROCESS MODELING

Shelley P. Gallup, Research Associate Professor
Meyer Institute of Systems Engineering
Susan G. Hutchins, Research Associate Professor
Department of Information Science
Sponsor: Joint Forces Command

OBJECTIVE: Standing Joint Force Headquarters (SJFHQ) processes were analyzed and modeled to capture emerging new processes with an emphasis on inter-agency and service/functional component interactions. Information on SJFHQ was documented at selected Regional Combatant Commands (RCC) and implemented in process models to be used in support of follow-on analyses for process and war fighting improvement.

SUMMARY: The SJFHQ Process Modeling effort involved an interdisciplinary team of researchers from command and control, systems engineering, systems analysis, operations research, human factors, physics and knowledge management domains, spanning three departments and one institute. This new effort for Joint Forces Command (JFCOM) involved capturing, modeling, and analyzing new processes that will be used by Standing Joint Force Headquarters. Per the direction of the Secretary of Defense, by FY05 each RCC will standup and employ a SJFHQ. The SJFHQ is part of the military's transformation: emphasis will be on using networked knowledge, an effects-based approach to planning and operations, and providing a coherently joint perspective to respond to the demanding challenges of today's operational environment.

INFORMATION SCIENCE

Information on SJFHQ was obtained during training events, and from other sources, to capture processes that emerge with an emphasis on inter-agency and service/functional component interactions. Process models consisted of paper models delineating the processes and information flows, and computer-based discrete event simulation models were exercised to show information flow timelines. Outputs of executable simulations were provided as inputs to discussion of SJFHQ requirements and end states.

DoD TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Standing Joint Force Headquarters, Process Models, Discrete-event Models, Collaborative Information Environment, Effects-based Operations, Military Transformation

SUPPORT FOR FORCENET EXPERIMENTATION PROGRAM
Shelley P. Gallup, Research Associate Professor
Meyer Institute of Systems Engineering
William G. Kemple, Associate Professor
Department of Information Science
Sponsor: Naval Air Systems Command

SUMMARY: This project provided experiment design, planning, analysis, and reporting expertise from the Meyer Institute of Systems Engineering (MI) and the Department of Information Science at the Naval Postgraduate School to the ForceNet experimentation continuum.

KEYWORDS: ForceNet, Meyer Institute

SEMANTICALLY ENABLED HABITAT FOR RAPID KNOWLEDGE, STORAGE, AND TRANSFER
CPT Marty F. Hagenston, USA
Department of Information Science
Sponsor: Space and Naval Warfare Systems Command-San Diego

SUMMARY: Established a semantically enabled environment to facilitate rapid knowledge capture storage, transfer, and generation process employing the Defense Advanced Research Project Agency's (DARPA) Agent Markup Language (DAML). The end state was an ontology-governed domain that set the conditions for autonomous software agents to represent contextual information to the computer.

KEYWORDS: DAML, Semantic, Autonomous Software

EMPLOYING COMMUNITY MODELS TO DELIVER VALUED INFORMATION AT THE RIGHT TIME (VIRT)
Rick Hayes-Roth, Professor
Department of Information Science
Sponsor: Naval Postgraduate School Research Initiation Grant

OBJECTIVE: Information superiority requires that decision-makers spend most of their available time considering and exploiting valuable information, but net-centric technologies have produced an information glut that degrades productivity. The goal of this project was to create a generic enterprise service (VIRT) that delivers valued information at the right time to each person and agent. This reduces the amount of time spent on low-value information, increases the time spent on high-value information, and significantly improves the productivity of war fighters.

SUMMARY: The scarcest resource in crisis situations is decision-maker time. Crises and war fighting depend on humans achieving high levels of performance at processing information and making best possible decisions. However, as net-centric technologies connect more people in ad hoc ways and reduce

barriers to communication, they exacerbate the experience of information glut, where people practically drown in excess information. In such a situation, humans and automated agents begin to "thrash," often focusing on low-value information or issues. To eliminate this problem, technology must be employed that assures people spend time on high-value information, information whose digestion and exploitation would materially improve outcomes. Researchers are working to create such technology. It understands how operator plans depend on assumed or forecast conditions. It knows which information sources can confirm or disconfirm those expectations. It monitors those sources for violations of expectations that might undercut plans and missions. It conveys just that information to planners and operators in time for them to reassess and perhaps re-plan their operations. It also filters information of low value, such as repetitive, redundant, and immaterial reports. In this way, it assures a significant increase in decision-making quality and productivity. As a consequence, VIRT will assuredly improve mission outcomes. This project was jointly undertaken with Fleet Numerical Meteorology and Oceanography Center (FNMOC).

DoD KEY TECHNOLOGY AREAS: Computing and Software, GIG and Enterprise Services, Net-centric Warfare, Information Superiority, Mission Planning and Execution

KEYWORDS: Information Superiority, Net-centric Warfare, GIG Services, Planning and Replanning, Community Models, VIRT, Smart Push

EXPEDITIONARY PERVASIVE SENSING PROGRAM
Douglas P. Horner, Research Associate Professor
Department of Information Science
Sponsor: Space and Naval Warfare Systems Command-San Diego

SUMMARY: The Naval Postgraduate School performed research and development of a prototype for advanced military planning and situational awareness to support the expeditionary pervasive sensing enabling experiments (EEE). The research continued from the previous year's Archangel Semantic Web (SWEB) work for military applications and focused on the use of Defense Advanced Research Projects Agency (DARPA) Control of Agent-Based Systems (CoABS), together with a Web Ontology Language (OWL)-based ontology knowledge base and inferencing rules to provide a web-based tool for automated and dynamic route planning.

KEYWORDS: Archangel, SWEB, Agent-Based Systems, OWL, Pervasive Sensing

TECHNICAL SUPPORT ON THE COMMAND AND CONTROL INTERFACE FOR THE EXPEDITIONARY SENSOR GRID (ESG) ENABLING EXPERIMENT PROGRAM
Douglas P. Horner, Research Associate Professor
Department of Information Science
Sponsor: Office of Naval Research

SUMMARY: The purpose of the research was to investigate the command-and-control (C2) interface for the Expeditionary Sensor Grid (ESG) Enabling Experiments (EEE). The experiments were designed to test hypotheses regarding the use of agent-based architectures to support sensor management. The C2 interface is the tool that allows the user to create and monitor agents tasked with specific objectives, monitor the performance of the grid network and receive, display, and analyze information received from the agent network. This work investigated requirements for the interface and investigated existing potential governmental off-the-shelf (GOTS) and commercial off-the-shelf (COTS) solutions.

KEYWORDS: ESG, Sensor Management, C2, Expeditionary Sensor Grid

EMAIL REDUCTION STUDY
Tom Housel, Professor
Department of Information Science
Sponsor: Department of the Navy Chief Information Officer
(Information Professional Working Group)

OBJECTIVE: The intent of this project was to test web-based collaborative and filtering technologies that: 1) increase productivity, demonstrating a favorable cost-benefit to the Department of the Navy (DoN), 2) contribute to reducing the effects of information overload on users due to high volumes of electronic mail, and 3) demonstrate a capability which may be scaled to address this problem within the Naval enterprise.

SUMMARY: The research focused on increasing productivity in the Naval enterprise through the use of collaborative and other web-based technologies to enable more efficient and effective information management. Email overload is a symptom of unproductive information management. A proof of concept trial was conducted at Fleet Numerical in Monterey, California, using Oracle collaborative suite capabilities. The capabilities were incrementally introduced and the subsequent impact on productivity was monitored and compared to a baseline productivity analysis, including email volume. The plan was to introduce other web-based technologies to facilitate better information management.

DoD KEY TECHNOLOGY AREAS: Sea Enterprise, Transformational Technologies, Electronic Business

KEYWORDS: E-mail, Web-based Technologies, Enterprise, Collaboration, Business Process Reengineering

ENTERPRISE TRANSFORMATION SOLUTIONS SITE
Tom Housel, Professor
Department of Information Science
Sponsor: Department of the Navy Chief Information Officer

OBJECTIVE: The goal of this research was to develop a procedural guide for the use of e-business and knowledge management tools, technology, and techniques to support transformation of core processes in the Naval operations (e.g., logistics, acquisitions, war fighting).

SUMMARY: The Electronic Transformation Solutions Site (ETSS) provided a means for moving from high-level transformation policy to executable procedures. The ETSS was designed to assist Navy staff to continually re-evaluate and improve their processes at both local and enterprise levels. The overarching goal of the ETSS project was to develop a mechanism for helping establish Department of the Navy (DoN) Chief Information Officer (CIO) little e-transformation policies and make the policies operational. This was done by developing and testing policies designed to assist DoN leaders in transforming their core processes. However, its longer-term objective was to assist the DoN leadership build new transformational capabilities.

DoD KEY TECHNOLOGY AREAS: Sea Enterprise, Transformational Technologies, Electronic Business

KEYWORDS: E-Commerce, E-Business, Transformation, Enterprise, Business Process Reengineering

INFORMATION SCIENCE

ENTERPRISE TRANSFORMATION OF VISITORS' QUARTERS AND PROPERTY-MANAGEMENT PROCESSES
Tom Housel, Professor
Department of Information Science
Sponsor: RADM Len Hering, Commander, Navy Region Northwest

OBJECTIVE: The goal of this research was to develop an enterprise system that provides superior customer service, increases the management and operations efficiency and effectiveness, and takes advantage of technological advances.

SUMMARY: The research focused on closing the system development gap between working prototypes and production-level high-volume transaction processing systems. This analysis identified that regional consolidation and integration of enabling e-business information technology assets would facilitate a positive change in the way Certificates of Non Availability (CNAs) are currently issued, processed, and tracked. Researchers used conservative cost estimates for both the visitors quarters (VQ) and the average cost of local area hotels, extrapolated the current utilization rates for the   Transient Quarters to the CONUS VQ capacity, and estimated that a 10 percent decrease in CNAs and a subsequent 10 percent increase in VQ utilization would result in a cost savings of $22.3 million annually for maximizing VQ utilization.

DoD KEY TECHNOLOGY AREAS: Sea Enterprise, Transformational Technologies, Electronic Business

KEYWORDS: E-Commerce, E-Business, Transformation, Enterprise, Business Process Reengineering, Visitors Quarters, Bachelors' Quarters

COGNITIVE TASK ANALYSIS OF INTELLIGENCE ANALYSTS
Susan G. Hutchins, Research Associate Professor
Department of Information Science
Sponsor: Office of Naval Research

OBJECTIVE: This effort sought to develop analytic models of the intelligence analyst that will ultimately be used to develop computational models of tasks performed by intelligence analysts. The goal was to develop a prototype system to aid intelligence analysts (IAs) through the use of novel human-information interaction techniques and study the impact of these techniques on performance and learning in intelligence tasks.

SUMMARY: A detailed, accurate cognitive model that delineates essential procedural and declarative knowledge is necessary to develop effective training procedures and systems. This research entailed building a model that conveys the intelligence analysts' understanding of the demands of the domain, the knowledge and strategies of domain practitioners, and how currently available systems and technology influence performance. A cognitive task analysis (CTA) was conducted to support development of a computational model of the analyst's processes, biases, and strategies. CTA is an extension of traditional task analysis techniques to produce information regarding the knowledge, thought processes, and goal structures that provide the foundation for task performance. The goal of CTA is to discover the cognitive activities that are required for performing a task in a particular domain to identify opportunities to improve performance.

The initial set of knowledge representations for the IAs job, obtained from the first set of interviews conducted in fiscal year 2002, provided the basis for the more detailed CTA. CTA can be viewed as a problem solving process where the questions posed to the subject-matter experts, and the data collected, are tailored to produce answers to the research questions, such as training needs and how these training problems might be solved. Because the nature of the IA's task places greater emphasis on deductive reasoning, looking for patterns of activity, and making judgments about the level of risk present in a particular situation, researchers needed to tailor the approach used to capture the essence of the IA's job. Thus, a hybrid approach was used to conduct the CTA, including a modified version of the critical decision method.

INFORMATION SCIENCE

COGNITIVE TASK ANALYSIS OF INTELLIGENCE INFORMATION MANAGER TO SUPPORT ASSISTING PEOPLE TO BECOME INDEPENDENT LEARNERS IN THE ANALYSIS OF INTELLIGENCE

Susan G. Hutchins, Research Associate Professor
Department of Information Science
Sponsor: Office of Naval Research

OBJECTIVE: The overall purpose of this effort was to support research on the development of models of information foraging and knowledge crystallization. Knowledge crystallization involves locating and gathering information from large collections of information, and synthesizing and developing an understanding of this information. A product is then typically developed in the form of a briefing, analysis, or a recommendation regarding a decision.

EVALUATION OF COLLABORATION ADVISOR TOOL

Susan G. Hutchins, Research Associate Professor
Department of Information Science
Sponsor: Office of Naval Research

OBJECTIVE: The purpose of this effort was to provide an empirical evaluation of the Collaboration Advisor Tool (CAT), a team self-help diagnosis and recommendation expert system. This tool helps a collaborative team to diagnose their work situation and identify the underlying reasons for team collaboration difficulties. CAT uses evidential reasoning to diagnose team problems and assign a level of concern for each of the twelve enablers of effective collaboration that are included in the tool.

SUMMARY: Collaboration is defined as the act of participants working as a group to strive towards a common purpose or to achieve a common goal. This collaborative form of group interaction entails multi-way communications and requires mutual awareness among collaborating group members. An assumption regarding a collaborative work environment is that the participants share common objectives and collectively work to accomplish those objectives. The assumption is that relationships among the participants are clearly defined and each participant has an understanding of the roles, duties, tasks, and expectations. Since the collaboration process will be impacted by the participants understanding of these elements, a tool to help participants define and clarify these elements should provide a valuable service.

A characteristic that distinguishes team members from members of groups is that team members have differentiated roles and responsibilities. Yet it is important for team members to understand the roles and responsibilities of their teammates in order for the overall team to function as a high-performing team. A body of research literature on effective team performance focuses on understanding what is variously referred to as team knowledge, shared mental models, and team cognition. This research stresses the importance of knowledge for effective team performance. For example, a team's understanding of a complex and dynamic situation at a given point in time will be influenced by the knowledge (i.e., team situation awareness) that the team possesses. Possessing shared knowledge among team members helps the team to coordinate implicitly when explicit communications are impeded, thus enhancing team performance.

An empirical evaluation of the Collaborative Advisor Tool was conducted with students in the summer quarter at the Naval Postgraduate School . When people collaborate to perform their work, knowledge is distributed and develops in different ways among members of the group. The teams' understanding of a complex, dynamic situation at any given point in time is influenced by the knowledge that the team possesses. However, a consistent level of group knowledge is necessary to accomplish the tasks.

INFORMATION SCIENCE

ADAPTIVE ARCHITECTURES FOR COMMAND AND CONTROL (A2C2)
William G. Kemple, Associate Professor
Department of Information Science
Sponsor: Office of Naval Research

OBJECTIVE: The goal of this research was to investigate adaptation in joint command and control (C2) architectures and to develop theories of C2, i.e., "congruence" of task and organization. Another goal was to use modeling to identify near-optimal organizational decisions for C2 tasks. Other goals included testing the theories and models in a series of experiments and supporting implementation of adaptable C2 architectures.

SUMMARY: The Adaptive Architectures for Command and Control (A2C2) research project was a multi-disciplinary program of basic and applied research featuring model-based experimentation and including "outreach" to Department of the Defense (DoD)/ Department of the Navy (DoN) operational, experimental, and concept development activities. The program was a collaborative effort involving industry, university, and government researchers. Program goals included: 1) extending 14+ years of naval composite warfare decision-making research into the Joint Command and Control (C2) arena; 2) focusing on adaptive architectures within decision-making organizations; and 3) producing results that range from the purely theoretical to those that can be used by operational forces. The prototype A2C2 experiment design combined an operational scenario, computer-based architecture models, and model-based predictions of the performance of those architectures on the operational scenario. The experiment tested these architectures in a series of human-in-the-loop experiments using military officers operating in a Joint setting as the test subjects and also provided feedback to the models.

PUBLICATIONS:

Levchuk, G.M., Levchuk, Y.N., Luo, J., Pattipati, K.R., and Kleinman, D.L., "Normative Design of Organizations – Part I: Mission Planning," *IEEE Transactions on SMC: Part A – Systems and Humans*, Vol. 37, No. 3, pp. 346-359, May 2002.

Levchuk, G.M., Levchuk, Y.N., Luo, J., Pattipati, K.R., and Kleinman, D.L., "Normative Design of Organizations – Part II: Organizational Structures," *IEEE Transactions on SMC: Part A – Systems and Humans*, Vol. 37, No. 3, pp. 360-375, May 2002.

Levchuk, G.M., Levchuk, Y.N., Pattipati, K.R., and Kleinman, D.L., "Mapping Flows onto Networks to Optimize Organizational Processes," *IEEE Transactions on SMC: Part A*, September 2002 (submitted and being revised).

Levchuk, G.M., Meirina, C., Pattipati, K.R., and Kleinman, D.L., "Normative Design of Organizations: Part III - Modeling Congruent, Robust, and Adaptive Organizations," *IEEE Transactions on SMC: Part A*, April 2003, (submitted).

Meirina, C., Levchuk, Y.N., Levchuk, G.M., Pattipati, K.R., and Kleinman, D.L., "Goal Management in Organizations: A Markov Decision Process (MDP) Approach," *IEEE Transactions on Systems, Man and Cybernetics: Part A - Systems and Humans*, September 2002, (submitted and being revised).

Pattipati, K.R., Meirina, C., Pete, A., Levchuk, G., and Kleinman, D.L., "Decision Networks and Command Organizations," *Systems Engineering and Management for Sustainable Development, Encyclopedia of Life Support Systems,* A.P. Sage (Ed.), 2002.

CONFERENCE PUBLICATIONS:

Diedrich, F.J., Hocevar, S.P., Entin, E.E., Hutchins. S.G., Kemple, W.G., and Kleinman, D.L., "Adaptive Architectures for Command and Control: Toward An Empirical Evaluation of Organizational Congruence and Adaptation," *Proceedings of the Command and Control Research and Technology Symposium,* NDU, Washington, D.C., June 2003.

Entin, E.E., Diedrich, F.J., Kleinman, D.L., Kemple, W.G., Hocevar, S.P., Rubineau, B., et al., "When Do Organizations Need to Change (Part II)? Incongruence in Action," *Proceedings of the Command and Control Research and Technology Symposium,* NDU, Washington, D.C., June 2003.

Entin, E.E., Weil, S.A., Kleinman, D.L., Hutchins, S.G., Hocevar, S.P., Kemple, W.G., et al., "Inducing Adaptation in Organizations: Concept and Experiment Design," *Proceedings of the Command and Control Research and Technology Symposium*, Coronado, CA, 2004.

Hocevar, S.P., Diedrich, F.J., Hutchins, S.G., Kemple, W.G., Kleinman, D.L., and Entin, E.E., "Divisional Versus Functional Organizations: Analysis of a Concept Experiment," *Proceedings of the 2002 Command and Control Research and Technology Symposium*, Naval Postgraduate School, Monterey, CA, 2002.

Kleinman, D.L., Levchuk, G.M., Hutchins, S.G., and Kemple W.G., "Scenario Design for the Empirical Testing of Organizational Congruence," *Proceedings of the 2003 Command and Control Research and Technology Symposium*, Washington, D.C., June 2003.

Levchuk, G.M., Ruan, S., Kleinman, D.L., Pattipati, K.R., and Kemple, W., "Congruence of Organizations and Missions: Theory Versus Practice in Experiment," *Proceedings of the 8th International Command and Control Research and Technology Symposium,* Washington, D.C., June 2003, (winner of Best Student Paper at the Conference).

PRESENTATIONS:

Hutchins, S.G., Entin, E.E., Weil, S.A., Kleinman, D.L., Hocevar, S.P., Kemple, W.G., et al., "Inducing Adaptation in Organizations: Concept and Experiment Design," Military Operations Research Society Symposium, Naval Postgraduate School, June 2004.

Kleinman, D.L., Levchuk, G.M., Hutchins, S.G., and Kemple W.G., "Scenario Design for the Empirical Testing of Organizational Congruence," 71st Military Operations Research Society Symposium, Quantico, VA, June 2003.

THESES DIRECTED:

Harrington, M., Hutchins, S.G., and Kemple, W.G., "A Comparative Analysis of Information Systems and Command and Control Program Concepts to Support the Common Operating Picture," Master's Thesis, Naval Postgraduate School, September 2002.

Johnson, C.A., "Common Relevant Operational Picture: An Analysis of Effects on the Prosecution of Time-Critical Targets," Master's Thesis, Naval Postgraduate School, 2002.

Maguire, G.M., Jones, C.S., and Kemple, W.G., "Concept of a Dynamic Organizational Schema for a Network-Centric Organization," Master's Thesis, Naval Postgraduate School, 2003.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Human Systems Interface

KEYWORDS: Command and Control, Joint Operations, Organizational Experiment

INFORMATION SCIENCE

SEMANTICALLY ENABLED HABITAT FOR RAPID KNOWLEDGE CAPTURE, STORAGE, AND GENERATION
Maj. Clyde E. Richards, USA
Department of Information Science
Sponsor: Space and Naval Warfare Systems Command-San Diego

SUMMARY: Established a semantically enabled environment to facilitate rapid knowledge capture, storage, transfer, and generation process employing the Defense Advanced Research Projects Agency (DARPA) Agent Markup Language (DAML). The end-state was an ontology-governed domain that set the conditions for autonomous software agents to represent contextual information to the computer.

EFFECTS OF EA-6B JAMMING ON ANTI-SHIP MISSILE DEFENSE (ASMD)
D. Curtis Schleher, Professor
Department of Information Science
Department of Electrical and Computer Engineering
Sponsor: Navy Warfare Development Command

OBJECTIVE: The goal of this research was to evaluate the effects of coordinated and uncoordinated jamming using the EA-6B and SLQ-32 on anti-ship cruise missile seekers targeted against aircraft carriers.

SUMMARY: Simulations were conducted for an Anti-Ship Cruise Missile (ASCM) attack against a Carrier Battle Group (CVBG) with an EA-6B defending the aircraft carrier. Initial simulations assumed independent operation of the EA-6B and SLQ-32 self-defense jamming systems. Optimum flight profiles and strategy were determined for the EA-6B. Experimental results determined the interference levels of the EA-6B jamming signals on the SLQ-32 and these were incorporated into the simulation. Further Monte Carlo simulations were run using a Joint Tactical Information Distribution System (JTIDS) coordinated SLQ-32 and EA-6B defending the aircraft carrier. These were expanded using connectivity between AEGIS ships, E2-C, and the SPQ-9. Results were documented in a classified report and tactical memorandum (TACMEMO).

THESIS DIRECTED:

Cox, W., "Utilization of the EA-6B for Aircraft Carrier Anti-Ship Missile Defense (ASMD)," Master's Thesis, Naval Postgraduate School, September 2002.

DoD KEY TECHNOLOGY AREA: Electronic Warfare

KEYWORDS: Anti-Ship Cruise Missile Defense

JAMMING TACTICS AND EMPLOYMENT OF EA-6B AGAINST ADVANCED RADAR AND TACTICAL DATA LINK SYSTEMS
D. Curtis Schleher, Professor
Department of Information Science
Department of Electrical and Computer Engineering
Sponsor: Navy Warfare Development Command

OBJECTIVE: The goal of this research was to investigate jamming tactics using the EA-6B Universal Exciter Upgrade (UEU) against the SA-15 Tactical Surface-to-Air Missile System.

SUMMARY: Performance of the SA-15 Tactical Acquisition and Tactical Engagement Radars, Identification, Friend or Foe (IFF) System, and Tactical Data Link were determined under various environmental conditions. Jamming effects against these systems using UEU waveforms and chaff were analyzed to develop a jamming strategy against the overall missile system. Parametric studies were performed to determine the relative effectiveness of various UEU waveforms as a function of the jamming

INFORMATION SCIENCE

ERP and waveform parameters. Results were documented in a classified report and tactical memorandum (TACMEMO).

THESIS DIRECTED:

O'Brien, S., "Jamming of Tactical Data Links," Master's Thesis, Naval Postgraduate School, March 2004.

DoD KEY TECHNOLOGY AREA: Electronic Warfare

KEYWORDS: EW, Tactical Data Link Jamming

MISSILE IMU MODEL
D. Curtis Schleher, Professor
Department of Electrical and Computer Engineering
Information Warfare Academic Group
Sponsor: Naval Air Warfare Center Weapon Division

OBJECTIVE: The goal of this research was to develop inertial-measurement unit (IMU) models that allow a missile's attitude to be determined from telemetry data provided by rate sensors aboard the missile. One model was developed for non-rolling missiles that use IMU quartz rate sensors. A second model was developed for a rolling missile that uses magnetohydrodynamic rate sensors and a magnetoresistive spin sensor. The model was to provide outputs that are within two degrees of the actual missile attitude. A three-dimensional animation of the missile's attitude was provided.

SUMMARY: SIMULINK models were successfully developed for both the rolling and non-rolling missiles. The models were calibrated using Carco Table test data that matched expected values to within two degrees RMS (root-mean square) on each axis. An animation capability was developed that allowed the resulting accurate attitude profile to be visually observed.

The models accepted digitized strapdown telemetry data that represented distorted rate sensor data. The non-rolling missile model compensated for the distortions and then applied these data through a Euler transformation to convert the strapdown rates to earth-referenced attitude measurements. An alternate Quaternion model was also provided that allowed the model to function at all missile attitudes.

The rolling missile model included a quadrature spin demodulator that extracted the strapdown rates from the telemetry data. The spin demodulator was driven by an arc tangent demodulator that was synchronized to a magnetroresistive spin sensor. It was determined that the ATA ARS-04E rate sensors were ineffective in this application. These were replaced by Tokin CG-16D sensors that exhibited good performance.

Flight test data obtained from live missile tests at White Sands Missile Range were processed through the model. Truth was obtained using a Laser Tracker and video camera that followed the missile. Agreement of the model output and the truth data was good.

THESES DIRECTED:

Hill, C., "Computer Modeling of Jamming Effects on Roll Stabilized Missiles," Master's Thesis, Naval Postgraduate School, September 2000.

Johnson, T., "Computer Modeling of Jamming Effects on Infrared Missiles," Master's Thesis, Naval Postgraduate School, June 1999.

Yen, C., "Modeling Jamming Effects on Rolling Airframe Missile," Master's Thesis, Naval Postgraduate School, September 2001.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Missile Attitude, SIMULINK, IMU

DEVELOPING THE NEXT GENERATION IEEE DEPENDABILITY STANDARD: IEEE 982 STANDARD DICTIONARY OF MEASURES OF THE SOFTWARE ASPECTS OF DEPENDABILITY

Norman F. Schneidewind, Professor
Department of Information Science
Sponsor: IEEE Standards Board (unfunded, continuing)

OBJECTIVE: The goal of this research was to develop an IEEE Software Engineering Standard for software dependability.

SUMMARY: This first phase of the project involved the development of measures to address reliability, maintainability, and availability. The second phase will address security, integrity, and confidentiality. This standard builds upon the IEEE 982.1 Standard Dictionary of Measures to Produce Reliable Software, but will delete outdated measures, modernize the standard with object-oriented measures, and modify measures where appropriate. Because 982 was originally issued in 1988 and has not been revised since then, much of it is obsolete. Thus, there is the need to both update existing measures and to include new measures that reflect developments in software technology since 1988. Applying the criteria on how a measure is chosen for inclusion in the dictionary, researchers have performed a measure-by-measure review and have added, modified, and deleted measures in the dictionary.

CONFERENCE PUBLICATIONS:

Schneidewind, N.F., "Application of IEEE Standard Dictionary of Measures of the Software Aspects of Dependability," *Supplementary Proceedings of the 14th International Symposium on Software Reliability Engineering*, pp. 129-134, Denver, CO, 17-20 November 2003.

Schneidewind, N.F., "The Role of the Revised IEEE Standard Dictionary of Measures of the Software Aspects of Dependability in Software Acquisition," *Conference on the Acquisition of Software-Intensive Systems*, Software Engineering Institute, Arlington, VA, Carnegie Mellon, Software Engineering Institute, 28-30 January 2003.

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

PRESENTATIONS:

Schneidewind, N.F., "Application of IEEE Standard Dictionary of Measures of the Software Aspects of Dependability," 14th International Symposium on Software Reliability Engineering, Denver, CO, 17-20 November 2003.

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

Schneidewind, N.F., "The Role of the Revised IEEE Standard Dictionary of Measures of the Software Aspects of Dependability in Software Acquisition," Conference on the Acquisition of Software-Intensive Systems, Software Engineering Institute, Arlington, VA, Carnegie Mellon, Software Engineering Institute, 28-30 January 2003.

THESIS DIRECTED:

Kinnison, W.P., "Evaluation of Software Engineering Tools," Master's Thesis, Naval Postgraduate School, March 2003.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Standards, Software Reliability

ESTIMATE AND CONTROL SOFTWARE FAULT CONTENT MORE EFFECTIVELY

Norman F. Schneidewind, Professor
Department of Information Science
Sponsor: Jet Propulsion Laboratory, California Institute of Technology

OBJECTIVE: The goal of this research was to identify the attributes of requirements that cause the software to be unreliable and quantify the relationship between requirements risk and reliability. If these attributes can be identified, then policies can be recommended to the National Aeronautics and Space Administration (NASA) for recognizing these risks and avoiding or mitigating them during development. Goals included extending and validating work in this area on the space shuttle to the Goddard Space Flight Center and the Jet Propulsion Laboratory software projects.

SUMMARY: While software design and code metrics have enjoyed some success as predictors of software quality, the measurement field is stuck at this level of achievement. If measurement is to advance to a higher level, attention must shift to the front-end of the development process, because it is during requirements analysis that errors are inserted into the process.

A requirements change may induce ambiguity and uncertainty in the development process that cause errors in implementing the changes. Subsequently, these errors propagate through later phases of development and maintenance. These errors may result in significant risks associated with implementing the requirements. For example, reliability risk (i.e., risk of faults and failures induced by changes in requirements) may be incurred by deficiencies in the process (e.g., lack of precision in requirements).

Researchers identified thresholds of risk factors (i.e., the attributes of a requirements change that can induce reliability risk) for predicting when the number of failures would become excessive (i.e., rise rapidly with the risk factor).

Two of the most important requirements risk factors of the space shuttle, as measured by their negative affect on software reliability, are space and issues. The former is defined as the amount of memory space required to implement the requirement change and the latter is defined as the number of possible conflicts among requirements. Researchers determined that these two risk factors had the highest statistically significant relationship with reliability (i.e., the greater the cumulative memory space required to implement changes and the greater the number of cumulative conflicting requirements issues caused by the changes, the greater the negative effect on reliability).

PUBLICATION:

Nikora, A.P., Schneidewind, N.F., and Munson, J.C., "Estimating and Controlling Software Fault Content More Effectively," Final Report, Jet Propulsion Laboratory, 14 February 2003.

PRESENTATION:

Schneidewind, N.F., "Everything You Wanted to Know About Software Reliability Engineering but Didn't Know Who to Ask," 14th International Symposium on Software Reliability Engineering, IEEE Computer Society Press, Denver, CO, 17-20 November 2003.

KEYWORDS: Software Reliability, Software Metrics, Modeling

INVESTIGATION OF THE RISK TO SOFTWARE RELIABILITY OF REQUIREMENTS CHANGES

Norman F. Schneidewind, Professor
Department of Information Science
Sponsor: (unfunded, continuing)

OBJECTIVE: The objective was to make the linkage between the need for the measurement of quality and reliability in the software development life cycle and the body of knowledge that is required to satisfy this need. A key attribute of quality is reliability. Thus, the focus was on this attribute. The software engineer would apply the body of knowledge to improve the reliability of software throughout the life cycle. In addition, the body of knowledge may be used as guidelines for practitioners, licensing of software professionals, and for training in software reliability measurement. The rationale was that without measurement, software engineers would not be able to achieve high reliability software. Thus, programmed measurement is key to developing reliable software.

SUMMARY: Because measurement is the key to achieving high reliability software, it is important for software engineers to be knowledgeable in this area. Using two approaches, researchers identified the body of knowledge in software reliability measurement that is required of the software engineer. The first approach developed a set of related issues, functions, and a body of knowledge. Issues determined the functions performed by the software engineer and these functions, in turn, determined knowledge requirements. The second approach identified knowledge requirements by keying the knowledge set to the life cycle phases and metrics used in each phase. The two approaches were compatible but different views of achieving the same objective and were provided to show the software engineer why (issue oriented) and when (phase oriented) the need for measurement arises.

PUBLICATIONS:

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

Schneidewind, N.F., "Naval Postgraduate School Case Study: Requirements Changes as Predictors of Software Reliability," *Six Sigma for Software Development*, 47 pages, San Jose, CA, 23-24 January 2003.

PRESENTATION:

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

THESIS DIRECTED:

Cummins, R., "Evaluation of Commercial Items Risk Factors," Master's Thesis, Naval Postgraduate School, March 2003.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Life Cycle, Core Knowledge, Reliability Measurement

MODELING THE FAULT CORRECTION PROCESS

Norman F. Schneidewind, Professor
Department of Information Science
Sponsor: (unfunded, continuing)

OBJECTIVE: There is a need for greater emphasis on fault correction modeling and prediction in software reliability models. This need stems from the obvious fact that the fault correction process is vital

to ensuring high quality software. If only failure prediction is addressed, reliability assessment will be incomplete because it would not reflect the reliability of the software resulting from fault correction. In addition to achieving greater accuracy in reliability prediction, there are by-product benefits associated with fault correction prediction as follows:

a. Predicting whether reliability goals have been achieved: If no predictions are made of the number of faults to be corrected, fault correction rate, and fault correction time, accurate prediction of reliability cannot be obtained.
b. Stopping rules for testing: the predicted number of remaining faults is less than or equal to a specified critical value, and the fault correction rate asymptotically approaches zero.
c. Tests and the allocation of test resources can be prioritized: Software with high values of number of remaining faults and low fault correction rates are given high priority in testing and the allocation of resources, such as personnel and computer time.

SUMMARY: In general, software reliability models have focused on modeling and predicting failure occurrence and have not given equal priority to modeling the fault correction process. However, there is a need for fault correction prediction, because there are important applications that fault correction modeling and prediction support: predicting whether reliability goals have been achieved, developing stopping rules for testing, formulating test strategies, and rationally allocating test resources. Because these factors are related, we integrate them in our model.

PUBLICATION:

Schneidewind, N.F., "Modeling the Fault Correction Processes," *The R & M Engineering Journal*, *American Society for Quality*, Part 1, Vol. 23, No. 4, pp. 6-15, 2003 December, (ISSN 0277-9633).

CONFERENCE PUBLICATIONS:

Schneidewind, N.F., "Fault Correction Profiles," *Proceedings of the 14th International Symposium on Software Reliability Engineering*, pp. 257-267, Denver, CO, 17-20 November 2003.

Voas, J. and Schneidewind, N.F., "Marrying Software Fault Injection Technology Results with Software Reliability Growth Models," *Supplementary Proceedings of the 14th International Symposium on Software Reliability Engineering*, pp. 230-231, Denver, CO, 17-20 November 2003.

PRESENTATIONS:

Schneidewind, N.F., "Fault Correction Profiles," 14th International Symposium on Software Reliability Engineering, Denver, CO, 17-20 November 2003.

Voas, J. and Schneidewind, N.F., "Marrying Software Fault Injection Technology Results with Software Reliability Growth Models," 14th International Symposium on Software Reliability Engineering, Denver, CO, 17-20 November 2003.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Software Reliability, Fault Correction Modeling

INFORMATION SCIENCE

REVISION OF IEEE P1633\ AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS (AIAA) R-013A RECOMMENDED PRACTICE ON SOFTWARE RELIABILITY
Norman F. Schneidewind, Professor
Department of Information Science
Sponsor: IEEE\ American Institute of Aeronautics and Astronautics (AIAA) Standards Boards, Unfunded

PRESENTATION:

Schneidewind, N.F., "Software Acquisition Life Cycle Measurement Plan Based on the Revised 'IEEE P1633\AIAA R-013A Recommended Practice on Software Reliability'," Workshop on Software Assessment, 14th International Symposium on Software Reliability Engineering, Denver, CO, 17-20 November 2003, (http://www.cs.colostate.edu/%7Emalaiya/issre/norm.pdf).

KEYWORDS: Software Acquisition, Life Cycle Measurement, IEEE, P1633\AIAA R-013A, Workshop on Software Assessment, Software Reliability Engineering

INTEGRATING HARDWARE AND SOFTWARE TECHNOLOGIES TO AUTOMATE THE INFORMATION CONDITION (INFOCON) IMPLEMENTATION PROCESS
LT Douglas K. Shamlin, USN
Department of Information Science
Sponsor: Space and Naval Warfare Systems Command-San Diego

SUMMARY: Developed an automated defense capable of managing Information Condition (INFOCON) changes for the Department of the Navy's Enterprise Information Systems.

KEYWORDS: INFOCON Information Condition

TRANSITION OF NAVAL EXPEDITIONARY FORCES MISSION PLANNING SYSTEMS TO A GLOBAL COLLABORATIVE CAPABILITY
Major Larry E. Smith, II, USMC
Department of Information Science
Sponsor: Space and Naval Warfare Systems Command-San Diego

SUMMARY: This joint research project recommended the general design for low cost, interim, commercial, off-the-shelf, geographically dispersed, real-time collaborative mission planning system. It also proposed the implementation process for this system to aide in the transformation of current Naval Expeditionary Force mission planning into a joint global real-time collaborative mission planning.

KEYWORDS: Global Collaborative, Mission Planning, Naval Expeditionary Force

FISCAL YEAR 2003 INFORMATION OPERATIONS (IO) / INFORMATION WARFARE (IW) RESEARCH
Brian D. Steckler, Lecturer
Department of Information Science
Sponsor: National Institute of Water and Atmospheric Research

SUMMARY: Supported the Computer and Network Security Group (CNSG's) Information Warfare curriculum, faculty, and research efforts, and information operations (IO) / information warfare (IW) fleet support activities.

KEYWORDS: CNSG, Information Warfare, IO

FISCAL YEAR 2003 LIAISON DESK FOR HEADQUARTERS U.S. PACIFIC COMMAND
Brian D. Steckler, Lecturer
Department of Information Science
Sponsor: U.S. Pacific Command

SUMMARY: Provided support to Headquarters U.S. Pacific Command for Exercise COBRA GOLD 2003 as part of responsibilities as Naval Postgraduate School Liaison Desk for U.S. Pacific Command.

KEYWORDS: Pacific Command, COBRA GOLD

NEMESIS NETWARVAN
Brian D. Steckler, Lecturer
Department of Information Science
Sponsor: Department of the Navy Chief Information Officer

SUMMARY: Nemesis is a mobile, reconfigurable lab resource for Naval Postgraduate School students and faculty to conduct research in the wireless local area network (WLAN) field.

KEYWORDS: Nemesis, Netwarvan

NEMESIS NETWARVAN
Brian D. Steckler, Lecturer
Department of Information Science
Sponsor: Naval Security Group Command

KEYWORDS: Nemesis, Netwarvan

TRANSFORMATIONAL COMMUNICATIONS TECHNOLOGIES FOR THE COMMAND AVIATION COMMAND AND CONTROL SYSTEMS (CAC2S) AT THE TACTICAL LEVEL
Brian D. Steckler, Lecturer
Department of Information Science
Sponsor: Space and Naval Warfare Systems Command-Charleston

JOINT INTELLIGENCE VIRTUAL UNIVERSITY IMPLEMENTATION
John W. Van Hise, Jr., Research Associate Professor
Department of Information Science
Sponsor: National Security Agency

SUMMARY: Developed, managed, and delivered graduate-level instruction, including synchronous, asynchronous, and blended technical and operational courseware via the Joint Intelligence Virtual University. The Naval Postgraduate School conducted a proof of concept study for the delivery of classified advanced-level education for the national intelligence community.

KEYWORDS: Synchronous, Asynchronous, Joint Intelligence Virtual University

INFORMATION SCIENCE

NAVAL SIMULATION SYSTEM (NSS) SOFTWARE CHANGE TESTING VALIDATION AND VERIFICATION
John W. Van Hise, Jr., Research Associate Professor
Department of Information Science
Sponsor: Commander Pacific Fleet

SUMMARY: The Naval Postgraduate School conducted research to test and validate requested NSS software changes designed to support Commander of the Pacific Fleet analysis tasks.

KEYWORDS: NSS Software, Validation, Verification

SUPPORT OF JOINT INTELLIGENCE VIRTUAL UNIVERSITY
John W. Van Hise, Jr., Research Associate Professor
Department of Information Science
Sponsor: Naval Security Group Command

CYBER-WARFARE: IDENTIFY, ATTACK, DEFEND, AND ASSESS
CPT Juan C. Vega, USA
Department of Information Science
Sponsor: Space and Naval Warfare Systems Command-San Diego

SUMMARY: The objective of this research was to support the information operations (IO) and homeland defense initiative by creating an improved executive level management tool detailing computer network defense and understanding a network attack and the integration of systems that detect threats and defend the U.S. homeland against asymmetric attacks.

KEYWORDS: Joint Intelligence Virtual University, JIVU, IO, Asymetric Attack

EXPLOITATION OF EXISTING VOICE OVER INTERNET PROTOCOL TECHNOLOGY TO PROVIDE SECURE VOICE OVER INTERNET PROTOCOL
LT Henry M. Vegter, USN
1stLt David T. Wallace, USMC
Department of Information Science
Sponsor: Space and Naval Warfare Systems Command-San Diego

SUMMARY: This research had two goals. First, to investigate existing technology used to communicate Voice Over Internet Protocol (VoIP), determine the capabilities and requirements for implementation of a VoIP system, and conduct a cost benefit analysis of VoIP versus Private Branch Exchange (PBX)-based phone systems. Second, with a thorough understanding of what industry offers in Voice Over Internet Protocol, experiment with and prototype a secure VoIP phone system. The result of this effort was a secure voice communications system that can be used anywhere there is switched network connectivity.

KEYWORDS: VOIP, Voice Over Internet, PBX

DEVELOPING TRAINING MATERIAL AND PROCEDURES TO TEACH VULNERABILITY ASSESSMENT TECHNIQUES IN A WEB-BASED DISTANCE LEARNING VIRTUAL LAB ENVIRONMENT

Captain Eric Walters, USMC
Department of Information Science
Sponsor: Space and Naval Warfare Systems Command-San Diego

SUMMARY: This research developed distance learning training materials for the use of Department of the Navy personnel.

KEYWORDS: Distance Learning

DEPARTMENT OF INFORMATION SCIENCE

2003
Faculty Publications
and Presentations

INFORMATION SCIENCE

PUBLICATIONS

Levchuk, G.M., Levchuk, Y.N., Luo, J., Pattipati, K.R., and Kleinman, D.L., "Normative Design of Organizations – Part I: Mission Planning," *IEEE Transactions on SMC: Part A – Systems and Humans*, Vol. 37, No. 3, pp. 346-359, May 2002.

Levchuk, G.M., Levchuk, Y.N., Luo, J., Pattipati, K.R., and Kleinman, D.L., "Normative Design of Organizations – Part II: Organizational Structures," *IEEE Transactions on SMC: Part A – Systems and Humans*, Vol. 37, No. 3, pp. 360-375, May 2002.

Pattipati, K.R., Meiriena, C., Pete, A., Levchuk, G., and Kleinman, D.L., "Decision Networks and Command Organizations," *Systems Engineering and Management for Sustainable Development, Encyclopedia of Life Support Systems,* A.P. Sage (Ed.), 2002.

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

Schneidewind, N.F., "Modeling the Fault Correction Processes," *The R & M Engineering Journal, American Society for Quality*, Part 1, Vol. 23, No. 4, pp. 6-15, 2003 December, (ISSN 0277-9633).

Schneidewind, N.F., "Naval Postgraduate School Case Study: Requirements Changes as Predictors of Software Reliability," *Six Sigma for Software Development*, 47 pages, San Jose, CA, 23-24 January 2003.

CONFERENCE PUBLICATIONS

Bordetsky, A.B., Ford, T., and Roberts, N., "Networks for Peace Operations: Knowledge Portals for Communication, Coordination and Collaboration," *Proceedings of the Symposium on Networks for Nation Building*, Academy of Management, Denver, CO, 2002.

Bordetsky, A.B., Hutchins, S., Kemple, B., and Bourakov, E., "Network Awareness for Wireless Peer-to-Peer Collaborative Environments," *Proceedings of the 37th Hawaii International Conference in Systems Sciences,* Big Island, HI, 2003.

Bordetsky, A.B. and Statnikov, R., "Multiple Criteria Fan-Out Mechanism for Peer-to-Peer Collaborative Networking," *Proceedings of the 11th International Conference in Telecommunication Systems*, Monterey, CA, 2003.

Diedrich, F.J., Hocevar, S.P., Entin, E.E., Hutchins. S.G., Kemple, W.G., and Kleinman, D.L., "Adaptive Architectures for Command and Control: Toward An Empirical Evaluation of Organizational Congruence and Adaptation," *Proceedings of the Command and Control Research and Technology Symposium,* NDU, Washington, D.C., June 2003.

Entin, E.E., Diedrich, F.J., Kleinman, D.L., Kemple, W.G., Hocevar, S.P., Rubineau, B., et al., "When Do Organizations Need to Change (Part II)? Incongruence in Action," *Proceedings of the Command and Control Research and Technology Symposium,* NDU, Washington D.C., June 2003.

Entin, E.E., Weil, S.A., Kleinman, D.L., Hutchins, S.G., Hocevar, S.P., Kemple, W.G., et al., "Inducing Adaptation in Organizations: Concept and Experiment Design," *Proceedings of the Command and Control Research and Technology Symposium*, Coronado, CA, 2004.

Hocevar, S.P., Diedrich, F.J., Hutchins, S.G., Kemple, W.G., Kleinman, D.L., and Entin, E.E., "Divisional Versus Functional Organizations: Analysis of a Concept Experiment," *Proceedings of the 2002 Command and Control Research and Technology Symposium*, Naval Postgraduate School, 2002.

Kleinman, D.L., Levchuk, G.M., Hutchins, S.G., and Kemple W.G., "Scenario Design for the Empirical Testing of Organizational Congruence," *Proceedings of the 2003 Command and Control Research and Technology Symposium*, Washington, D.C., June 2003.

Levchuk, G.M., Ruan, S., Kleinman, D.L., Pattipati, K.R., and Kemple, W., "Congruence of Organizations and Missions: Theory Versus Practice in Experiment," *Proceedings of the 8th International Command and Control Research and Technology Symposium,* Washington, D.C., June 2003, (winner of Best Student Paper at the Conference).

Schneidewind, N.F., "Application of IEEE Standard Dictionary of Measures of the Software Aspects of Dependability," *Supplementary Proceedings of the 14th International Symposium on Software Reliability Engineering*, pp. 129-134, Denver, CO, 17-20 November 2003.

Schneidewind, N.F., "Fault Correction Profiles," *Proceedings of the 14th International Symposium on Software Reliability Engineering*, pp. 257-267, Denver, CO, 17-20 November 2003.

Schneidewind, N.F., "The Role of the Revised IEEE Standard Dictionary of Measures of the Software Aspects of Dependability in Software Acquisition," *Conference on the Acquisition of Software-Intensive Systems*, Software Engineering Institute, Arlington, VA, Carnegie Mellon, Software Engineering Institute, 28-30 January 2003.

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

Voas, J. and Schneidewind, N.F., "Marrying Software Fault Injection Technology Results with Software Reliability Growth Models," *Supplementary Proceedings of the 14th International Symposium on Software Reliability Engineering*, pp. 230-231, Denver, CO, 17-20 November 2003.

PRESENTATIONS

Hutchins, S.G., Entin, E.E., Weil, S.A., Kleinman, D.L., Hocevar, S.P., Kemple, W.G., et al., "Inducing Adaptation in Organizations: Concept and Experiment Design," Military Operations Research Society Symposium, Naval Postgraduate School, June 2004.

Kleinman, D.L., Levchuk, G.M., Hutchins, S.G., and Kemple W.G., "Scenario Design for the Empirical Testing of Organizational Congruence," 71st Military Operations Research Society Symposium, Quantico, VA, June 2003.

Schneidewind, N.F., "Application of IEEE Standard Dictionary of Measures of the Software Aspects of Dependability," 14th International Symposium on Software Reliability Engineering, Denver, CO, 17-20 November 2003.

Schneidewind, N.F., "Everything You Wanted to Know About Software Reliability Engineering But Didn't Know Who to Ask," 14th International Symposium on Software Reliability Engineering, IEEE Computer Society Press, Denver, CO, 17-20 November 2003.

Schneidewind, N.F., "Fault Correction Profiles," 14th International Symposium on Software Reliability Engineering, Denver, CO, 17-20 November 2003.

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

Schneidewind, N.F., "The Role of the Revised IEEE Standard Dictionary of Measures of the Software Aspects of Dependability in Software Acquisition," Conference on the Acquisition of Software-Intensive

Systems, Software Engineering Institute, Arlington, VA, Carnegie Mellon, Software Engineering Institute, 28-30 January 2003.

Schneidewind, N.F., "Software Acquisition Life Cycle Measurement Plan Based on the Revised 'IEEE P1633\AIAA R-013A Recommended Practice on Software Reliability'," Workshop on Software Assessment, 14th International Symposium on Software Reliability Engineering, Denver, CO, 17-20 November 2003, (http://www.cs.colostate.edu/%7Emalaiya/issre/norm.pdf).

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

Voas, J. and Schneidewind, N.F., "Marrying Software Fault Injection Technology Results with Software Reliability Growth Models," 14th International Symposium on Software Reliability Engineering, Denver, CO, 17-20 November 2003.

REPORTS

Bordetsky, A.B., Bach, E., et al., "An Analysis of the Impact of Modern Collaborative Technology on Battle Rhythm at the Tactical Level," Final Report to Space and Naval Warfare Systems Command, 2003.

Nikora, A.P., Schneidewind, N.F., and Munson, J.C., "Estimating and Controlling Software Fault Content More Effectively," Final Report, Jet Propulsion Laboratory, 14 February 2003.

DEPARTMENT OF OPERATIONS RESEARCH

JAMES EAGLE
CHAIR

OPERATIONS RESEARCH

OVERVIEW:

The Naval Postgraduate School Operations Research (OR) program is a world-class curriculum designed to teach students the science of helping people and organizations make better decisions.

This science is necessary in today's increasingly complex operating environment in which officers and managers must respond quickly to a vast array of demands while also weighing the options and consequences of each into his or her final decision. OR offers a scientific approach through the use of many tools and techniques in order to assist an individual in his or her decision making process.

The military specifically uses OR at the strategic, operational, and tactical levels. OR applications cover the gamut of military activities including: National policy analysis, resource allocation, force composition and modernization, logistics, human resources, battle planning, flight operations scheduling, intelligence, command and control, weapon selection, engagement tactics, maintenance and replenishment, and search and rescue.

The Department of Operations Research mission is:
- To educate analysts who are fully capable of conducting independent analytical studies of military problems, and have an educational basis for continued learning and development.
- To provide the United States government and our allies with military officers who have a comprehensive knowledge of military operations research, and who can perform and manage quantitative analysis of operational and other Defense problems.
- To provide operations research and general analysis support to the Department of Defense (DoD).
- To develop and maintain a world-class research program in operations research and related areas.

CURRICULA SERVED:

- Modeling, Virtual Environments, and Simulation (MOVES)
- Electronic Warfare Systems International
- Information Systems and Operations
- Information Systems Technology
- Information Warfare
- Joint C4I
- Intelligence Information Management
- Naval/Mechanical Engineering
- Operations Analysis
- Operational Logistics
- Advanced Science (Applied Mathematics)
- Product Development 21
- Space Systems Operations International
- Space Systems Operations
- Systems Engineering/Integration
- Manpower Systems Analysis
- Undersea Warfare
- Undersea Warfare International

DEGREES GRANTED:

- Master of Science in Operations Research
- Master of Science in Applied Science
- Doctor of Philosophy

RESEARCH THRUSTS:

- Probability and Stochastic Processes
- Optimization
- Statistics and Data Analysis
- Human Factors and Systems Integration
- Simulation and War Gaming
- Search, Detection and Evasion

RESEARCH CHAIRS:

- Chair for Manpower Modeling
- Chair of Applied Systems Analysis
- Chair of Tactical Analysis

RESEARCH FACILITIES:

- Secure Computing and Simulation Lab (WARLAB)
- Optimization Lab
- Human Systems Integration Laboratory (HISL)

RESEARCH PROGRAM (Research and Academic)-FY2003:

The Naval Postgraduate School's sponsored program exceeded $71 million in FY2003. Sponsored programs include both research and educational activities funded from an external source. A profile of the sponsored program for the Department of Operations Research is provided below.

Size of Program: $2,335K

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EXTENSIBLE ANALYST TOOLKIT FOR MILITARY PLANNING SYSTEMS

Gordon H. Bradley, Professor
Arnold H. Buss, Research Assistant Professor
Department of Operations Research
Sponsor: Air Force Office of Scientific Research

OBJECTIVE: The purpose of this study was to design and develop an architecture for dynamic map-based military planning applications using new platform-independent software technology. The toolkit was a collection of components that support the rapid construction of map-based military planning systems. The existing components for map and image display, network modeling, and optimization algorithms were augmented by components to support large-scale optimization and to construct hierarchical optimization models. This is a continuing research project.

SUMMARY: The research designed and developed an Extensible Analyst Toolkit, called the "Monterey Project" that was demonstrated by constructing a map-based planning system for dynamic military planning. The architecture coordinated a collection of components that operated over heterogeneous computer networks. The system accessed and displayed data, maps, overlays, algorithms, and other information. The components performed tasks such as displaying maps, satellite images, and overlays; accessing, entering, and modifying data; constructing and displaying models of military operations; and accessing and executing algorithms to analyze operations. A component to present and analyze elevation data and execute line of sight algorithms was incorporated into the system. A component to combine discrete event simulation and optimization was also developed.

PUBLICATION:

Bradley, G.H., "Introduction to Extensible Markup Language (XML) with Operations Research Examples," *Institute for Operations Research and the Management Sciences (INFORMS) Computing Society Newsletter,* Vol. 24, No. 1, Spring 2003, 14 pages, 2003.

CONFERENCE PRESENTATIONS:

Bradley, G., "Extensible Markup Language (XML), Optimization, and Simulation," Air Force Office of Scientific Research Optimization and Discrete Mathematics Program Review, Estes Park, CO, 27-28 May 2003.

Bradley, G., "Tutorial: Extensible Markup Language with Operations Research Examples," Eighth Institute for Operations Research and the Management Sciences (INFORMS) Computing Society Conference, Chandler, AZ, 8-10 January 2003.

Buss, A.H., "Simkit and Combat XXI," Modeling, Virtual Environments, and Simulation Open House 2003, Monterey, CA, 5-7 August 2003.

Buss, A.H., "Simulation and Simulation/Optimization Capabilities for the Extensible OR Toolkit," Air Force Office of Scientific Research Optimization and Discrete Mathematics Program Review, Estes Park, CO, 27-28 May 2003.

THESES DIRECTED:

Margolis, M., "Operational Availability and Cost Trade-Off Analysis for the Multi-Mission Maritime Aircraft," Master's Thesis, Naval Postgraduate School, September 2003.

Nawara, T., "Tactical Route Planning for Submarine Mine Detection and Avoidance," Master's Thesis, Naval Postgraduate School, September 2003.

Schoch, E., "A Simulation of the I3 to D Repair Process and Sparing of the F414-Ge-400 Jet Aircraft Engine," Master's Thesis, Naval Postgraduate School, September 2003.

LARGE-SCALE OPTIMIZATION
Gordon H. Bradley, Professor
Gerald G. Brown, Distinguished Professor
R. Kevin Wood, Professor
Department of Operations Research
Sponsor: Office of Naval Research

OBJECTIVE: The purpose of this project was to develop large-scale mathematical programming techniques to solve constrained shortest-path problems, model the optimal outfitting and pre-positioning of theater ballistic missile defenses for the Area Air Defense Commander, and continue development of map-based military planning systems based on component technology using Extensible Markup Language (XML) and related technologies to represent and structure data for network optimization. This is a continuing research project.

SUMMARY: Near-shortest-path enumeration was combined with Lagrangian relaxation to yield an algorithm for constrained shortest paths that was orders of magnitude faster than its competitors. This research implemented and demonstrated a two-sided optimization, based on interdiction theory, where the attacker (e.g., North Korea) optimally fired ballistic missile salvos at a set of targets of interest to the United States (e.g., Japanese cities), and the Area Air Defense Commander optimally outfitted and pre-positioned defensive interceptor platforms in anticipation of such an attack. The prototype developed by this research mimics what was done for the U.S. Navy by a system using outright enumeration on a large server farm; this project prototype produced a provably optimal solution on a laptop in minutes. Another part of this research extended a toolkit of methods to quickly construct graph and network algorithms. The algorithms were integrated into a dynamic map-based military planning system that operated over heterogeneous computer networks. An XML language was developed for networks and graphs and a reference implementation was in progress.

PUBLICATIONS:

Balcioglu, A. and Wood, R.K, "Enumerating Near-Min s-t Cuts," *Network Interdiction and Stochastic Integer Programming*, D.L. Woodruff (Ed.), Kluwer Academic Publishers, pp. 21-49, 2003.

Bradley, G.H., "Introduction to Extensible Markup Language (XML) with Operations Research Examples," *INFORMS Computing Society Newsletter,* Vol. 24, Number 1, 14 pages, Spring 2003.

Brown, G.G., Dell, R.F., Holtz, H., and Newman, A.M., "How Space Command Optimizes Long-Term Investment in Space Systems," *INTERFACES*, Vol. 33, pp.1-14, 2003.

Brown, G.G., Dell, R.F., and Newman, A.M., "Optimizing Military Capital Planning," 2002 (in review).

Morton, D.P., Salmeron, J., and Wood, R.K., "A Stochastic Program for Optimizing Military Sealift Subject to Attack," *Stochastic Programming E-Print Series*, 2003, (http://dochost.rz.hu-berlin.de/speps/).

Salmeron, J., Wood, R.K., and Baldick, R., "Analysis of Electric Grid Security Under Terrorist Threat," *IEEE Transactions on Power Systems*, 2003, (to appear).

CONFERENCE PUBLICATION:

Carlyle, W.M. and Wood, R.K., "Lagrangian Relaxation and Enumeration for Solving Constrained Shortest-Path Problems," *Proceedings of the 38th Annual Operational Research Society of New Zealand (ORSNZ) Conference, Operational Research Society of New Zealand*, Hamilton, New Zealand, pp. 3-12, 2003.

CONFERENCE PRESENTATIONS:

Bradley, G., "Extensible Markup Language (XML), Optimization, and Simulation," Air Force Office of Scientific Research Optimization and Discrete Mathematics Program Review, Estes Park, CO, 27-28 May 2003.

Bradley, G., "Tutorial: Extensible Markup Language with Operations Research Examples," Eighth Institute for Operations Research and the Management Sciences (INFORMS) Computing Society Conference, Chandler, AZ, 8-10 January 2003.

Brown, G.G., "Has IT Made OR Obsolete?" Plenary Address, Institute for Operations Research and the Management Sciences (INFORMS), Phoenix, AZ, 4-6 May 2003, (http://www.nps.navy.mil/orfacpag/resumePages/presentations/linked-presentations/aegisBrownWoodSanJose02.pdf).

Brown, G., Dell, R., and Newman, A., "Optimization Models for Military Capital Planning," Institute for Operations Research and the Management Sciences (INFORMS) Annual Meeting, Atlanta, GA, 19-22 October 2003.

Carlyle, W.M. and Wood, R.K., "K-Shortest and Near-Shortest Simple Paths," Department of Engineering Science Seminar, University of Auckland, Auckland, New Zealand, 29 March 2003, (http://www.nps.navy.mil/orfacpag/resumePages/presentations/linked-presentations/aegisBrownWoodSanJose02.pdf).

Carlyle, W.M. and Wood, R.K., "Lagrangian Relaxation and Enumeration for Solving Constrained Shortest-Path Problems," 38th Annual Operational Research Society of New Zealand Conference, University of Waikato, Hamilton, New Zealand, 21-22 November 2003.

Spoerl D. and Wood, K., "A Stochastic Generalized Assignment Problem," Institute for Operations Research and the Management Sciences (INFORMS) Annual Meeting, Atlanta, GA, 19-22 October 2003.

Spoerl, D. and Wood, K., "A Stochastic Generalized Assignment Problem," Military Operations Research Society Symposium, Quantico, VA, 10-12 June 2003.

Wood, K., Brown, G., and Carlyle, M., "Tutorial: How to Attack a Linear Program," Military Operations Research Society, Quantico, VA, 10-12 June 2003.

Wood, K., Brown, G., Carlyle, M., and Salmeron, J., "Tutorial: How to Build a Robust Supply Chain or Harden the One You Have," Institute for Operations Research and the Management Sciences (INFORMS) Annual Meeting, Atlanta, GA, 19-22 October 2003.

TECHNICAL REPORT:

Carlyle, M., Brown, G., and Washburn, A.R., "Assessment and Investment Model (AIM)," Naval Postgraduate School Technical Report, NPS-OR-03-009-PR, October 2003.

THESES DIRECTED:

Bruggeman, J., "A Multi-Year Ammunition Procurement Model for Department of the Navy Non-Nuclear Ordnance," Master's Thesis, Naval Postgraduate School, September 2003.

Drexler, J.A., "Enhancing Persistence when Optimally Scheduling Depot-Level Repair Activity for the United States Marine Corps," Master's Thesis, Naval Postgraduate School, June 2003.

Seagren, C.W. "Improving Optimal Aimpoints for Multiple GPS-Guided Munitions," Master's Thesis, Naval Postgraduate School, September 2003.

KEYWORDS: Integer Programming, Stochastic Programming, Dynamic Planning, Network Optimization

ASSESSMENT AND INVESTMENT MODEL (AIM) DEVELOPMENT
Gerald G. Brown, Distinguished Professor
Matthew Carlyle, Associate Professor
Alan R. Washburn, Professor
Department of Operations Research
Sponsor: Naval Supply Systems Command

OBJECTIVE: The Navy spends billions of dollars every year on munitions. The Navy's Non Nuclear Ordnance Requirements (NNOR) system accumulates the required inventory of each munition by summing the estimated quantities needed for fighting wars, training, and other functions. The trouble is that NNOR is not cost constrained, so the total list of needed munitions may not be affordable. Indeed, the list has not been even nearly affordable in recent years. The Assessment and Investment Model (AIM) is intended to buy as much of the NNOR list as possible over a sequence of years, while recognizing that all munitions are not equally crucial to the nation's needs.

SUMMARY: AIM is an optimization-based model where the requirement for each munition is separated into several "tiers" that represent different levels of desirability, after which the objective is to maximize the tier level of the munition with the lowest tier. AIM includes a cost model that pays proper attention to procuring certain munitions in sufficient quantity to keep production lines open. AIM was delivered to the sponsor, where it is currently undergoing testing and further development.

TECHNICAL REPORT:

Brown, G., Carlyle, M., and Washburn, A., "Assessment and Investment Model (AIM)," Naval Postgraduate School Technical Report, NPS-OR-03-009-PR, 2003.

THESIS DIRECTED:

Bruggeman, J., "A Multi-Year Ammunition Procurement Model for Department of the Navy Non-Nuclear Ordnance," Master's Thesis, Naval Postgraduate School, September 2003.

KEYWORDS: Munition, NNOR

A TOOLKIT FOR EVALUATING ALGORITHMS FOR INTERNETTING OF FIRES
Arnold H. Buss, Assistant Professor
Department of Operations Research
Sponsor: U.S. Army TRADOC Analysis Command

OBJECTIVE: The objective of this research was to develop a decision support algorithm which will dynamically allocate both human and weapons resources for use in future combat systems.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Future Combat Systems, Army Objective Force Concept, Decision Support Tools, Dynamic Allocation of Weapons Resources, Human Performance in Combat Situations, Psychological Predictors of Human Decision Making

OPERATIONS RESEARCH

EQUIPMENT READINESS AND MAINTENANCE TREND ANALYSIS
Samuel E. Buttrey, Assistant Professor
Department of Operations Research
Sponsor: U.S. Marine Corps Combat Development Command

SUMMARY: Analyzed readiness, maintenance, and spare parts data for four Marine Corps systems using the completed report for the AAVP7A1 as a guide, and in accordance with the statement of work provided.

KEYWORDS: Equipment Readiness, Marine Corps, AAVP7A1

OFFICER CANDIDATE SCHOOL DATA ANALYSIS STUDY
Samuel E. Buttrey, Assistant Professor
Department of Operations Research
Sponsor: United States Marine Corps - Marine Corps Systems Command

SUMMARY: Assisted Marine Corps Combat Development Command (MCCDC) in analyzing survey and demographic data from Marine Corps Officer Candidate School.

KEYWORDS: Demographics, Marine Corps Officer Candidate School

OFFICER RECRUITING STRUCTURE II, TASK 2
Samuel E. Buttrey, Assistant Professor
Department of Operations Research
Sponsor: U.S. Marine Corps - Marine Corps Systems Command

SUMMARY: Assisted Marine Corps Combat Development Command (MCCDC) in analyzing accession into the different officer programs by race, ethnicity, college attended, years of college, and other factors.

KEYWORDS: Demographics, Marine Corps Officer Candidate School

SENSOR MIX STUDY
W. Matthew Carlyle, Associate Professor
Department of Operations Research
Sponsor: U.S. Army Training Analysis Command Monterey

OBJECTIVE: The purpose of this research was to develop mathematical programming models for determining sensor mix for the objective force unit of action

SUMMARY: This study included the development of a large mathematical programming model for determining an optimal mix of sensors for the Army's objective force unit of action. For a given scenario, including red-force nominal positions, available sensor platforms, sensors, logistical capacity, etc., an optimal inventory of sensors was determined that provide adequate coverage and target detection possibilities. Maj. Stephanie Tutton, USA, graduated in 2003 from the Department of Operations Research; her thesis covered the development and implementation of the first version of the sensor mix model. A follow-on student, Major Thomas Doll, German Army, developed enhancements to the original model that allowed probabilistic line-of-sight calculations to be incorporated, thus representing various terrain types in the scenarios. His thesis will be submitted in June of 2004. Current research includes the integration of the sensor mix model with DAFS, a simulation model that includes sensor employment and performance estimates.

PRESENTATION:

Carlyle, W.M., "Optimal Sensor Mix for the Army Future Combat System Unit of Action," 71st Military Operations Research Society Symposium, WG-12, Quantico, VA, 2003.

THESIS DIRECTED:

Tutton, S., "Optimizing the Allocation of Sensor Assets for the Unit of Action," Master's Thesis, Naval Postgraduate School, June 2003.

KEYWORDS: Optimization, Sensors, Army

OPTIMIZATION MODELS FOR INSTALLATION MANAGEMENT
Robert F. Dell, Associate Professor
Department of Operations Research
Sponsor: U.S. Army, Assistant Chief of Staff for Installation Management

OBJECTIVE: The purpose of this research was to develop optimization models to assist with installation management.

SUMMARY: The investigator provided research, support, and development of optimization models to assist the Army's Assistant Chief of Staff for Installation Management. The integer-linear programs Optimal Stationing of Army Forces (OSAF), Budget Allocation for Environmental Cleanup (BAEC), and Base Realignment and Closure Action Scheduler (BRACAS) were the primary 2003 development effort. The Center for Army Analysis and The Army Basing Study used OSAF for numerous stationing studies and the Army will use OSAF to help plan its 2005 base realignment and closures. The Army's Base Realignment and Closure Office used BAEC to help plan over $350 million in environmental cleanup.

PRESENTATIONS:

Dell, R.F., "Funding Environmental Cleanup at Army Installations," National Meeting of the Institute for Operations Research and the Management Sciences, Atlanta, GA, 19-22 October 2003.

Dell, R.F., "Optimizing Military Capital Planning," Institute for Operations Research and the Management Sciences (INFORMS) Conference on Operations Research and Management Sciences Practice, Phoenix, AZ, 4-6 May 2003.

Dell, R.F., Brown, G.G., and Newman A., "Optimization Models for Military Capital Planning," National Meeting of the Institute for Operations Research and the Management Sciences, Atlanta, GA, 19-22 October 2003.

Dell, R.F. and Tarantino, W.J., "How Optimization Guides Army Stationing," National Meeting of the Institute for Operations Research and the Management Sciences, Atlanta, GA, 19-22 October 2003.

Dell, R.F. and Tarantino, W.J., "An Integer Linear Program to Recommend Army Stationing," 71st Military Operations Research Society Symposium, Marine Corps Base Quantico, VA, 10-12 June 2003.

TECHNICAL REPORT:

Dell, R.F. and Tarantino, W.J., "How Optimization Supports Army Base Closure and Realignment," Naval Postgraduate School Technical Report, NPS-OR-03-003-PR, April 2003.

THESIS DIRECTED:

Richards, C., "Modeling Unit Facility Requirements in an Integer Linear Program to Recommend Army Stationing," Master's Thesis, Naval Postgraduate School, September 2003.

KEYWORDS: BRAC, Capital Budgeting, Optimization, Mixed Linear Integer Programming Application

CAN/NAVAL POSTGRADUATE SCHOOL ANALYSIS INITIATIVE
James N. Eagle, Professor
Department of Operations Research
Sponsor: Space and Naval Warfare Systems Command

DEVELOPMENT OF NUCLEAR NONPROLIFERATION ASSESSMENT METHODOLOGIES
James N. Eagle, Professor
Department of Operations Research
Sponsors: U.S. Department of Energy – National Nuclear Security Administration

SUMMARY: Professor James N. Eagle, Chairman of the Department of Operations Research at the Naval Postgraduate School, supported the NNSA/NA-241 Nuclear Proliferation Assessment Methodologies (NPAM) project by participating in a working group consisting of U.S. National Laboratory and academic professionals. The working group developed guidelines for the practical application of NPAM to address questions and issues related to the proliferation of nuclear weapons and weapons-useable materials and related technologies, as input to policy.

KEYWORDS: NNSA/NA-241, Nuclear Proliferation, NPAM

RESOURCE SCHEDULING TOOLS FOR HOMELAND DEFENSE OPERATIONS: EMERGENCY MEDICAL MANAGEMENT, DISASTER RELIEF, AND SHIPMENT/BAGGAGE SCREENING
Donald P. Gaver, Distinguished Professor
Patricia A. Jacobs, Professor
Department of Operations Research
Sponsor: U.S. Department of Justice

OBJECTIVE: The goal of this research was to develop and utilize models and software to explain and justify the extra asset and personnel requirements imposed by new threats, and to provide ways of evaluating new proposed sensors, strategies, tactics, and concepts of operation (CONOPS) for combating a variety of threats and/or natural disasters.

SUMMARY: Models have been developed to study procedures for the allocation of resources to combat a terrorist biological attack.

CONFERENCE PRESENTATION:

Gaver, D.P. and Jacobs, P.A., "The Uncertain Time Critical Tasking Problem with Long-Tailed Demand," Canadian Operations Research Society/INFORMS International Meeting, Banff, Canada, May 2004, (invited).

OTHER:

Gaver, D.P. and Jacobs, P.A., "Planning Service to Provide Disaster Relief: Generic Command and Control Models," (report in progress).

Gaver, D.P., Jacobs, P.A., and Pilnick, S.E., "Small Worlds by Design," (report in progress).

Glazebrook, K.D., Gaver, D.P., and Jacobs, P.A., "Allocating Scarce Medical Resources in a Multi-Location Epidemic," Working Paper, August 2003.

Samorodnitsky, G., Gaver, D.P., and Jacobs, P.A., "A Model for Infection Spread and Immunization Effect," Working Paper, June 2003.

DoD KEY TECHNOLOGY AREAS: Biomedical, Human Systems Interface, Environmental Quality

KEYWORDS: Service Systems, First Responders, Homeland Security

STOCHASTIC MODELS WITH HEAVY TAILS AND LONG RANGE DEPENDENCE
Donald P. Gaver, Distinguished Professor
Department of Operations Research
Sponsor: Office of Naval Research, Naval Postgraduate School

OBJECTIVE: The purpose of this research was to formulate and study models for the adaptive scheduling of time critical tasks under imperfect information in joint warfare with a view towards guiding allocation of acquisition and eventually operational resources. The emphasis was on modeling the impact of information obtained from realistically imperfect sensor systems on interactive and joint conflicts.

SUMMARY: Models for allocation of service to time-critical tasks with uncertain outcomes were formulated and studied.

TECHICAL REPORT:

Gaver, D.P., Jacobs, P.A., and Samorodnitsky, G., "Modeling and Analysis of Uncertain Time-Critical Tasking Problems (UTCTP)," Naval Postgraduate School Technical Report, NPS-OR-03-005, October 2003.

OTHER:

Bullock, G., "Uncertain Time Critical Tasking," C++ software.

Gaver, D.P., Jacobs, P.A., and Samorodnitsky, G., "Modeling and Analysis of Uncertain Time-Critical Tasking Problems (UTCTP)," (submitted to a technical journal).

Glazebrook, K.D., Mitchell, H.M., Gaver, D.P., and Jacobs, P.A., "The Analysis of Shooting Problems via Generalized Bandits," (forthcoming).

Samorodnitsky, G., Gaver, D.P., and Jacobs, P.A., "Choosing the Best Customer to Serve and the Ratio Control Problem," (forthcoming).

DoD KEY TECHNOLOGY AREAS: Human-System Interface, Modeling and Simulation

KEYWORDS: Combat Models, Bayesian Perception Updating, Decision Analysis

SYSTEM OF STUDY OF THE JOINT PERSONNEL RECOVERY AGENCY (JPRA) MISSION
Donald P. Gaver, Distinguished Professor
Patricia A. Jacobs, Professor
Department of Operations Research
Sponsor: Joint Personnel Recovery Agency

OBJECTIVE: The goal of this research was to develop and utilize models and software to assist decision makers in the planning of personnel recovery missions

SUMMARY: High-level-low-resolution models for the study of benefits and potential challenges of joint personnel recovery operations have been formulated and studied.

OTHER:

Bullock, G. and Simons, R., "Personnel Recovery (PR)," JAVA software, September 2003.

Gaver, D.P. and Jacobs, P.A., "Formulation of and Modeling for Joint Personnel Recovery Agency (JPRA) Management Problems," Working Paper, July 2003.

Gaver, D.P. and Jacobs, P.A., "Stochastic Models for Personnel Rescue, and Analogous Modern Military Situations," Working Paper, September 2003.

Gaver, D.P., Jacobs, P.A., and Glazebrook, K.D., "Loss Models with Specialized Servers, with Application to Joint Personnel Recovery," Working Paper, August 2003.

DoD KEY TECHNOLOGY AREAS: Human-System Interface, Modeling and Simulation

KEYWORDS: Combat Models, Bayesian Perception Updating, Decision Analysis

TRAINING AND RESEARCH SUPPORT FOR DIRECTOR, OPERATIONAL TEST AND EVALUATION
Donald P. Gaver, Distinguished Professor
Patricia A. Jacobs, Professor
Department of Operations Research
Sponsors: Director, Operational Test and Evaluation and Naval Postgraduate School

OBJECTIVE: The purpose of this research was to develop training and reference material on a web site and a new methodology for operational testing use, emphasizing modeling and simulation.

SUMMARY: Models for system reliability growth via failure model removal were formulated and studied. Materials for an operational test and evaluation web site were developed.

PUBLICATION:

Gaver, D.P., Jacobs, P.A., Glazebrook, K., and Seglie, E., "Probability Models for Sequential- Stage System Reliability Growth via Failure Mode Removal," *International Journal of Reliability, Quality and Safety Engineering*, Vol. 10, No. 1, pp. 15-40, March 2003.

CONFERENCE PUBLICATION:

Gaver, D.P., Jacobs, P.A., and Seglie, E., "Dynamic System Acquisition and Testing Tradeoffs," *Safety and Reliability*, *Proceedings of the ESREL 2003 Conference*, T. Bedford and P.H.A.J.M. van Gelder (Eds.), Lisse, The Netherlands: A.A. Balkema Publishers, pp.649-652, 2003.

CONFERENCE PRESENTATIONS:

Gaver, D.P., Jacobs, P.A., and Seglie, E., "Dynamic System Acquisition and Testing Tradeoffs," European Safety and Reliability Conference, Maastricht, The Netherlands, 15-18 June 2003, (invited).

Gaver, D.P., Jacobs, P.A., and Seglie, E., "Test and Evaluation Challenges Posed by the New DoD 5000.1 Defense Acquisition Directive," U.S. Army Conference on Applied Statistics 2003, Napa Valley, CA, 29-31 October 2003, (contributed).

KEYWORDS: Military Test and Evaluation, Statistical Data Analysis, Decision Analysis, Modeling and Simulation

CHAIR OF WARFARE INNOVATION FOR SEA TRIAL EXPERIMENTATION, ANALYSIS, AND RESEARCH INITIATIVES
CAPT Jeffrey E. Kline, USN, Military Faculty
Department of Operations Research
Sponsor: Naval Warfare Development Command

CHAIR OF COST ANALYSIS
Robert A. Koyak, Assistant Professor
Robert R. Read, Professor
Department of Operations Research
Sponsor: Office of the Secretary of Defense, Program Analysis and Evaluation Branch

OBJECTIVE: The purpose of this project was to institute the Chair of Cost Analysis at Naval Postgraduate School under Office of the Secretary of Defense (OSD) sponsorship, and to initiate student and faculty research in cost analysis.

SUMMARY: The Program Analysis & Evaluation (PA&E) branch of OSD entered into a Memorandum of Understanding (MOU) with the Superintendent of Naval Postgraduate School (NPS) to institute and maintain a Chair of Cost Analysis at NPS. The function of the chair is to promote research in cost analysis at NPS both among students and faculty. One Masters student in Operations Research initiated thesis research in Fall 2003 under the auspices of this Chair.

KEYWORDS: Cost Estimation, Acquisition, Evaluation

OPTIMIZING MILITARY SUPPLY CHAINS DURING MILITARY OPERATIONS
Moshe Kress, Professor
Department of Operations Research
Sponsor: Unfunded

OBJECTIVE: The goal of this research was to develop dynamic stochastic optimization models for deploying supplies during military operations.

SUMMARY: Two models were developed for designing optimal operational logistics systems. One model was a multi-period network optimization model that captured key dynamic features of scenario-dependent operational logistics systems. Given an operational scenario, and its associated projection of demands, the model attempted to answer the following question: What is the least cost mix of logistics assets, and its distribution among the various echelons of the military force, such that (time-dependent) logistic and operational requirements are satisfied? The second model was a two-stage stochastic programming model that combined chance-constraints with recourse. Chance constraints with recourse are most appropriate for military logistics problems, where probability measures of effectiveness better fit operational requirements

than expected values. It was shown that the resulting optimization problem could be decomposed into two problems that were solved sequentially by an efficient combinatorial algorithm.

PUBLICATIONS:

Kress, M., "Network Optimization Models for Operational Logistics Systems," Center for Military Analysis, 23/03, 2003.

Kress, M., Penn, M., and Polukarov, M., "Two-Stage Supply-Chain with Recourse and Probabilistic Constraints," *Operations Research*, 2003, (submitted).

PRESENTATIONS:

Kress, M., "On the Design of Military Supply Chains During Military Operations," IE Department, University of Michigan, February 2003.

Kress, M., "On the Design of Military Supply Chains During Military Operations," Naval Postgraduate School, March 2003.

THESES DIRECTED:

Avital, I., "Two-Period, Stochastic Supply-Chain Models with Recourse for Naval Surface Warfare," Master's Thesis, Naval Postgraduate School, March 2004.

Ng, Y.S., "Optimizing a Military Supply Chain in the Presence of Random Non-Stationary Demands," Master's Thesis, Naval Postgraduate School, December 2003.

KEYWORDS: Operational Logistics, Multi-period Networks, Stochastic Programming, Recourse

POLICY AND OPERATIONAL ISSUES IN BIODEFENSE LOGISTICS
Moshe Kress, Professor
Department of Operations Research
Sponsor: Naval Postgraduate School

OBJECTIVE: The purpose of this research was to develop new mathematical models and methods for evaluating alternative policies and determining optimal procedures for responding to a bioattack on the general population.

SUMMARY: Two research efforts were conducted: 1) a model was developed that incorporates logistical, operational, and epidemiological aspects, for evaluating alternative vaccination policies, and this model was implemented for deriving policy recommendations; 2) a queuing model was developed for determining resource requirements and operational implications of a vaccination center. The first research project comprised a difference-equation model that extended and expanded earlier work by Kaplan, Craft, and Wein. It proposed a new vaccination policy – the prioritized vaccination policy. Utilizing the model, it was shown that the proposed vaccination policy was significantly more effective than the existing vaccination policies. The second research developed queuing models (Jackson Networks) for evaluating the resources needed to complete a mass vaccination process of the entire population within a specified period of time.

PUBLICATION:

Federgruen, A. and Kress, M., "Mass-Vaccination: Can It Be Done in Time? Completion Times in Queueing Systems," *Operations Research*, (submitted).

PRESENTATIONS:

Kress, M., "Policies for Biodefense Revisited: The Prioritized Vaccination Process for Smallpox," Institute for Operations Research and the Management Sciences (INFORMS), Atlanta, GA, October 2003.

Kress, M., "Policies for Biodefense Revisited: The Prioritized Vaccination Process for Smallpox," Naval Postgraduate School, May 2003.

TECHNICAL REPORT:

Kress, M., "Policies for Biodefense Revisited: The Prioritized Vaccination Process for Smallpox," Naval Postgraduate School Technical Report, NPS-OR-03-008, 2003, (submitted for publication in *Mathematical Biosciences*).

KEYWORDS: Bioattack, Vaccination, Logistics

TOPICS IN FIRING THEORY
Moshe Kress, Professor
Department of Operations Research
Israel David, Senior Lecturer
Ben-Gurion University, Israel
Sponsor: Unfunded

OBJECTIVE: The purpose of this research was to extend previous work on optimal aiming points to account for situations where multiple types of weapon systems are employed against an asymmetrical target.

SUMMARY: Pattern firing occurs when a weapon system is capable of selecting individual aiming-points for each one of its munitions. Many military operations research problems concern pattern firing, in particular when the ballistic error is negligible compared to the aiming error. Previous work by David and Alalouf has specified the optimal aiming-points for pattern-firing on a linear target, by n identical munitions that are subject to systematic (aiming) error only. Under the same distributional assumption on the error, this research generalized the previous results to the case where the munitions (weapons) varied in lethality and the target was asymmetrical. The results of this research can be utilized to determine effective bomb-release tactics for air-to-ground missions.

PUBLICATION:

David, I. and Kress, M., "'No Overlap No Gap' and the Attack of a Linear Target by n Different Weapons," *Journal of the Operational Research Society (JORS)*, (submitted).

KEYWORDS: Target Coverage, Firing Theory, Air-ground Operations

FEASIBILITY STUDY ON APPLICATIONS OF UV FILAMENTS TO SURFACE WAVE PROPAGATION
Andrés Larraza, Associate Professor
Department of Physics
David C. Jenn, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Air Warfare Center - Weapons Division

SUMMARY: Conducted a feasibility study on the application of UV laser atmospheric filaments to microwave propagation along the conductive path.

DoD KEY TECHNOLOGY AREA: Directed Energy Weapons

DESIGNING SIMULATION EXPERIMENTS TO SUPPORT THE FUTURE COMBAT SYSTEMS' SYSTEM-OF-SYSTEMS SUPPORTABILITY STUDY

Thomas W. Lucas, Associate Professor
Department of Operations Research
Sponsor: U.S. Army Training and Doctrine Command Analysis Center

OBJECTIVE: The goal of this research was to assist the United States Army is designing long running, high-resolution simulation experiments in support of Future Combat System (FCS) supportability.

SUMMARY: At the request of General Paul Kern, Commanding General, U.S. Army Materiel Command, the Training and Doctrine Command Analysis Center (TRAC) was asked to help in a study led by the Army Materiel Systems Analysis Activity (AMSAA) on the number of FCS vehicles of various types needed in a variety of conditions to ensure mission success. This research assisted the Training and Doctrine Command Analysis Center in determining input combinations for simulation runs of the Combined Arms and Support Task Force Evaluation Model (CASTFOREM). Over a dozen variables were varied. The time required to get the necessary data and the long run times restricted the number of runs that could be made. To give the experimenters options, multiple candidate designs were recommended, and quality measures were provided (e.g., orthogonality and space-filling metrics) on those designs. AMSAA selected and implemented a recommended design.

THE VALUE OF INFORMATION, MILITARY DECISION-MAKING, AND ANALYSIS OF COMBAT DATA

Thomas W. Lucas, Associate Professor
Department of Operations Research
Sponsor: Naval Postgraduate School

OBJECTIVE: The purpose of this research was to validate models and look for invariant trends in data sets on historical battles. This work used simple models and exploratory analysis to support decision-making and search for insights on the value of information.

SUMMARY: This research explored the validation of Lanchester equations as models of the attrition process for the Battle of Kursk in World War II. The Center for Army Analysis (CAA's) CDB90G data set, which contains about 140 attributes on nearly 660 land battles, was used to investigate which factors, over time, are associated with victory. In addition, simple models were used to determine the effects of varying levels of information. Finally, approaches were devised on how analysts should use models to support decision-makers.

PUBLICATIONS:

Lucas, T.W., "How Damage Functions Affect Estimates of Fratricide and Collateral Damage," *Naval Research Logistics*, 50, pp. 306-321, June 2003.

Lucas, T.W. and Dinges, J.A., "Considering Force Engagement Levels in Fitting Lanchester Equations to the Battle of Kursk," *Military Operations Research*, (under revision).

Lucas, T.W. and McGunnigle, J., "When is Model Complexity Too Much? Illustrating the Benefits of Simple Models With Hughes' Salvo Equations," *Naval Research Logistics*, 50, pp. 197-217, April 2003.

Lucas, T.W. and Turkes, T., "Fitting Lanchester Equations to the Battles of Kursk and Ardennes," *Naval Research Logistics*, 51, pp. 95-116, February 2004.

PRESENTATIONS:

Lucas, T.W., "Fitting Lanchester Equations to the Battles of Kursk and Ardennes," 20th International Symposium on Military Operations Research, Oxford, United Kingdom, August 2003.

Lucas, T.W., "Improving the Analytical Contribution of Warfighting Experiments," Defence Science and Technology Agency (DSTA) Seminar, Singapore, November 2003.

Lucas, T.W., "Military Modeling for Decision-Making," Defence Science and Technology Agency (DSTA) Seminar, Singapore, November 2003.

THESIS DIRECTED:

Cakan, A., "Determining the Importance of Nationality on the Outcome of Battles Using Classification Trees," Master's Thesis, Naval Postgraduate School, June 2003.

KEYWORDS: Modeling and Simulation, Combat Analysis, Decision-Making

BLUE-ON-BLUE AND ADAPTIVE JOINT C4ISR NODE
LTC Saverio M. Manago, USA, Military Faculty
Department of Operations Research
Sponsor: Naval Security Group Command

CONCEPT OF OPERATIONS (CONOPS) DEVELOPMENT AND FRATRICIDE REDUCTION USING THE ADAPTIVE JOINT C4ISR NODE
LTC Saverio M. Manago, USA, Military Faculty
Department of Operations Research
Sponsor: Naval Postgraduate School

OBJECTIVE: The purpose of this project was to assist Joint Forces Command (JFCOM) in the development of Concept of Operations (CONOPS) for the Adaptive Joint C4ISR Node (AJCN) through the use of war gaming and analysis.

SUMMARY: This project's team developed and conducted a war game that employed the AJCN in a strategic and operational setting. Initial analysis and review of war game resulted in several insights, which were passed on to JFCOM. Databases for Joint Conflict and Tactical Simulation (JCATS) were developed and laboratory facilities updated to reflect state of the art in joint combat models. Connectivity to the Global Command and Control System – Joint (GCCS-J) is underway to facilitate analysis and visual representation of actual operations in JCATS.

KEYWORDS: AJCN, C4ISR, Fratricide Prevention, Combat Modeling, Simulation

SIGNALS INTELLIGENCE (SIGINT) DATA OVERLOAD
LTC Saverio M. Manago, USA, Military Faculty
Department of Operations Research
Sponsor: Space and Naval Warfare Systems Command San Diego

OBJECTIVE: The goal of this research was to examine issues related to signals intelligence (SIGINT) overload of operators in the Counterintelligence Center (CIC) and to build lab capability in the Sensitive Compartmented Information Facility (SCIF) to conduct further research.

SUMMARY: Dr. Jeff Crowson, Naval Postgraduate School faculty member, provided research and support to assist in the assessment of human factors and how they impact on the ability of operations officers and sailors to assimilate, fuse, and understand data. LTC Manago purchased equipment to provide additional research capability for follow on projects in the SCIF.

KEYWORDS: Human Factors, Data Fusion, Situational Understanding, Data Overload, Vigilance

HUMAN-SYSTEMS INTEGRATION ISSUES IN AUTONOMOUS COLLABORATIVE FLIGHT OF ARMY UNMANNED AERIAL VEHICLES
Michael E. McCauley, Research Professor
Department of Operations Research
Sponsor: Army/National Aeronautics and Space Administration Rotorcraft Division,
National Aeronautics and Space Administration Ames Research Center

OBJECTIVE: This research reviewed and summarized the development of concepts, architectures, and systems for human interface and control of multiple, semi-autonomous Unmanned Aerial Vehicles (UAVs).

SUMMARY: In current Army UAV operations, a unit of over 20 humans operates three UAVs sequentially. Future systems must look toward an improved human-to-UAV ratio, which can be enabled by automation. An important Human Systems Integration issue is to define the roles and responsibilities of the human operators in semi-autonomous UAV systems. The research literature was reviewed in cockpit automation, teleoperation of robots, mixed-initiative systems, semi-autonomous systems, human-robot interfaces, and current UAV systems. Issues of automation, supervisory control, adaptive function allocation, and levels of autonomy were investigated. A final report provided recommendations for defining the roles of the human and the semi-automated subsystems and design of the user interfaces for future UAV control systems.

KEYWORDS: UAVs, Autonomous Collaborative Flight, Human-Systems Integration, Human Interface

MOTION IN ARMY ROTORCRAFT SIMULATION AND TRAINING
Michael E. McCauley, Research Professor
Department of Operations Research
Sponsor: Rotary Wing Aviation Research Unit, Army Research Institute

OBJECTIVE: The purpose of this research was to review and summarize the evidence for the training effectiveness of simulator motion bases and other motion cuing devices for Army rotorcraft pilot training.

SUMMARY: The U.S. Army is undergoing major revisions in pilot training programs. New simulators are likely to be acquired or operated as part of the Flight School XXI initiative. A long-standing debate in the simulation community has been the value of motion cuing devices, including hexapod motion bases, for training effectiveness, user acceptance, or the mitigation of a side-effect known as simulator sickness. In this project, the scientific literature was reviewed for empirical evidence supporting the training effectiveness of motion. In short, there was no such empirical evidence. Simulator motion bases contribute to precise aircraft control by experienced test pilots. Some trainees and instructors seemed to prefer motion to no motion. There was no evidence to suggest that simulator training effectiveness for Army pilots would suffer from the lack of a motion base, but cost savings in acquisition and maintenance were certain.

KEYWORDS: Rotorcraft, Pilot Training, Flight School XXI. Motion Cuing

FATIGUE AND HUMAN PERFORMANCE IN U.S. NAVAL SUBMARINERS
Nita L. Miller, Visiting Assistant Professor
Department of Operations Research
Sponsor: Naval Submarine Medical Research Laboratory

SUMMARY: The investigator provided consultation and support of research to assess the sleep patterns and fatigue of U.S. Navy submariners. The project focused on the analysis of actigraphy data and other performance measures that were collected from personnel aboard submarines. The study sought to determine if there were demonstrable differences in human performance that were attributable to watchstanding schedules.

KEYWORDS: Fatigue, Submarine, Actigraphy, Human Performance

HUMAN FACTORS ANALYSIS FOR FUTURE COMBAT SYSTEMS C4ISR EXPERIMENT
Nita L. Miller, Visiting Assistant Professor
Department of Operations Research
Sponsor: U.S. Army TRADOC Analysis Command

OBJECTIVE: This project was designed to assist the U.S. Army TRADOC Analysis Command (TRAC) collect and analyze relevant human factors associated with mental workload and situational awareness of the participants in the C4ISR (Communication, Command and Control, and Computers, Intelligence, Surveillance and Reconnaissance) experiment.

DoD KEY TECHNOLOGY AREAS: Command, Control, Communications, and Human Systems Integration

KEYWORDS: Human Systems Integration, C4ISR, Workload

NETFIRES DYNAMIC ALLOCATION OF WEAPONS EFFECTS
Nita L. Miller, Visiting Assistant Professor
Department of Operations Research
Sponsor: TRADOC Analysis Command

SUMMARY: The objective of this report was to develop a Bayesian network that represented human factors and the impact they have on combat operations. The model enhanced decision-making capability, and was especially relevant to the force protection issues of operational tempo and risk.

KEYWORDS: Baynesian Network, Human Factors, Decision Making, Tempo, Risk

PROCESS TRACKING OF INFORMATION IN AN FUTURE COMBAT SYSTEMS COMMAND-AND-CONTROL (C2) ENVIRONMENT
Nita L. Miller, Visiting Assistant Professor
Department of Operations Research
Sponsor: Defense Advanced Research Projects Agency

SUMMARY: The purpose of this project was to provide support to the Defense Advanced Research Projects Agency (DARPA) FCS Command and Control (C2) experiment team to assist them in their analysis of describing the flow of data elements through the C2 system. This analysis included analyses of human factors.

KEYWORDS: C2, Data Elements, DARPA

LINES OF COMMUNICATION AND AGENT BASED SYSTEMS
Peter Purdue, Professor
Department of Operations Research
Sponsor: Joint Staff (J8)

OBJECTIVE: The goal of this project was to support a conference/workshop on Complex Systems and National Security.

SUMMARY: Alidade Consulting was selected to organize and conduct the conference/workshop. The event was held as part of the "3rd International Workshop on New Horizons in Search Theory," 2-5 September 2003 in Newport, Rhode Island.

PUBLICATION: A CD was created and distributed to all participants and the sponsor.

KEYWORDS: Lines of Communication, Agent-Based Systems, Alidade, Complex Systems

NAVAL POSTGRADUATE SCHOOL SUPPORT FOR UNDERSECRETARY OF DEFENSE (PERSONNEL AND READINESS)
Peter Purdue, Professor
Department of Operations Research
Sponsor: Office of the Secretary of Defense (Personnel and Readiness)

OBJECTIVE: The goal of this research was to provide analytic support on topics as directed by the Office of the Secretary of Defense, Undersecretary of Defense, Personnel and Readiness.

SUMMARY: In concert with Professors Washburn, Franke, Eaton, and Conner, the Principal Investigator carried out a detailed study of the U.S. Air Force (USAF) Operational Support Aircraft (OSA) utilization. This research was an in depth examination of the USAF claim that the C21 fleet (a major component of the OSA) was a vital and cost effective means of developing aircraft commanders. Professor Purdue and Dr. John Enns, Office of the Secretary of Defense (OSD), conducted a study of the manning of UAVs. In particular, researchers examined the USAF claim that UAVs should be "piloted" by rated pilots. Alternate piloting options were also costed out.

PUBLICATIONS:

Two major reports were written and submitted directly to the sponsor.

PRESENTATION:

Purdue, P., "Manning Unmanned Vehicles," 20th International Symposium on Military Operations Research, Oxford, England, 26-29 August 2003.

KEYWORDS: Operational Support Aircraft, C21, UAV, Piloting

NAVAL POSTGRADUATE SCHOOL / N81 SUPPORT RELATIONSHIP
Peter Purdue, Professor
Department of Operations Research
Sponsor: Chief of Naval Operations (N81)

OBJECTIVE: The purpose of this work was to conduct a program of general research and development, analysis, and education on Naval issues in areas of interest to the Chief of Naval Operations (CNO), Code N81.

SUMMARY: The principal investigator carried out a search for executive-style courses that N81 could use in developing young analysts, both in N81 and as part of an internship program. The PI also examined the structure of the Operations Research (1515) civilian community within the Navy and reported on possible ways to develop the community. Additional short-term studies were conducted at the sponsor's request.

PUBLICATIONS: Letter reports were provided directly to the sponsor.

KEYWORDS: Executive education, Operations Research 1515, Civilian

DYNAMIC ALLOCATION OF STRIKE FORCE ASSETS (YEAR 2)
Richard E. Rosenthal, Professor
Department of Operations Research
Sponsor: Space and Naval Warfare Systems Command - San Diego

SUMMARY: The Space and Naval Warfare Systems Command (SPAWAR) is developing the Real-time Execution Decision Support System (REDS). Within the System, SPAWAR envisions a mathematical model for composing strike packages from available assets and allocating those packages to targets. This proposal was for the second year of a Naval Postgraduate School (NPS) research project in support of SPAWAR. The first year's research resulted in the development of integer programming optimization models that can be used for designing and assigning strike packages in both static and dynamic contexts. These models contain a persistence feature to encourage optimal solutions to conform to recommendations made in previous runs of the model. The second year of this research focused on speeding up solution times (the largest instance considered to date took three minutes on a personal computer), removed limiting assumptions on strike package composition, and developed new features to add more modeling realism.

KEYWORDS: Strike Force Assets, REDS, Real-Time Executive Decision Support

OPTIMIZATION MODELING FOR PLANNING INVESTMENTS IN AIRLIFT
Richard E. Rosenthal, Professor
Laura Williams. Research Assistant Professor
Sponsor: Office of the Secretary of Defense

SUMMARY: This annual proposal for continued support of the Office of the Secretary of Defense (Program Analysis and Evaluation) aided in the POM process with respect to military airlift. Researchers used the Naval Postgraduate School/Rand Mobility Optimization (NRMO) and other optimization modeling approaches to prioritize investments in the military airlift system. Areas of study included, but were not limited to, infrastructure improvements and tanker fleet investments.

KEYWORDS: Military Airlift, NRMO, Rand Mobility Optimization

OPTIMIZING TOMAHAWK LAND ATTACK PREDESIGNATION
Richard E. Rosenthal, Professor
Javier Salmeron, Research Assistant Professor
Department of Operations Research
Sponsor: Naval Surface Warfare Center-Dahlgren Division

OBJECTIVE: The purpose of this project was to continue research on optimization models and methods for Tomahawk land attack missile predesignation.

SUMMARY: During 2003, the Naval Surface Warfare Center (NSWC) Dahlgren Division implemented a Java code called Land-Attack Predesignation (LAP) for conducting heuristic allocation of Tomahawk missiles to targets. NSWC's development was based on Naval Postgraduate School (NPS) research, which was conducted in earlier years of this project. The NSWC implementation adhered to earlier specifications

provided in past NPS project reports. The first phase of the implementation was completed and sent to NPS by the end of June 2003 for testing purposes. NPS researchers used a test bed of cases from previous theses in order to assess the validity and efficiency of this LAP code. A preliminary report on this testing was sent to NSWC for review in August 2003. While most cases provided the expected answers, there were a few instances experiencing execution errors (and, thus, no solution). The project report described and diagnosed these exceptions, and provided remedies for each exception type. Additionally, small examples were created to validate specific model features independently of the others. In these tests, one small example was constructed in which the algorithm substantially failed to provide a near-optimal solution. This project also recommended specific actions to NSWC, such as double-checking the implementation of the platform selection and release from tasking according to the so-called "scores" in the algorithm.

KEYWORDS: Tomahawk Predesignation, Combinatorial Programming, Heuristics Optimization

OPTIMIZING TOMAHAWK LAND ATTACK PREDESIGNATION
Richard E. Rosenthal, Professor
Department of Operations Research
Sponsor: Naval Surface Warfare Center-Dahlgren Division

SUMMARY: The goal was to continue improving the design, development, and testing of procedures with which the fleet can allocate tasks requiring land attack missiles to specific surface ships and submarines. The objective was to meet the tasking requirements as closely as possible while simultaneously considering factors such as retaining maximal follow-on firing capability, and leveling missile allocation across designated platforms. Researchers extended a model that was capable of producing an allocation in a realistic amount of time, while capturing details such as different types of land attack weapons, platform and launcher loadouts and capabilities, and battle group compositions. These extensions included providing the user with guidance when a full allocation cannot be achieved, accepting a partially manually-derived solution, and incorporating multiple-strike "waves" of tasking assignments that may have been passed to various points in the chain of command. Additionally, the model's allocations must be tested against real data, e.g., obtained from manual assignment made during fleet exercises.

KEYWORDS: Tomahawk, Predesignation

HOMELAND SECURITY RESEARCH AND TECHNOLOGY PROPOSAL (OPTIMIZING ELECTRIC GRID DESIGN UNDER ASYMMETRIC THREAT)
Javier Salmeron, Research Assistant Professor
R. Kevin Wood, Professor
Department of Operations Research
Sponsor: U.S. Department of Justice

OBJECTIVE: This research continued work on optimization models and methods for analyzing the vulnerability of electric power systems to potential disruptions caused by terrorist attacks.

SUMMARY: This research extended the team's earlier work to improve the security of electric power grids subject to disruptions caused by terrorist attacks. To identify critical system components (e.g., generators, transmission lines, buses, transformers), bi-level optimization models were devised that identified maximally disruptive attack plans for terrorists, who were assumed to have limited offensive resources. A new model captured the dynamics of system operation as a network was repaired after an attack, and an earlier heuristic was adapted for that model's solution. The team also developed a new, mixed-integer programming model (MIP) for the problem; a model that could be solved exactly using standard optimization software, at least in theory. Preliminary testing showed that optimal solutions were readily achieved for certain standard test problems, although not for the largest ones, which the heuristic seemed to handle well. However, optimal solutions provided a benchmark to measure the accuracy of the heuristic: the heuristic typically achieved optimality gaps of less than 10%, but occasionally the gap reached 25%. Research will continue to refine the heuristic algorithm, the MIP formulation, and the

algorithms to solve it. Progress was also demonstrated on a graphical user interface that allowed this research's interdiction analysis to be performed in a friendly environment.

PUBLICATION:

Salmeron, J., Wood, R.K., and Baldick, R., "Analysis of Electric Grid Security Under Terrorist Threat," *IEEE Transactions on Power Systems*, 2003-II, (to appear).

CONFERENCE PRESENTATION:

Brown, G., Carlyle, M., Salmeron, J., and Wood, K., "How to Build a Robust Supply Chain, or Harden the One You Have," Institute for Operations Research and the Management Sciences (INFORMS), Atlanta, GA, 2003.

TECHNICAL REPORT:

Salmeron, J., Wood, R.K., and Baldick, R., "Optimizing the Electric Grid Under Asymmetric Threat," Naval Postgraduate School Technical Report, NPS-OR-03-002, 2003-I.

THESIS DIRECTED:

Stathakos, D., "An Enhanced Graphical User Interface for Analyzing the Vulnerability of Electrical Power Systems to Terrorist Attacks," Master's Thesis, Naval Postgraduate School, 2003.

KEYWORDS: Optimization, Homeland Security, Electric Power Grids

ADAPTIVE EXPLORATION OF AGENT-BASED COMMAND AND CONTROL SIMULATIONS
Susan M. Sanchez, Professor
Thomas W. Lucas, Associate Professor
Department of Operations Research
Sponsor: U.S. Marine Corps Combat Development Command

SUMMARY: The overall objective of this study was to provide an expert-driven, adaptive, sequential approach for rapid identification of robust command and control (C2) decisions. These are decisions that tend to work well despite uncertainty in modeling assumptions and real-world conditions.

KEYWORDS: Command and Control, C2, Agent-Based Simulation

NAVAL POSTGRADUATE SCHOOL STUDY ON ADAPTIVE EXPLORATION OF AGENT-BASED SIMULATIONS
Susan M. Sanchez, Professor
Thomas W. Lucas, Associate Professor
Department of Operations Research
Sponsor: U.S. Marine Corps Warfighting Laboratory

OBJECTIVE: The purpose of this research was to develop a framework that facilitates high-dimensional exploration of simulations.

SUMMARY: Analysts used combat models to provide information to decision-makers who must make and justify decisions involving billions of dollars and impacting many lives. This research continued a multi-year effort to define, test, and implement a new set of high-dimensional search strategies for use in rapidly exploring agent-based simulations. The efficiency of the search strategies under a variety of scenarios was examined with computational experiments. These experiments were conducted on a variety

of agent-based simulations involving peace enforcement, littoral combat ships, logistics support in urban disaster relief operations, network centric warfare, and fighting the global war on terrorism.

PUBLICATIONS:

Cioppa, T.M. and Lucas, T.W., "Efficient Nearly Orthogonal and Space-filling Latin Hypercubes," *Technometrics*, (under review).

Kleijnen, J.P.C., Sanchez, S.M., Lucas, T.W., and Cioppa, T.M., "A User's Guide to the Brave New World of Designing Simulation Experiments," *INFORMS Journal on Computing*, (revised and resubmitted).

Lucas, T.W. and Sanchez, S.M., "NPS Hosts the Marine Corps Warfighting Laboratory's Sixth Project Albert International Workshop," *Naval Postgraduate School RESEARCH*, 13, 2, Naval Postgraduate School, pp. 45-46.

Lucas, T.W. and Sanchez, S.M., "Smart Experimental Designs Provide Military Decision-Makers with New Insights from Agent-Based Simulations," *Naval Postgraduate School RESEARCH*, 13, 2, Naval Postgraduate School, pp. 20-21, 57-59, 63.

Lucas, T.W., Sanchez, S.M., Cioppa, T.M., and Ipekci, A.I., "Generating Hypotheses on Fighting the Global War on Terrorism," *Maneuver Warfare Science 2003*, United States Marine Corps Project Albert, Quantico, VA, pp. 107-124, 2003.

Wan, S.C., Choo, C.S., Ng, E.C., Ang, C.K., Lucas, T.W., and Fry, A., "Modeling Communications in Sensor Networks Using Agent-Based Distillations," *Maneuver Warfare Science 2003*, United States Marine Corps Project Albert, Quantico, VA, pp. 23-38, 2003.

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Wolf, E.S., Sanchez, S.M., Goerger, N.C., and Brown, L.P., "Using Agents to Model Logistics," *Military Operations Research*, (under review).

CONFERENCE PUBLICATION:

Sanchez, S.M. and Wu, H.-F., "Frequency-Based Designs for Terminating Simulations: A Peace-Enforcement Example," *Proceedings of the 2003 Winter Simulation Conference*, S. Chick, P.J. Sanchez, D. Morrice, and D. Ferrin (Eds.), Piscataway, NJ: Institute of Electrical and Electronic Engineers, pp. 952-959, 7-10 December 2003, (invited paper).

PRESENTATIONS:

Lucas, T.W., "High-Dimensional Explorations of Agent-based Simulations," Modeling, Virtual Environments, and Simulation (MOVES) Open House, Naval Postgraduate School, August 2003.

Milton, R., Sanchez, S.M., Wolf, E., Steele, M., Johnson, S., Middleton, D., et al., "Expeditionary Logistics," 7th Project Albert International Workshop, Woodbridge, VA, September 2003.

Sanchez, S.M. and Wolf, E.S., "Using Agent-Based Models for Expeditionary Logistics," Institute for Operations Research and the Management Sciences (INFORMS) 2003 Annual Meeting, Atlanta, GA, October 2003.

Wolf, E.S., "Inbrief: Team Logistics," 6th Project Albert International Workshop, Monterey, CA, March 2003.

Wolf, E.S., "Using Agents to Model Logistics in an Urban, Humanitarian Assistance/Disaster Relief Operation," 7th Project Albert International Workshop, Woodbridge, VA, September 2003.

Wolf, E.S., "Using Agents to Model Logistics," 71st Military Operations Research Society Symposium, Quantico, VA, June 2003.

Wolf, E.S., Smith, N., and Widdowson, B., "Outbrief: Team Logistics," 6th Project Albert International Workshop, Monterey, CA, March 2003.

THESES DIRECTED:

Efimba, M.E., "An Exploratory Analysis of the Littoral Combat Ships' Ability to Protect Expeditionary Strike Groups," Master's Thesis, Naval Postgraduate School, September 2003.

Wolf, E.S., "Using Agent-Based Distillations to Explore Logistics Support to Urban, Humanitarian Assistance/Disaster Relief Operations," Master's Thesis, Naval Postgraduate School, September 2003.

KEYWORDS: Modeling and Simulation, Design of Experiments, Agent-based Models

GRADUATE EDUCATION EXCELLENCE
David A. Schrady, Professor
Department of Operations Research
Sponsor: Naval Postgraduate School

OBJECTIVE: The objective was to provide the opportunity for scholarly work that relates to both graduate education and one's professional competence, outside the normal requirements of reimbursably-funded sponsored research.

SUMMARY: The support provided by the Graduate Education Excellence funds was used to revise course notes later used as text for two courses: OA 3501, Inventory Models: Theory and Navy Practice and OS 4580, Logistics Systems Analysis. Also supported was study and documentation of the logistics operations of Operation Iraqi Freedom. Finally, these funds supported preparation of a short paper and presentation on a logistical analysis of the littoral combat ship. The paper and presentation were based on a student thesis, but were substantially new.

CONFERENCE PUBLICATION:

Schrady, D.A. and Rudko, D., "Logistics Analysis of the Littoral Combat Ship," *Proceedings of the International Symposium on Military Operational Research*, Oxfordshire, UK, 27 August 2003.

PRESENTATION:

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

KEYWORDS: Sustainability, Expeditionary Logistics, Expeditionary Maneuver Warfare

NAVAL LOGISTICS COMMAND AND CONTROL
David A. Schrady, Professor
Department of Operations Research
Sponsor: Office of Naval Research

OBJECTIVE: The objective of this project was to support Lockheed Martin, Naval Electronics and Surveillance Systems (NE&SS), in defining top-level requirements to support Naval logistics command and control (NLC2). Logistics command and control is a part of the Office of Naval Research (ONR) Future Naval Capabilities program.

SUMMARY: The project involved a team consisting of Lockheed Martin (LM), NE&SS and Advanced Technology Laboratory (ATL), Penn State University Applied Research Laboratory (ARL), Metron, Incorporated, and Naval Postgraduate School (NPS). An NLC2 Needs and Functional Assessment Workshop was held at Penn State from 30-31 July 2003. The workshop brought together researchers and Fleet logistics professionals and resulted in the specification of the requirements for NLC2. A project review meeting was held 18-19 September 2003 at Metron, Solano Beach, CA, involving the sponsor and other organizations. Virtually all of the on-going work related to logistics command and control in the Navy and Marine Corps was reviewed. Lockheed Martin prepared a final report to ONR, including inputs from all participants.

KEYWORDS: Sea Basing, Logistics Command and Control, Autonomic Logistics

CONTROL VARIATES TECHNIQUES FOR MONTE CARLO SIMULATION
Roberto Szechtman, Assistant Professor
Department of Operations Research
Sponsor: Naval Postgraduate School

OBJECTIVE: In this paper, an overview of classical results about the variance reduction technique of control variates was presented. Aspects of the theory that were of importance to the practitioner were emphasized, as well as the presentation of relevant applications.

CONFERENCE PUBLICATION:

Szechtman, R., "Control Variates Techniques for Monte Carlo Simulation," *Proceedings of the 2003 Winter Simulation Conference*, New Orleans, LA, December 2003.

PRESENTATION:

Szechtman, R., "Control Variates Techniques for Monte Carlo Simulation," 2003 Winter Simulation Conference, New Orleans, LA, 2003.

KEYWORDS: Monte Carlo, Variance Reduction

EFFICIENT MONTE CARLO SIMULATION OF CONDITIONAL EXPECTATION DISTRIBUTIONS
Roberto Szechtman, Assistant Professor
Department of Operations Research
Paritosh Desai
Stanford University
Sponsor: Naval Postgraduate School

OBJECTIVE: The purpose of this research was to find optimal Monte Carlo simulation strategies of conditional expectation distributions.

PRESENTATION:

Paper draft, 2003 Institute for Operations Research and the Management Sciences (INFORMS) Conference, Atlanta, Georgia.

KEYWORDS: Monte Carlo, Conditional Expectation Distributions

EXACT CONDITIONAL ASYMPTOTICS OF LARGE DEVIATIONS IN R^D
Roberto Szechtman, Assistant Professor
Department of Operations Research
Peter W. Glynn, Professor
Management Science and Engineering, Stanford University
Sponsor: Naval Postgraduate School

OBJECTIVE: Sharp conditional large deviation results for several general conditioning sets in more than one dimension were obtained. The results were new and extended theory that was already available in the unconditioned scenario. Applications to logistics were also developed.

KEYWORDS: Conditioning Sets, Large Deviation Results

ON CONTROL VARIATES TECHNIQUES
Roberto Szechtman, Assistant Professor
Department of Operations Research
Sponsor: Naval Postgraduate School

OBJECTIVE: The purpose of this project was to author a chapter that appeared in *Elsevier Handbooks in Operations Research and Management Science: Simulation.* The focus was on the relation between control variates techniques and other variance reduction techniques, such as conditional Monte Carlo, importance sampling, stratified sampling, and correlation induction.

KEYWORDS: Elsevier, Monte Carlo, Importance Sampling, Stratified Sampling, Correlation Induction

TARGETING OPTIMIZATION
Alan R. Washburn, Professor
Department of Operations Research
Sponsor: TRADOC Analysis Command

SUMMARY: Created software for optimally aiming a weapon set at a target set. The main purpose of the software was to enable studies of the value of global versus local information in making optimal weapon assignments, in the context of network-centric warfare. A subsidiary purpose was to illuminate tradeoffs between information and firepower.

KEYWORDS: Targeting Optimization, Network-Centric Warfare

STATISTICAL PROBLEMS IN SCORING OF IMPACT LOCATIONS OF PROJECTILES FIRED FROM AIRCRAFT
Lyn R. Whitaker, Associate Professor
Department of Operations Research
Sponsor: U.S. Army Yuma Proving Ground

SUMMARY: The U.S. Army's Yuma Test Center (YTC) tests the accuracy of guns and other munitions fired at targets. One method used by YTC for determining the impact points of munitions is ground-level

inspection, also known as the "Stradia" method. YTC has also adopted an alternative method, known as overhead scoring (OHS), to determine impact points. With OHS, the test range is aerially videotaped during the test event, and the videotape is inspected at a later time. The proposed research was concerned with the development of statistical techniques for calibrating test metrics based on OHS in order to make them comparable to Stradia scoring. Another focus was to conduct preliminary analysis of a test event at YTC in August 2003. Statistical tools were developed to assist in the data analysis effort that followed.

KEYWORDS: Yuma Test Center, Stradia, Munitions Accuracy, OHS

SUPPORT FOR THE CENTER FOR OPERATIONS RESEARCH, NATIONAL SECURITY AGENCY (U)
R. Kevin Wood, Professor
Department of Operations Research
Sponsor: National Security Agency

OBJECTIVE: The purpose of this project was to provide on-call analytical support to the National Security Agency (NSA), to provide support for Naval Postgraduate School (NPS) students working on projects of interest to NSA, and to provide support for NPS faculty visits to NSA to deliver presentations on current research.

SUMMARY: A paper on enumerating near-min cuts was completed, several lectures were presented for the Operations Research group at NSA, and a doctoral student at NPS began research on a network diversion problem. Certain manpower problems at NSA were also investigated.

PUBLICATION:

Balcioglu, A. and Wood, R.K., "Enumerating Near-Min s-t Cuts," *Network Interdiction and Stochastic Integer Programming*, D.L. Woodruff (Ed.), Kluwer Academic Publishers, pp. 21-49, 2003.

KEYWORD: Optimization

DEPARTMENT OF OPERATIONS RESEARCH

2003
Faculty Publications
and Presentations

PUBLICATIONS

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Szechtman, R., "Control Variates Techniques for Monte Carlo Simulation," *Proceedings of the 2003 Winter Simulation Conference*, New Orleans, LA, December 2003.

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Bradley, G., "Extensible Markup Language (XML), Optimization, and Simulation," Air Force Office of Scientific Research Optimization and Discrete Mathematics Program Review, Estes Park, CO, 27-28 May 2003.

Bradley, G., "Tutorial: Extensible Markup Language with Operations Research Examples," Eighth Institute for Operations Research and the Management Sciences (INFORMS) Computing Society Conference, Chandler, AZ, 8-10 January 2003.

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GRADUATE SCHOOL OF ENGINEERING AND APPLIED SCIENCES

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DEPARTMENT OF AERONAUTICS AND ASTRONAUTICS

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AERONAUTICS AND ASTRONAUTICS

OVERVIEW:

The Department of Aeronautics and Astronautics is an integral part of the Graduate School of Engineering and Applied Sciences. Aero/Astro faculty members conduct research and teach courses covering air and space vehicles, missiles, propulsion, aerodynamics, avionics, control systems, structures, turbomachinery, computational and experimental methods, orbital mechanics and combat survivability that emphasize total systems design. The uniqueness of this approach is that air and space vehicles are considered part of a larger combat system that includes all aspects of war fighting.

Navy and Marine Corps aircraft are designed to operate abroad ships as part of a larger battle group. Challenges normally not considered by aircraft operating from land bases become design constraints for shipboard compatibility. By working in a Total System Design Group, Aero/Astro faculty and students are exposed to the constraints of shipbuilding, software development and weapons compatibility. Additional issues such as acquisition methods, analysis of alternatives, and order of battle scenarios can be explored by working with the Graduate School of Business and Public Policy, the Graduate School of Operations and Information Sciences, and the School of International Graduate Studies. Aero/Astro faculty and students are exposed to a wide variety of disciplines to develop capable runway-independent aircraft and robust space systems.

CURRICULA SERVED:

- Aeronautical Engineering (Curriculum 610)
- Engineering/Avionics (Curriculum 611)
- NPS-TPS Cooperative Program (Curriculum 612)
- Space Systems Engineering (Curriculum 591)

DEGREES GRANTED:

- Master of Science in Aeronautical Engineering
- Master of Science in Engineering Science
- Master of Science in Astronautical Engineering
- Aeronautical and Astronautical Engineer
- Doctor of Engineering

RESEARCH THRUSTS:

- Aerospace Vehicle Design
- Aerodynamics, Aeroelasticity, V/STOL Aircraft Technology
- Flight Mechanics and Controls
- Structures, Structural Dynamics, Composite Mechanics, Fracture and Fatigue
- Propulsion and Gas Dynamics
- Avionics
- Rotary Wing Aircraft Technology
- Aircraft Combat Survivability
- Spacecraft Systems, Attitude Control and Smart Structures
- Spacecraft Guidance, Control and Optimization

RESEARCH FACILITIES:

- Aeronautical Engineering Laboratories:
  - Aerodynamics Laboratory
  - Gas Dynamics Laboratory
  - Combustion Laboratory

- o Turbo-Propulsion Laboratory
- o Computation Laboratory
- o Flight Mechanics Laboratory
- o Structures and Composite Laboratory
- o Controls Laboratory
- o Avionics Laboratory
- o Survivability and Lethality Assessment Laboratory
- o Rotorcraft Laboratory
- o Aeronautics Design Laboratory
- Spacecraft Laboratories:
  - o FLTSATCOM Laboratory
  - o Spacecraft Test Laboratory
  - o Spacecraft Attitude Dynamics Laboratory
  - o Spacecraft Design Laboratory

RESEARCH CENTERS:

- Navy-NASA Joint Institute of Aeronautics
- Spacecraft Research and Design Center
- Turbo-Propulsion Laboratory
- Vertical Flight Technology Center
- Aerodynamics Decelerator Systems Center

RESEARCH PROGRAM (Research and Academic)-FY2003:

The Naval Postgraduate School's sponsored program exceeded $71 million in FY2003. Sponsored programs included both research and educational activities funded from an external source. A profile of the sponsored program for the Department of Aeronautics and Astronautics is provided below:
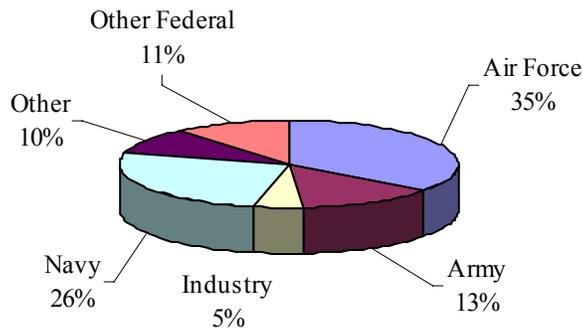
Size of Program: $2,888K

AERONAUTICS AND ASTRONAUTICS

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ACQUISITION, TRACKING AND POINTING OF MILITARY SPACECRAFT
Brig N. Agrawal, Professor
Department of Aeronautics and Astronautics
Sponsor: National Reconnaissance Office

SUMMARY: The objective of this project was to evaluate state-of-the-art acquisition, tracking, and pointing technologies and to develop a roadmap to develop these technologies to meet the performance requirements of future military spacecraft. The tasks included evaluation of state-of-art, development of a new course on acquisition, tracking and pointing; and organization of a workshop in summer 2003 at the Naval Postgraduate School in this area.

KEYWORDS: Spacecraft, Course

ANGULAR RATE ESTIMATION BY DYNAMIC GYRO FOR SPACECRAFT ATTITUDE CONTROL
Brig N. Agrawal, Professor
Department of Aeronautics and Astronautics
Sponsor: National Reconnaissance Office

SUMMARY: Unpredictable rate gyroscope degradation/failures have impacted National Aeronautics Space Administration (NASA) spacecraft missions, such as SKYLAB and the Hubble space telescope, as well as several Department of Defense and European Space Agency satellites. An alternative source of angular rate information, dynamic gyro, is based on software implemented real-time dynamic model of the spacecraft. In 2002, at the Naval Postgraduate School, research was performed to determine the effectiveness of dynamic gyros. Several error sources were introduced comparable with the hardware used for the spacecraft. Sinusoidal rate gyros bias error was introduced for different amplitudes. Inertia error was introduced by assuming it to be 10% relative error between two bodies was assumed to be 0.1 degree. Raction wheel error was introduced to be 2%. In 2003, three tasks were emphasized: upgrade of the Kalman filter for noisy rate gyros, combining dynamic gyros and rate gyros, and experimental validation of dynamic gyros.

KEYWORDS: Space, Real-time Dynamic Model, Dynamic Gyro

DUAL LINE OF SIGHT CONTROL
Brig N. Agrawal, Professor
Department of Aeronautics and Astronautics
Sponsor: Space Missile Command

SUMMARY: The objective of this project was to develop a bifocal relay mirror test bed, with single axis rotation between the apertures, to investigate dual line of sight control issues. Using analytical simulations and experiments on the test bed, improved integrated beam control and attitude control techniques were developed and demonstrated.

KEYWORDS: Relay Mirror, Line of Sight Control, Attitude Control, Optical Payload

DUAL LINE-OF-SIGHT CONTROL
Brig N. Agrawal, Professor
Department of Aeronautics and Astronautics
Sponsor: Space Missile Command

OBJECTIVE: The objective of this project was to develop a bifocal relay mirror test bed, with single axis of rotation between apertures, to investigate dual line of sight control issues. Using analytical simulations

and experiments on the test bed, improved integrated beam control and attitude control techniques were developed and demonstrated.

KEYWORDS: Bifocal Relay Mirror, Integrated Beam Control, Attitude Control, Line-of Sight-Control

FINE POINTING AND TRACKING CONTROL OF IMAGING SPACECRAFT
Brig N. Agrawal, Professor
Department of Aeronautics and Astronautics
Sponsor: National Reconnaissance Office

SUMMARY: The objective of the proposed research program was to develop technologies for fine acquisition, tracking, and pointing control of future imaging spacecraft. The emphasis in the program was on fast slewing of flexible imaging spacecraft and finer optical beam jitter, tracking, and pointing control. The work was performed in two phases. Phase I consisted of developing improved techniques and validating them analytically by performing analytical simulations and experimentally by using flexible spacecraft simulator for fast slewing and precision positioning hexapod and the optical test bed for finer optical beam and jitter control. In Phase II, a three-axis analytical model was developed by including flexibility and control moment gyros control. The improved techniques were validated analytically by simulations and experimentally by using a new attitude control simulator.

KEYWORDS: Optical Beam Control, Imaging Spacecraft

MULTI-BODY FLEXIBLE DYNAMICS AND CONTROLS MODELS
Brig N. Agrawal, Professor
Department of Aeronautics and Astronautics
Sponsor: National Reconnaissance Office

SUMMARY: The objective of the proposed research was to evaluate different techniques for the multi-body flexible dynamic and control models and associated off-the-shelf software packages. The key factors in the evaluation for the software were accuracy of prediction, processing requirements, run time, overall algorithmic robustness, and software re-usability. The goal was to improve accuracy of analytical prediction of spacecraft attitude dynamic and control performance and to develop "industry standard" models and associated software packages.

KEYWORDS: Dynamic Control Models, Software Reusability, Spacecraft Attitude Dynamic

RELAY MIRROR TESTBED
Brig N. Agrawal, Professor
Department of Aeronautics and Astronautics
Sponsor: Air Force Research Laboratory

SUMMARY: The objective of this project was to develop a bifocal relay mirror testbed, with single axis of rotation between the aperatures, to investigate dual line of sight control issues. Using analytical simulations and experiments on the test bed, improved integrated beam control and attitude control techniques were developed and demonstrated. The emphasis of this project was on the optical payload and beam control for the testbed.

KEYWORDS: Relay Mirror, Line of Sight Control, Attitude Control, Optical Payload

**IDENTIFICATION AND CHARACTERIZATION OF CRITICAL ISSUES FOR PULSE
DETONATION ENGINE DEVELOPMENT**
Christopher Brophy, Research Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: Office of Naval Research

SUMMARY: Characterized physical and operational requirements for the cyclical detonation of a liquid fuel aerosol for pulse detonation engine applications. The investigation explored valving, fuel injection, and timing requirements, as well as the necessary physical properties such as minimum droplet size, fuel distribution, and ignition energy.

KEYWORDS: Pulse Detonation, Liquid Fuel Aerosol, Engine Development

LIQUID ROCKET ENGINE SIGNATURE STUDIES
Christopher Brophy, Research Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: Air Force Research Laboratory

SUMMARY: Characterized the spatial distribution and mass concentration of soot in a liquid rocket engine exhaust plume for both well mixed and film cooled geometries. Multi-wavelength transmission measurements, planar imaging, and tomography were applied to specified motor geometries and conditions. Modeling of the heat transfer processes were also compared to experimental results.

KEYWORDS: Soot, Liquid Rocket Engine, Heat Transfer

**NAVAL POSTGRADUATE SCHOOL SMALL BUSINESS INNOVATION RESEARCH (SBIR)
PROGRAM**
Christopher Brophy, Research Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: Office of Naval Research

PULSE DETONATION TECHNOLOGY DEVELOPMENT
Christopher Brophy, Research Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: General Electric Aircraft Engines

UNSTEADY FUEL INJECTION STUDIES
Christopher Brophy, Research Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: Arnold Engineering Development Center

SUMMARY: Operated a liquid fuel rocket engine in an unsteady manner for diagnostic purposes. Naval Postgraduate School (NPS) personnel monitored temporal soot loading and additional diagnostics were determined and provided by sponsor during site visit.

KEYWORDS: SBIR, Pulse Detonation, Unsteady Fuel Injection, Liquid Fuel Rocket Engine, Soot

A FUNDAMENTAL STUDY OF COMPRESSIBLE DYNAMIC STALL AND ITS CONTROL OVER A VARIABLE DROOP LEADING EDGE AIRFOIL

M.S. Chandrasekhara, Professor
Department of Mechanical and Astronautical Engineering
Sponsor: U.S. Army Research Office

OBJECTIVE: The goal of this research was to investigate basic vorticity dynamics issues of compressible dynamic stall control using a Variable Droop Leading Edge (VDLE) airfoil.

SUMMARY: The effort was initiated in September 2002. The goal of the project was to identify the fundamental fluid mechanics issues associated with dynamically drooping the airfoil leading edge as a means to control dynamic stall. It is well known that a large amount of vorticity is produced in the flow prior to onset of dynamic stall. Control requires its management. The data obtained in this study were primarily the unsteady pressures on the VDLE airfoil surfaces. The pressure gradients were subsequently computed to determine the vorticity flux distributions. These gradients were quantified using spline fits to the pressure data from very detailed measurements of the airfoil surface contour. The key result obtained indicated that the peak vorticity flux dropped by more than 50% when the airfoil leading edge was drooped when dynamic stall control was also observed. This validated the hypothesis that management of the vorticity holds the key for effective flow control. Further studies are ongoing to establish the flow physics for different flow conditions, when different mechanisms induce dynamic stall.

PUBLICATION:

Chandrasekhara, M.S., Martin, P.B., and Tung, C., "Compressible Dynamic Stall Control Using a Variable Droop Leading Edge Airfoil," AIAA Paper No. 2003-0048, AIAA 41st Aerospace Sciences Meeting and Exhibit, Reno, NV, *Journal of Aircraft*, 6-9 January 2003, (to appear).

PRESENTATION:

A brief preliminary "framer" movie (as a raster metafile) that depicted the differences in vorticity fluxes for a typical case studied was supplied to U.S. Army Research Office (USARO).

KEYWORDS: Compressible Dynamic Stall, Airfoil, VDLE

FURTHER STUDIES OF VARIABLE DROOP LEADING EDGE (VDLE) AIRFOIL WITH FLAPS FOR COMPRESSIBLE DYNAMIC STALL CONTROL

M.S. Chandrasekhara, Professor
Department of Mechanical and Astronautical Engineering
Sponsor: National Aeronautics and Space Administration Ames Research Center

OBJECTIVE: The goal of this research was to continue ongoing studies of dynamic stall control using different flap approaches.

SUMMARY: Ongoing National Aeronautics and Space Administration (NASA) Ames Research Center (ARC) and U.S. Army Air Force Doctrine Document-supported research has shown that a Gurney flap is very effective in recovering the lost lift of the variable droop leading edge (VDLE) airfoil in unsteady flow conditions. The U.S. Army was attempting to use a split flap on its rotor blades and its effects on the performance characteristics of the rotor were unknown. Hence, it was decided to pursue a two dimensional study of such a configuration. This project was initiated in September 2003. At the time of writing, the design coordinates of the split flap were finalized and an "igis" file of the same was being readied for fabrication using stereo lithography. Discussions were started with vendors who could supply the part at the smallest expense. Once fabricated, the flap was attached to the VDLE airfoil and tested as before at different flow conditions to evaluate its performance.

KEYWORDS: VDLE, NASA, ARC, AFDD, Airfoil, Compressible Synamic Stall Control

AERONAUTICS AND ASTRONAUTICS

STEADY AND UNSTEADY FLOW CONTROL FOR DYNAMIC STALL AND HUB-DRAG REDUCTION

M.S. Chandrasekhara, Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Army Aviation and Missle Command (AMCOM)/Aviation and Missile Research, Development, and Engineering Center (AMRDEC)

OBJECTIVE: The goal of this research was to conduct hub-drag reduction studies using synthetic jet blowing and to study the variable-droop leading-edge (VDLE) airfoil flow for dynamic stall control.

SUMMARY: This was a combination of two tasks, but the majority of the effort was devoted to the hub-drag reduction aspects, since the VDLE airfoil was studied and reported separately. A new model was fabricated with movable slot locations where synthetic jet blowing could be introduced. The actuators for these were supplied under a proprietary contract by a vendor. Tests were conducted using smoke flow visualization and detailed wake surveys using automated experiment control software. Automated wake surveys, conducted using LabView Software developed by the National Aeronautics and Space Administration (NASA) Ames, were obtained for many different flow conditions and analyzed to determine the effect of oscillatory blowing on the wake dimensions and shape. Results indicated that synthetic blowing produced 30% to 40% reductions in drag and also reduced the extent of separation. This project concluded with this preliminary result. This project was also conducted to support the U.S. Army/Israel memorandum of agreement.

CONFERENCE PUBLICATION:

Martin, P.B., Tung, C., Chandrasekhara, M.S., and Arad, E., "Active Separation Control Measurements and Computations for a NACA 0036 Airfoil," *American Institute of Aeronautics and Astronautics* (*AIAA*) *Paper No. 03-3516, AIAA 21st Applied Aerodynamic Conference*, Orlando, FL, June 2003.

PRESENTATION:

Martin, P.B., Presentation Regarding Status of Project, U.S. Army /Israel MOA Meeting, Israel, November 2003.

KEYWORDS: Dynamic Stall, Hub Drag, VDLE

STUDY OF A VARIABLE DROOP LEADING EDGE (VDLE) AIRFOIL WITH A GURNEY FLAP IN THE COMPRESSIBLE DYNAMIC STALL FACILITY

M.S. Chandrasekhara, Professor
Department of Mechanical and Astronautical Engineering
Sponsors: National Aeronautics and Space Administration ARC / U.S. Army AvRDEC

OBJECTIVE: The goal of this research was to enhance the performance of a variable droop leading edge (VDLE) airfoil by attaching a simple Gurney flap.

SUMMARY: An ongoing research project demonstrated that using a variable droop leading edge (VDLE) airfoil enabled compressible dynamic stall control. In fact, excellent results were obtained. The price paid was minimal, in terms of a slightly reduced (10-15%) lift coefficient, but both the drag and adverse pitching moment were dramatically improved. Hence, it was decided to attach a Gurney flap that is used in many aeronautical and engineering applications to improve the lift as well. Three different flap heights were fabricated using an inexpensive approach. Using hot melt glue from craft stores, flap material from hobby shops was attached to the VDLE airfoil trailing edge and tested. Extremely impressive results were recorded which showed that a 1% chord height Gurney flap was successful in more than recovering the "lost lift" described above. Increases in drag and moment coefficients were almost insignificant. These results were prepared for presentation in the 42nd Aerospace Science meeting in January 2004.

CONFERENCE PUBLICATION:

Chandrasekhara, M.S., Martin, P.B., and Tung, C., "Compressible Dynamic Stall Performance of a Variable Droop Leading Edge Airfoil with a Gurney Flap," *American Institute of Aeronautics and Astronautics (AIAA) Paper No. 2004-0041, AIAA 42nd Aerospace Sciences Meeting and Exhibit*, Reno, NV.

KEYWORDS: VDLE, Gurney Flap, Compressible Dynamic Stall

SUPPORT OF FLORIDA STATE UNIVERSITY (FSU) / FLORIDA A&M UNIVERSITY (FAMU) EXPERIMENTAL STUDIES OF COMPRESSIBLE DYNAMIC STALL
M.S. Chandrasekhara, Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Florida A&M University

OBJECTIVE: The goal of this research was to investigate compressible dynamic stall control using supersonic micro-jets.

SUMMARY: In support of the final year of the Florida State University (FSU) research using microjets to control compressible dynamic stall, new tests were carried out in the compressible dynamic stall facility. Two unsteady pressure transducers were mounted on the airfoil upper surface at 2.5% and 7.5% chord lengths from the leading edge and the local time dependent pressures were measured as the airfoil executed sinusoidal pitching oscillations. Cases with and without blowing were considered at two Mach numbers and one reduced frequency, at different blowing pressures. These quantitative tests were aimed at validating earlier results that showed qualitative success in dynamic stall control using microjet blowing. Separate tests became necessary when it was realized that the new holes that were drilled to fill-up the 200 micron jets that were used in an intermediate study to reduce the mass flux were of 300 microns, instead of the original 400 microns. Once this problem was rectified, reasonable results were obtained. More tests were planned but not conducted because of lack of support for FSU manpower to replace the graduating student.

CONFERENCE PUBLICATION:

Shih, C., Beahn, J., Krothapalli, A., and Chandrasekhara, M.S., "Control of Compressible Dynamic Stall Using Microjets," ASME Fluids Engineering Meeting, Honolulu, HI, June 2003, under preparation for *AIAA Journal*.

KEYWORDS: Microjet, FAMU, Compressible Dynamic Stall

F/A-18 C/D AVIONICS ARCHITECTURE STUDY
Russell W. Duren, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Warfare Center - Weapons Division

SUMMARY: Worked with F/A-18 advanced weapons laboratory personnel on a continuing system-wide assessment of the F/A-18 C/D avionics system. Identified best solution(s) from a list developed in the first year of the study. Performed additional studies for risk mitigation.

F/A-18 C/D AVIONICS ARCHITECTURE STUDY
Russell W. Duren, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Warfare Center - Weapons Division

SUMMARY: Worked with F/A-18 advanced weapons laboratory personnel on a continuing system-wide assessment and upgrade of the F/A-18 C/D avionics system, performed feasibility studies and assisted in implementation of improvements to the mission computer operational flight program.

KEYWORDS: F/A-18 C/D, Avionics

F/A-18 C/D AVIONICS ARCHITECTURE STUDY
Russell W. Duren, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Warfare Center -Weapons Division

SUMMARY: Worked with F/A-18 advanced weapons laboratory personnel on a continuing system-wide assessment and upgrade of the F/A-18 C/D avionics system. Identified most promising areas for further research.

KEYWORDS: F/A-18 C/D, Avionics

CASCADE VORTEX SHEDDING STUDY
Garth V. Hobson, Professor
Department of Aeronautics and Astronautics
Sponsor: National Aeronautics and Space Administration - Glenn Research Center

SUMMARY: This research investigated the conditions under which vortex shedding occurs in the present cascade tunnel. Experimental laser Doppler velocimetry measurements were performed in the tunnel under the most favorable vortex shedding conditions.

KEYWORDS: Cascade Tunnel, Doppler, Velocimetry, Shedding

FAN AND COMPRESSOR INLET DISTORTION STUDIES AND TECHNOLOGY TRANSFER
Garth V. Hobson, Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Warfare Center - Aircraft Division

SUMMARY: Developed and validated tools for the inlet distortion for advanced compression system for Navy engines. Predicted transfer functions using computational fluid dynamics (CFD) code MSU-Turbo for F414-GE-400 three-stage fan and compared it to test data. Developed transient models for thermal and pressure distortion for the F414-GE-400 fan stages. Assisted Naval Air Systems Command (NAVAIR) engineer in predicting performance of F110-GE-400 using the transient models. Interfaced with GE/ Naval Air warfare Center (NAVAIR).

KEYWORDS: Inlet Distortion, Advanced Compression, Computational Fluid Dynamics, CFD, MSU-Turbo, F414-GE-400

GUIDANCE, NAVIGATION, AND CONTROL FOR PRECISION AIRDROP
Richard Howard, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: U.S. Army Soldier and Biological Chemical Command

SUMMARY: Developed and evaluated parameter estimation tools for extracting aerodynamic parameters from flight test data, and conducted advanced aerodynamic modeling and simulation for low-glide and high-glide airdrop delivery systems.

KEYWORDS: Precision Airdrop, Low Glide, High Glide

MODELING AND INSTRUMENTATION FOR PRECISION AIRDROP
Richard Howard, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: U.S. Army Yuma Proving Ground

SUMMARY: Supported the development of guidance, navigation, and control technologies for precision airdrop through improved system modeling and simulation, parameter estimation of test data, and improved instrumentation and data.

KEYWORDS: Precision Airdrop, Modeling, Instrumentation

MODELING AND INSTRUMENTATION FOR PRECISION HIGH-GLIDE AIR DELIVERY
Richard Howard, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: U.S. Army Yuma Proving Ground

SUMMARY: Supported the development of platform technologies for precision high-glide air delivery through improved system modeling and simulation, parameter estimation of test data, and improved instrumentation and data analysis.

KEYWORDS: High Glide, Air Delivery

SIMULATION OF A POINTING SYSTEM FOR SMART MUNITIONS TESTING
Richard Howard, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: U.S. Army Yuma Proving Ground

SUMMARY: Supported the development of a computer simulation to study issues of the direct use of raw azimuth and elevation measurements, calibration, delay times, and instrumentation towards the accurate pointing determination of smart munitions.

KEYWORDS: Pointing Determination, Smart Munitions

CONTINUED DEVELOPMENT OF THE AFFORDABLE GUIDED AIRDROP SYSTEM
Isaac I. Kaminer, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: U.S. Army Yuma Proving Ground

OBJECTIVE: The goal of this research was to continue efforts in the development of a low-cost guidance, navigation, and control system for airdrop leading to the demonstration of autonomous guidance of a flat-

circular parachute. This effort was supported with simulation, hardware development, model development, instrumentation development, and assistance with data analysis, test planning, and system demonstration.

KEYWORDS: Airdrop, Parachute, Autonomous Guidance, Modeling

DEVELOPMENT AND FLIGHT OF A SHIPBOARD AUTOLAND SYSTEM FOR THE SILVER FOX UNMANNED AERIAL VEHICLE (UAV)
Isaac I. Kaminer, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: Office of Naval Research

SUMMARY: This proposal focused on the development and flight-testing of a shipboard autoland system for the Swarm Unmanned Aerial Vehicle (UAV) built by Advanced Ceramics Research (ACR). Specifically, researchers proposed to develop an aerodynamic model of the Swarm. Flight-test data obtained by ACR and LCDR Krapels was used to refine the model; the dynamic model was used to investigate possible autoland strategies. These strategies accounted for physical limitations of the UAV, the impact of the ship's motion and turbulence, and specifically addressed crew safety. Developed a GNC system to land the vehicle on the ship. The GNC system addressed the limitations imposed by the Piccolo Autopilot and was implemented as a part of the ground station provided by Cloud Cap, and thus required no changes to the autopilot. Flight-tested the GNC System and worked with LCDR Krapels to make the final autoland assembly fleet ready. Results of the complete effort were documented.

KEYWORDS: GNC, Autoland, Silver Fox, UAV, Cloud Çap

DEVELOPMENT OF THE HIGH-GLIDE AIRDROP SYSTEM
Isaac I. Kaminer, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: U.S. Army Soldier and Biological Chemical Command

OBJECTIVE: To continue efforts in the development of a low-cost guidance, navigation, and control system for airdrop leading to the demonstration of autonomous guidance of a high glide payload delivery system; to support this effort with simulation, hardware development, model development, instrumentation Development; and to assist with data analysis, test planning, and system demonstration.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Sensors, Modeling and Simulation

KEYWORDS: Airdrop, Parafoil, High Glide, Autonomous Guidance, Modeling

PARTICIPATION IN NATO SCI023 TECHNOLOGY PANEL
Isaac I. Kaminer, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: Air Force Research Laboratory

UNMANNED AERIAL VEHICLE (UAV) FLIGHT MANAGEMENT RESEARCH AND EVALUATION
Isaac I. Kaminer, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: Air Force Research Laboratory

COMPETENCY EDUCATION PACKAGE FOR AIRCRAFT STRUCTURES
Ramesh Kolar, Research Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Warfare Center - Aircraft Division

OBJECTIVE: The goal of this research was to develop and teach courses in aircraft fracture and fatigue, aircraft practical stress analysis, and aircraft ground loads for Naval Air Systems Command (NAVAIR) engineers in structures competency.

KEYWORDS: Structures Competency, Aircraft Fracture, Fatigue, Stress Analysis

FINITE ELEMENT MULTI-DISCIPLINARY ANALYSIS OF FLIGHT VEHICLES
Ramesh Kolar, Research Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: Stirling Dynamics

INTEGRATED SOFTWARE TOOLBOX FOR AEROELASTIC MODELING AND DYNAMIC STABILITY ANALYSIS OF AIR VEHICLES
Ramesh Kolar, Research Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: Scientific Sys Co., Inc.

CROSS-FLOW FAN FOR VERTICAL TAKEOFF AND LANDING (VTOL) AIRCRAFT
Max F. Platzer, Distinguished Professor
Department of Aeronautics and Astronautics
Sponsor: National Aeronautics and Space Administration Glenn Research Center

AN EXPERIMENTAL AND COMPUTATIONAL INVESTIGATION OF OSCILLATING AIRFOIL UNSTEADY AERODYNAMICS AT LARGE MEAN INCIDENCE
Max F. Platzer, Distinguished Professor
Department of Aeronautics and Astronautics
Sponsor: University of Kentucky

AEROASSISTED MANEUVERS AND MISSION DESIGN
Isaac Michael Ross, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: National Aeronautics and Space Administration – Jet Propulsion Laboratory

EVALUATION OF FAST OPTIMIZATION TECHNIQUES FOR MULTI-DYNAMICAL SYSTEMS
Isaac Michael Ross, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: Draper Laboratory

REAL-TIME-OPTIMIZATION FOR SLEW MANEUVER DESIGN AND CONTROL
Isaac Michael Ross, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: National Reconnaissance Office

SUMMARY: This was an unclassified proposal. The objective of this multi-year, multi-faculty research proposal was to develop, simulate, and ground-test the feasibility of a revolutionary real-time-optimization algorithm for spacecraft slew maneuvers. The proposed research has a potentially large payoff for military spacecraft that require rapid maneuvering. This proposal was for the development of the algorithm and the software, while a companion proposal by Professor Loomis, et al., was for development of the flight-ready processor on which the algorithm can be hosted. At the end of the third year, the expected outcome of this research work is a laboratory demonstration of this advanced attitude maneuver for NPSAT1 - a Naval Postgraduate School spacecraft manifested for launch in 2006.

KEYWORDS: Spacecraft Slew Maneuvers, Algorithm, Flight-Ready Processor, NPSAT1

SPACE CONTROL
Isaac Michael Ross, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: Navy Tactical Exploitation of National Capabilities

SUMMARY: This was an unclassified version of a classified proposal. The long-range objective of this research was to develop a domain of excellence at the Naval Postgraduate School in research and instruction in the emerging area of space control. The fiscal year 2003 objective of this research was to investigate certain interconnected issues pertaining to the control of space. The control of space included the topics of assured access to space, surveillance of space, protection of national assets, and negation. This research included an investigation of using Navy and non-Navy assets to achieve the desired objectives.

KEYWORDS: Space Control, Surveillance, National Assets

ADVANCED FAN AND COMPRESSOR DEVELOPMENT STUDIES
Raymond P. Shreeve, Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Warfare Center - Aircraft Division

OBJECTIVE: The goal of this research was to develop or validate tools for the design of advanced compression systems for Navy engines: i) to obtain cascade wind tunnel data critical to stall prediction and wake-generated blade excitation; ii) to develop a geometry package geared to the optimized design (by CFD and FEM analysis) of transonic blading; and iii) to test an advanced transonic axial stage and establish the means to economically evaluate more advanced designs.

KEYWORDS: Compression Navy Engines, Cascade Tunnel, Stall Prediction, Blade Excitation, Transonic Blading, Axial Stage

HIGH-CYCLE FATIGUE (HCF) / SPIN TEST RESEARCH
Raymond P. Shreeve, Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Warfare Center - Aircraft Division

OBJECTIVE: The goal of this research was to develop high-cycle fatigue (HCF) spin-test techniques. Following the successful implementation of air-jet excitation (AJE), oil-jet excitation (OJE), and eddy-current excitation (ECE) techniques using two small rotors, tests were conducted to evaluate damping techniques on engine turbine and fan rotors. This program was conducted in close association with the

Naval Air Warfare Center Aircraft Division (NAWCAD), and with the participation of Hood Technology Corporation, jointly funded by the Air Force.

KEYWORDS: HCF Spin Test, AJE, OJE, ECE, NAWCAD. Hood Technology

DEPARTMENT OF AERONAUTICS AND ASTRONAUTICS

2003
**Faculty Publications
and Presentations**

JOURNAL PUBLICATIONS

Chandrasekhara, M.S., Martin, P.B., and Tung, C., "Compressible Dynamic Stall Control Using a Variable Droop Leading Edge Airfoil," *American Institute of Aeronautics and Astronautics (AIAA) Paper 2003-0048, Journal of Aircraft*, November- December 2003.

Chandrasekhara, M.S. and Wilder, M.C., "Heat Flux Gage Studies of Compressible Dynamic Stall," *American Institute of Aeronautics and Astronautics (AIAA) Paper 2002-0291, AIAA Journal*, Vol. 41, No. 5, pp. 757-762, May 2003.

Sahin, M., Sankar, N.L., Chandrasekhara, M.S., and Tung, C., "Dynamic Stall Alleviation Using a Deformable Leading Edge Concept - A Numerical Study," *American Institute of Aeronautics and Astronautics (AIAA) Paper No. 00-0520, Journal of Aircraft,* Vol. 40, No. 1, pp. 77-85, January-February 2003.

CONFERENCE PUBLICATIONS

Chandrasekhara, M.S., Martin, P.B., and Tung, C., "Compressible Dynamic Stall Control Using a Variable Droop Leading Edge Airfoil," *AIAA Paper 2003-0048*, Reno, NV, January 2003.

Martin, P.B., McAlister, K.W., Chandrasekhara, M.S., and Geissler, W., "Dynamic Stall Measurements and Computations for a VR-12 Airfoil with a Variable Droop Leading Edge," *AHS Forum 59*, Phoenix, AZ, 6-8 May 2003, (awarded the American Helicopter Society "Best Paper Award" for 2003).

Martin, P.B., Tung, C., Chandrasekhara, M.S., and Arad, E., "Active Separation Control Measurements and Computations for a NACA 0036 Airfoil," *AIAA-03-3516*, Orlando, FL, June 2003.

CONFERENCE PRESENTATION

Shih, C., Beahn, J., Krothapalli, A., and Chandrasekhara, M.S., "Control of Compressible Dynamic Stall Using Microjets," ASME Fluids Engineering Meeting, Honolulu, HI, June 2003.

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

JEFFREY B. KNORR
CHAIR

ELECTRICAL AND COMPUTER ENGINEERING

OVERVIEW:

The Department of Electrical and Computer Engineering (ECE) has a broad research program, reflecting the variety of skills and interests of the faculty. ECE faculty research projects are supported by systems commands, warfare centers, the services, basic research agencies, other universities, and industry. These research projects can be grouped into ten major research thrust areas that support the curricula serviced by the Department as well as the several Department of Defense (DoD) Plans. Unique to the Department and the Naval Postgraduate School is the ability of faculty and students to perform military relevant classified research at all levels. The Department's research program ensures that our graduate students will have a creative and meaningful thesis experience, that our curricula and courses will remain at the cutting edge, that we can recruit and retain quality faculty, and that we can provide our sponsors with cutting edge solutions to their problems.

CURRICULA SERVED:

- Electronic Systems Engineering
- Information Warfare
- Electronic Warfare
- Space Systems Operations
- Space Systems Engineering
- Undersea Warfare
- Joint C4I Systems
- Information Technology Management
- Aeronautical Engineering

DEGREES GRANTED:

- Master of Science in Electrical Engineering
- Master of Science in Engineering Science
- Electrical Engineer
- Doctor of Philosophy

RESEARCH THRUSTS:

- Communication Systems:
  Professor Tri Ha, Professor R. Clark Robertson
- Communication Networks:
  Assistant Professor John McEachen, Professor Murali Tummala, Military Assistant Professor Robert Ives, Associate Professor Xiaoping Yun
- Computer/Information Systems:
  Professor Jon Butler, Associate Professor Douglas Fouts, Professor Herschel Loomis, Visiting Instructor Randy Wight
- Electromagnetic Systems:
  Professor Jeffrey Knorr, Research Associate Professor Richard Adler, Associate Professor David Jenn, Professor Michael Morgan, Research Associate Andrew Parker, Research Associate Professor Ray Vincent, Visiting Associate Professor Jovan Lebaric
- Infra-Red and Electro-Optics:
  Distinguished Professor John Powers, Professor Phillip Pace, Visiting Associate Professor Ron Pieper
- Guidance, Control and Navigation Systems:
  Associate Professor Roberto Cristi, Associate Professor Gary Hutchins, Associate Professor Xiaoping Yun
- Power Electronics, Electric Machines and Distribution:

Associate Professor Robert Ashton, Associate Professor John Ciezki
- Radar, Surveillance and Information Warfare Systems:
  Professor Jeffrey Knorr, Professor Phillip Pace, Research Associate Professor Lonnie Wilson, Professor R. Clark Robertson
- Signal Processing/Acoustic Systems:
  Associate Professor Roberto Cristi, Associate Professor Monique Fargues, Associate Professor Ralph Hippenstiel, Professor Charles Therrien, Professor Murali Tummala, Professor Lawrence Ziomek
- Signals Intelligence/Space Systems:
  Associate Professor Douglas Fouts, Professor Tri Ha, Associate Professor Ralph Hippenstiel, Professor Herschel Loomis, Assistant Professor John McEachen, Associate Professor Sherif Michael, Assistant Professor Todd Weatherford
- Solid State Microelectronics:
  Associate Professor Douglas Fouts, Associate Professor Sherif Michael, Assistant Professor Todd Weatherford

RESEARCH FACILITIES:

- Signal Enhancement Lab
- Power Electronics Lab
- Digital Signal Processing Lab
- Electronics (Analog VLSI/Radiation Hardening) Lab
- Electronic Warfare Lab
- Electromagnetic Lab
- Optical Electronics Lab
- Robotics Lab
- Advanced Networking Lab
- VLSI Lab
- Secure Computing Lab

RESEARCH CENTERS:

- Center for Electronic Warfare Simulation and Modeling
- Center for Reconnaissance Research
- Center for Signal Processing
- Cryptologic Research Center
- Center for Radiation Hardened Electronics

RESEARCH CHAIR:

- National Security Agency Cryptologic Chair

RESEARCH PROGRAM (Research and Academic)-FY2003:

The Naval Postgraduate School's sponsored program exceeded $71 million in FY2003. Sponsored programs included both research and educational activities funded from an external source. A profile of the sponsored program for the Department of Electrical and Computer Engineering is provided below:

Size of Program: $3,946K

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ELECTRICAL AND COMPUTER ENGINEERING

CONCEALED WEAPONS DETECTION FOR HOMELAND SECURITY, PHASE II
Richard Adler, Research Associate Professor
Jovan Lebaric, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: U.S. Department of Justice

OBJECTIVE: This objective of this project was to design the system, initial hardware configuration, and proof-of-concept measurements to experimentally validate the approach of a concealed weapons detection system based on the analysis of ultra-wideband (UWB) radio-frequency (RF) signals.

SUMMARY: Researchers have successfully completed the selection of the radar cross-section (RCS) method, waveform, transceiver, initial hardware/software configuration, and proof-of-concept measurements. A directional antenna approach for improved performance was also designed. Measurements of concealed weapons and difference reflections indicated that the weapon was detectable even with varying weapon placement and orientation (for example, weapon placed behind the back).

THESES DIRECTED:

Dowdy, B., "Design and Experimental Evaluation of an Ultra-wideband System for Radar and Communications Applications," Master's Thesis, Naval Postgraduate School, June 2003.

Marroni, L., "Synchronization Performance Analysis in an Ultra-Wideband Receiver Simulation Using Real Ultrawideband Received Signals," Master's Thesis, Naval Postgraduate School, September 2003.

Monsour, S., "System Design for Ultrawideband (UWB) Communications," Master's Thesis, Naval Postgraduate School, December 2003.

KEYWORDS: Radio Frequency, Weapons Detection, Ultra-wideband

DIRECTIONAL ULTRA-WIDEBAND ANTENNA WITH DIELECTRIC/MAGNETODIELETRIC LENS
Richard Adler, Research Associate Professor
Jovan Lebaric, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Information Warfare Activity

OBJECTIVE: The objective of this project was to design, simulate, prototype, and validate a directional ultra-wideband antenna for subsurface use. The antenna has a dielectric lens to allow beam scattering in the azimuth plane without rotating joints, while reducing radar cross-section (RCS).

SUMMARY: The antenna design and measurements were presented, and prototypes were delivered to the sponsor for field-testing. Measurement at both the Naval Postgraduate School (NPS), independent validation via the Naval Undersea Warfare Center (NUWC), and operational tests onboard Navy platforms in summer 2003 verified the antenna performance and durability. Advantages included the compact size/weight, low RCS, low visual signature, increasing gain with frequency, nearly constant aperture, and reduced EMI. The antenna development received sponsor commendation and award.

KEYWORDS: Antennas, Ultra-wideband, Electronics

DIRECTIONAL ULTRAWIDEBAND ANTENNA FOR SHIPBOARD APPLICATIONS
Richard Adler, Research Associate Professor
Jovan Lebaric, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: The objective of this project was to design, simulate, prototype, and validate a directional ultra-wideband antenna for shipboard use.

SUMMARY: The antenna concept was developed at the Naval Postgraduate School (NPS) and validated via prototype measurements at both NPS and independent (third party) validation via SSC San Diego, with extensive field measurement results (such as gain, VSWR) in close agreement with predicted performance. The antenna provided increasing gain with frequency, ultra-wideband, and nearly constant aperture.

PATENT:

Patent application submitted November 2003, (patent pending).

KEYWORDS: Antennas, Ultra-wideband, Information Warfare

INTERFERENCE AND NOISE MEASUREMENTS IN PORTIONS OF THE RADIO SPECTRUM
Richard Adler, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: National Science Foundation

SUMMARY: This was a program to evaluate the use and occupancy of wireless communication bands and to measure the noise and interference levels in selected bands at selected locations. The information gathered will allow the National Science Foundation and the Federal Communications Commission to manage the civil use of the radio spectrum in the United States.

KEYWORDS: Wireless Communication, Radio Interference, Noise, FCC, Civil Spectrum

MATERIALS FOR THE CLADDING OF ULTRA-WIDEBAND ANTENNAS
Richard Adler, Research Associate Professor
Jovan Lebaric, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Information Warfare Activity

OBJECTIVE: This objective of this project was to implement a composite polymer, using commercially available materials, to achieve approximate equality of the relative permeability and permittivity for beam focusing and matching, and to reduce the antenna out-of-band radar cross section.

SUMMARY: Researchers developed and validated a unique antenna material and shape combination concept, enabling reduced radar cross-section (RCS) and target performance characteristics. The research resulted in several prototypes verifying the technology via measurements. Work was accepted and commended by the sponsor.

KEYWORDS: Antennas, Ultra-wideband, Electronic Warfare

ELECTRICAL AND COMPUTER ENGINEERING

ADVANCED POWER ELECTRONICS AND CONTROL TECHNOLOGY PROGRAM
Robert William Ashton, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Surface Warfare Center – Carderock Division

OBJECTIVE: The objective was to transition advanced technology solid-state switches and power conversion phase-legs into the Program Definition and Risk Reduction (PDRR) Electromagnetic Aircraft Launch System (EMALS). Transition will occur only after the advanced commercial, off-the-shelf (COTS) hardware has been designed, constructed, tested, and evaluated.

SUMMARY: This research involved the engineering design of advanced power conversion modules under current Navy development. Tasks included but were not limited to the following: investigated power converter design options; assisted in design and development of advanced reconfigurable zonal electric distribution system hardware; debugged and tested power conversion hardware; provided support to interface working groups for Integrated Fight Through Power (IFTP). Support included conducting appropriate tests, analyzing/evaluating technical documentation/data, and providing comments. The results/recommendations were documented. Additionally, the Principle Investigator attended technical meetings as required, and provided monthly status reports. Travel to CDNSWC-SSES (Naval Surface Warfare Center, Carderock Division, Naval Ship Systems Engineering Station), Philadelphia, and other locations specified by CDNSWC-SSES was required to implement the above objectives.

KEYWORDS: Power System, Pulse Power, Motor Controller, Launch Systems

INTEGRATED FIGHT-THROUGH POWER AND ADVANCED POWER CONVERTER MODULES
Robert William Ashton, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Surface Warfare Center – Carderock Division

SUMMARY: This research provided support for the interface working groups and integrated fight-through power (IFTP). This task required the investigation of available power converter design options. Additionally, assistance in the design and development of advanced reconfigurable zonal electric distribution system hardware was provided in the form of testing, debugging, and documentation. Support included conducting appropriate tests, analyzing/evaluating technical documentation/data, and providing comments. The Principle Investigator attended technical meetings, as required, and provided monthly status reports. Travel to CDNSWC-SSES Philadelphia was required to implement the above objectives.

KEYWORDS: Integrated Fight Through Power, IFTP, Power Conversion,

PERFORMANCE ANALYSIS OF THE DIFFERENTIAL SERVICES ARCHITECTURE IN PROVIDING QUALITY OF SERVICE FOR THE AUTOMATED DIGITAL NETWORK SYSTEM
LCDR Dean Barsaleau, USN
Department of Electrical and Computer Engineering
Sponsor: Space and Naval Warfare Systems Command - San Diego

SUMMARY: This research explored the Quality of Service (QoS) architectures, mechanisms, and protocols proposed for implementation in the U.S. Navy's automated digital network system (ADNS), focusing on differentiated services and the issues involved in implementing this architecture into ADNS. The goal of this research was to determine the actual performance of this architecture in providing guaranteed QoS for different traffic classes and markings under different bandwidths and congestion levels over the current "best effort" shipboard networks.

KEYWORDS: Differential Services Architecture, Automated Digital Network, ADNS, Shipboard Network

NAVAL RESERVE SECURITY GROUP COMMAND (NRSGC) PERSONNEL RESEARCH SUPPORT
Randy L. Borchardt, Research Associate
Department of Electrical and Computer Engineering
Sponsor: Naval Reserve Security Group Command

SUMMARY: Fiscal year 2003 funding support for Sensitive Compartmented Information Facility (SCIF) enhancements to support research conducted by Naval Reserve Security Group Command (NRSGC) personnel.

KEYWORDS: NRSGC, Personnel Research, SCIF

DESIGN ALGORITHMS FOR LOGIC CIRCUITS USING DECISION DIAGRAMS AND DECOMPOSITION
Jon T. Butler, Professor
Department of Electrical and Computer Engineering
Tsutomu Sasao
Kyushu Institute of Technology, Japan
Sponsor: Naval Postgraduate School (stated unfunded)

OBJECTIVE: The goal of this research was to produce efficient design algorithms for digital logic circuits.

SUMMARY: *Bi-decompositions*. The paper "On Bi-Decomposition of Logic Functions," (T. Sasao and J.T. Butler, *International Workshop on Logic Synthesis*, Vol. 2, Session 8-1, pp.1- 6, 18-21 May 1997) has inspired research by groups at the University of California-Los Angles (UCLA) and Portland State University. Indeed, the term "bi-decomposition," used by others in conference and journal papers, was first used in this paper. Beginning in April 2003, researchers spent approximately three months at the Kyushu Institute of Technology in Iizuka, Japan, working on problems associated with bi-decompositions. A major result of that work was proof that a fast (divide-and-conquer) method for finding the minimal sum-of-products expression succeeds when at least one of the functions is orthodox. Experimental studies conducted in this time showed that it was also a good heuristic in cases where it did not succeed; namely, in many cases when it did not produce an exact minimal solution, it produced a good near-minimal sum-of-products expression. These results and others were presented in a manuscript accepted by the Asian South Pacific Design Automation Conference (ASP-DAC 2004).

Average Path Length in Decision Diagrams. Also, during these three months, previous work on binary decision diagrams continued. Specifically, the average path length (APL) was derived for additional functions including the "Achilles heel" function. A paper on this subject was completed and submitted to the *IEEE Transactions on Computer*s.

PUBLICATION:

Butler, J. T. and Sasao, T., "Average Path Length of Binary Decision Diagrams," *IEEE Transactions on Computers*, (submitted and major revision requested).

CONFERENCE PUBLICATIONS:

Butler, J.T. and Sasao, T., "On the Average Path Length in Decision Diagrams of Multiple-Valued Functions," *Proceedings of the 23rd International Symposium on Multiple-Valued Logic*, Meiji University, Tokyo, Japan, pp. 383-390, May 2003.

Nagayama, S., Mishchenko, A., Sasao, T., and Butler, J.T., "Minimization of Average Path Length in BDDs by Variable Reordering," *12th International Workshop on Logic and Synthesis*, Laguna Beach, CA, 28-30 May 2003.

Sasao, T. and Butler, J.T., "A Fast Method to Derive Minimum SOPs for Decomposable Functions," *Asian South Pacific Design Automation Conference (ASP-DAC 2004),* (accepted).

PRESENTATIONS:

Butler, J.T., "Average Path Length in Binary Decision Diagrams," International Christian University, Mitaka, Japan, 15 May 2003.

Butler, J.T., "On the Average Path Length in Decision Diagrams of Multiple-Valued Functions," 23rd International Symposium on Multiple-Valued Logic, Meiji University, Tokyo, Japan, 19 May 2003.

KEYWORDS: Digital Systems, Compact Circuits, Computer-aided Design Tools, Sum-of-products Expressions

IO CHALLENGE SUPPORT
LCDR Christopher Eagle, USN, Military Faculty
Department of Electrical and Computer Engineering
Sponsor: Space and Naval Warfare Systems Command – San Diego

SUMMARY: The CRC supported the SSC-SD Alliance Team (Code 287, S7S 242) with the second phase of the IO challenge to help them build the project roadmap, schedule, and deliverables.

The purpose of the IO Challenge was to determine how to best focus multidisciplinary expertise against compelling Information Technology problems faced by the Department of Defense (DoD) and the intelligence community, and to identify research areas that will lead to solutions. The Naval Postgraduate School CRC faculty and students collaborated with other technology agencies and DoD organizations participating in the ARDA IO Challenge classified workshops to identify the unique IO challenges and help build a roadmap for solutions.

KEYWORDS: Information Technology, ARDA IO Challenge

INVESTIGATIONS IN THE DISCRIMINATION BETWEEN CHEMICAL/BIOLOGICAL AND HIGH EXPLOSIVE SIGNATURES FOR THE EARLY WARNING OF BIOLOGICAL AND CHEMICAL THREATS
Monique P. Fargues, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Edgewood Chemical/Biological Center, Aberdeen Proving Grounds

OBJECTIVE: This study investigated whether signatures collected by a seismic sensor may be used to differentiate between simulated Chemical/Biological and high explosive signatures.

SUMMARY: The study continued a research effort started during 2002. The research was split into two parts. The first phase focused on pre-processing schemes designed to facilitate the extraction of explosion only sections, and selected wavelet-based discriminative features. The second phase considered a variant to a Fisher Discriminant (LDA) based classifier to discriminate between various explosion types.

Two classifier implementations were considered; the first investigated discrimination between HE and CB types, while the second investigated discrimination between explosion and detonation types, i.e., Chemical Airburst (CA), Chemical Point (CP), High explosive Airburst (HA), and High explosive Point (HP) detonation types.

Discrimination results obtained at three sensor locations showed classification performances between 89% and 97% for the two-class implementation, and between 75% and 84% for the four-class

implementation, for the labeled data recorded at three sensors. Associated blind decision results for the three sensors investigated were provided for sponsor evaluation. Decision confidence levels were also included.

Labeled and blind test results were included in the report indicated below.

CONFERENCE PUBLICATIONS:

Fargues, M.P., Reiff, C., and Gonski, D., "Discrimination of Chemical/Biological Versus High Explosive Artillery Rounds Using Acoustic and Seismic Data Fusion," *2003 Aero-Sense SPIE Proceedings*, Vol. 5099, Orlando, FL, April 2003.

Fargues, M.P., Reiff, C., Nelson, B., Gonski, D., and Birenzvige, A., "Chemical/Biological Round Discrimination Using Acoustic, Seismic, and Imaging Data," *Proceedings of the 2003 Asilomar Conference on Signals, Systems, and Computers*, Pacific Grove, CA, November 2003.

TECHNICAL REPORT:

Fargues, M.P., "Discrimination Between Chemical/Biological and High Explosive Seismic Signatures (QualTron Seismic Data)," Naval Postgraduate School Technical Report, NPS-EC-04-001, 1 December 2003.

KEYWORDS: Classification

ADVANCED ALGORITHMS AND SOFTWARE ENVIRONMENT DEVELOPMENT FOR RECONFIGURABLE PLATFORMS
Douglas J. Fouts, Professor
Department of Electrical and Computer Engineering
Sponsor: National Security Agency

OBJECTIVE: To establish various libraries of open-source functions for a computer with a reconfigurable architecture; to use these libraries to benchmark and compare the performance and correctness of a computer with a reconfigurable architecture against a typical workstation; to study and experiment with the programming languages, methodologies, environments, and applications to move reconfigurable computing closer to the typical programming environment with which most applications developers are already familiar.

SUMMARY: Three different algorithms were successfully ported to the SRC-6e reconfigurable computer. The first was a false radar target image synthesis algorithm for countering imaging inverse synthetic aperture radar. The second algorithm was based on the well-known CORDIC algorithm and was used for extracting the phase of a complex signal. The third algorithm was a 64-bit encryption algorithm. Together, these three applications created an excellent suite for benchmarking and evaluating the SRC-6e. The suite was executed on both the SRC-6e and on PCs with standard architectures. Performance measurements were taken and documented.

PRESENTATIONS:

Duren, R., Fouts, D., and Zulaica, D., "Performance Comparison of CORDIC Implementations on the SRC-6e Reconfigurable Computer," 2003 Military Applications of Programmable Logic Devices Conference, Washington, D.C., 9-11 September 2003.

Fouts, D., Duren, R., and Zulaica, D., "Algorithm and Programming Considerations for Embedded Reconfigurable Computers," 2003 High Performance Embedded Computing Workshop, MIT Lincoln Laboratory, 22-25 September 2003.

ELECTRICAL AND COMPUTER ENGINEERING

THESIS DIRECTED:

Macklin, K.R., "Performance Evaluation of a Reconfigurable Computer for Image Synthesis Applications," Master's Thesis, Naval Postgraduate School, September 2003.

KEYWORDS: Reconfigurable Computing, Computer Performance Evaluation, Computer Architecture, Parallel Processing

ADVANCED DIGITAL ANALYSIS TECHNIQUES
Tri T. Ha, Professor
Department of Electrical and Computer Engineering
Sponsor: National Institute of Water and Atmospheric Research (NIWA)

OBJECTIVE: The goal of this project was to perform research to apply modern signal processing techniques to enhance the Signals Analysis Laboratory's (SAL) ability to transform signals intelligence (SIGINT) data into actionable intelligence for operational forces in a timely manner. Another goal was to implement these techniques in a simple, automated fashion within the construct of existing analysis systems.

SUMMARY: The Signals Analysis Laboratory (SAL) at the U.S. Naval Security Group Activity Yokosuka, Japan, was a component laboratory within the National Institute of Water and Atmospheric Research (NIWA)-sponsored Global Signals Analysis Laboratory (GSAL). It was tasked with providing advanced signal classification and processing services in support of operational fleet units within the U.S. SEVENTH FLEET Area of Responsibility. Research conducted under this project focused on developing innovative signal processing techniques, which provided break-through capabilities for information superiority. Toward this end, research included the application of modern spectral analysis techniques, advanced classification methods, and modern solutions to common technical impediments such as signal-to-noise enhancement, interference mitigation, and reference tone stabilization. Ultimately, capabilities developed under this project may provide actionable intelligence to operational consumers through the insightful analysis of traditional SIGINT parameters and the discovery of previously unexploited signal characteristics. The goals of this research included value-added processing of signals to obtain complete readability of special signal internals and high-confidence platform-to-emitter correlation from all types of SIGINT based on previously unexploited signal parameters. Additionally, the SAL occasionally encountered signal quality problems such as low signal-to-noise ratio, the presence of in-band interference, and reference tone instability. These problems could render the data invalid for analysis, leaving this considerable investment of resources fruitless. For instance, analog information developed under a Chief of Naval Operations High Interest Program was obtained at a very high expense in terms of the opportunity cost for platform utilization and total man-days dedicated to the mission. However, through research of modern signal processing methods, many of these technical difficulties could be overcome in post-mission processing of the data. Intelligence consumers could then make well-informed operational decisions by leveraging the information superiority provided through SAL operations

KEYWORDS: COMINT, ELINT, Modulation, Detection, Recognition, Exploitation, Computer, Software, Communications, Materials and Processes

DETECTION, CLASSIFICATION, AND PROCESSING OF WIRELESS LOCAL AREA NETWORK SIGNALS
Tri T. Ha, Professor
Department of Electrical and Computer Engineering
Sponsor: National Institute of Water and Atmospheric Research (NIWA)

OBJECTIVE: The goal of this research was to develop a prototype using commercially available low-cost hardware and software solutions to detect, classify, and process a wireless IEEE 802.11a orthogonal frequency division multiplexing (OFDM) compliant network signal. Research included evaluating the most

promising products on the ground and in the air, with the goal of deploying the prototype with ground units or high endurance aircraft.

SUMMARY: As the need to send larger amounts of information increased, the military was looking into viable solutions to push this information throughout the battle space. IEEE 802.11a wireless local area network (LAN) presented an attractive high-speed information network solution, providing up to 54 Mb/s data rate. At the same time, wireless LAN introduced increased security risk due to its vulnerability to exploitation of the wireless physical layer. This research developed a prototype system using low-cost hardware and software solutions to detect and process wireless IEEE 802.11a signals. Using the prototype, performance data was collected to determine whether IEEE 802.11a was a feasible option as a high-speed information network for military use. In addition, the performance data collected could provide a good basis for predicting the expected performance in operational scenarios and valuable information for proper deployment planning.

KEYWORDS: IEEE 802.11a, Wireless, LAN, OFDM

JAMMING STRATEGIES BASED ON AN/USQ-146 SYSTEMS
Tri T. Ha, Professor
Department of Electrical and Computer Engineering
Sponsor: National Institute of Water and Atmospheric Research (NIWA)

OBJECTIVE: The goals of this research were to develop jamming strategies for various target waveforms based on the capability of the AN/USQ-146 System, to evaluate the most promising jamming strategies, and provide guidelines for their usage.

SUMMARY: As the need for larger amounts of information increased, the military was looking into solutions to push this information throughout the battle space, up to and including the front line unit and denying the enemy this same capability. The AN/USQ-146 system employed innovative jamming algorithms and features that allowed it to effectively deny many potential target networks. This research explored the ways in which AN/USQ-146 tools could be employed to ensure the protection of information as well as the denial of other wireless traffic throughout the battle space. Both theoretical analysis and simulation models of the jammer AN/USQ-146 were developed.

THESIS DIRECTED:

Dalakos, A., "Performance Evaluation of the AN/USQ-146 Jammer Over Uncoded Slow FH/MFSK Military Communication Systems and the IEEE 802.11a Wireless LAN Commercial Communication Standard," Master's Thesis, Naval Postgraduate School, September 2003.

KEYWORDS: Jammer, Wireless, Analysis, Simulation

NATIONAL SECURITY AGENCY (NSA) / APPLIED TECHNOLOGY DIVISION (ATD) CRYPTOLOGIC RESEARCH LAB AND THESIS RESEARCH SUPPORT
Tri T. Ha, Professor
Department of Electrical and Computer Engineering
Sponsor: National Security Agency

SUMMARY: Supported the Cryptologic Research Laboratory, under the auspices of the Cryptologic Research Center, at the Naval Postgraduate School, wherein graduate students and faculty performed research in support of the National Security Agency's (NSA) Applied Technology Division.

KEYWORDS: Cryptologic Research, NSA/ATD

ELECTRICAL AND COMPUTER ENGINEERING

WIRELESS COMMUNICATIONS SHORT COURSE FOR NAVY SECURITY GROUP
Tri T. Ha, Professor
Jovan Lebaric, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: National Institute of Water and Atmospheric Research (NIWA)

OBJECTIVE: The goal of this course was to provide students with a foundation of current and emerging wireless communications systems. Attendees will gain an understanding of the principles, technologies, and applications of cellular telephone communications, wireless local area networks, antennas and propagation, software defined radios, and smart antennas.

SUMMARY: Four offerings (25 attendees each) of the five-day short course were delivered at the Naval Postgraduate School (NPS). The instruction of six contact hours and one one-hour lab assignment per day included five one-hour lecture units per day and one one-hour computer lab per day. Each one-hour lecture unit was composed of a 30-minute lecture, a 10-minute quiz, a 10-minute question and answer session, and a 10-minute break. A typical day of instruction consisted of three lecture units in the morning, a one-hour lunch break, one one-hour hands-on lab in the afternoon, one one-hour assignment in the afternoon, and two lecture units in the afternoon.

KEYWORDS: Cellular, Wireless, LNA, Antenna, Propagation, Software-Defined Radio

ANTENNA DESIGN FOR UNMANNED AIR VEHICLE (UAV) APPLICATIONS
David C. Jenn, Professor
Department of Electrical and Computer Engineering
Sponsor: TEMASEK (Singapore)

OBJECTIVE: The antennas on the unmanned aerial vehicles (UAVs) have special design requirements, such as small size and light weight. The field of view (antenna pattern coverage) is also a primary design requirement. The locations of the antennas are limited on small UAVs. A single antenna might be used for all onboard systems, and therefore, it would have to operate in multiple frequency bands simultaneously.

SUMMARY: This research examined several of the unique aspects and requirements of UAV antennas, and proposed several antenna designs. The designs were simulated using state of the art computational electromagnetics codes. They included a broadband counter-wound spiral antenna for dual linear polarization, and a printed circuit dipole capable of simultaneous sum and difference element patterns. Mutual coupling in a small array was also modeled, to examine its effect on the direction finding angle of arrival measurements. Some methods of mutual coupling compensation were suggested.

THESES DIRECTED:

Chua, Eng Hock, "Reduction Of Mutual Coupling In Small Dipole Array Antennas," Master's Thesis, Naval Postgraduate School, March 2003.

Chee Hwee Ong, "Modeling of the ring-hybrid dipole antenna and mutual coupling in a small antenna array," Master's Thesis, Naval Postgraduate School, December 2003.

Lock Wai Lek Willy, "Effects of radio wave propagation in urbanized areas on UAV-GCS command and control," Master's Thesis, Naval Postgraduate School, December 2003.

Lim Teck Yong, "Broadband counterwound spiral antenna for subsurface radar applications,' Master's Thesis, Naval Postgraduate School, December 2003.

KEYWORDS: Electronic Warfare, Sensors, Electronics

ELECTRICAL AND COMPUTER ENGINEERING

SURVEY OF THE CURRENT CAPABILITIES OF PLASMA ANTENNAS AND POTENTIAL SIGNALS INTELLIGENCE (SIGINT) APPLICATIONS
David C. Jenn, Professor
Department of Electrical and Computer Engineering
Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: The term plasma antenna has been applied to a wide variety of antenna concepts that incorporate some use of an ionized medium. In the vast majority of approaches, the plasma, or ionized volume, simply replaces a solid conductor. A highly ionized plasma is essentially a good conductor, and therefore plasma filaments can serve as transmission line elements for guiding waves, or antenna surfaces for radiation. This study summarized the basic theory behind the operation of plasma antennas based on a survey of patents and technical publications. Methods of exciting and confining plasmas were discussed, and the current state of the art in plasma technology was examined.

SUMMARY: The basic theory of wave electromagnetic wave propagation and interaction with plasmas was summarized. Extensive literature and patent searches were performed and the existing theories and methods were evaluated with regard to plasma antenna applications. Current experimental programs were also studied. Several working plasma antennas were described, and their performance parameters were discussed.

TECHNICAL REPORT:

Jenn, D.C., "Plasma Antennas: Survey of Techniques and the Current State of the Art," Naval Postgraduate School Technical Report, NPS-CRC-03-001, 29 September 2003.

KEYWORDS: Electronic Warfare, Sensors, Electronics

WEATHER PROCESSOR FOR RAPID SCANNING TACTICAL RADAR
Jeffrey B. Knorr, Professor
Department of Electrical and Computer Engineering
Sponsor: ProSensing, Inc., Amherst, Massachusetts

OBJECTIVE: The objective of this project was to provide improved support for air operations in the battlespace by adding a weather processor to a rapid scan tactical radar.

SUMMARY: An Army AN/MPQ-64 Sentinal radar (Forward Area Air Defense) was acquired in spring 1999 and brought to operational status at the Naval Postgraduate School's (NPS) Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) during fall 1999 and winter 2000. A Small Business Innovation Research (SBIR) project, N01-035, Weather Processor for Rapid Scanning Tactical Radars, was initiated with ProSensing, Inc., Amherst, Massachusetts, to add a Doppler processor to the radar. The SBIR project progressed to Phase II, and during 2003, a Cooperative Research and Development Agreement (CRADA) was signed between ProSensing and NPS. The CRADA covered collaboration on the addition of the weather processor to the radar, test, and evaluation. It was anticipated that installation, test, and evaluation of the weather processor would occur during 2004. NPS provided analytical support related to acquisition, processing, and display of reflectivity, velocity, and velocity spread data for meteorological phenomena observed using the Sentinal radar.

KEYWORDS: Weather Processor, Rapid Scanning Radar

CLASSIFIED COMMUNICATIONS SATELLITE SYSTEM
Herschel H. Loomis, Jr., Professor
Department of Electrical and Computer Engineering
Sponsor: Boeing Satellite Systems, Inc.

FISCAL YEAR 2003 SUPPORT FOR THE COMPUTER NETWORK RESEARCH LABORATORY AND THESIS RESEARCH
Herschel H. Loomis, Jr., Professor
Department of Electrical and Computer Engineering
Sponsor: National Security Agency

SUMMARY: This effort continued to expand and enhance the capabilities and research focus of the Computer Network Research Laboratory.

KEYWORDS: Communications Satellite, Computer Network Research Laboratory

MARITIME DOMAIN AWARENESS WORKSHOP
Herschel H. Loomis, Jr., Professor
Department of Electrical and Computer Engineering
Sponsor: Navy Tactical Exploitation of National Capabilities (TENCAP)

SUMMARY: This project planned and hosted a workshop on the fusion of data on shipping to provide a timely maritime domain awareness picture in support of homeland defense. The workshop identified technical means for creating the maritime picture, an experiment to verify these means, and the future research and development needed to produce an operational maritime domain awareness system.

KEYWORDS: Maritime Domain Awareness, Homeland Defense

MIDAS NAVY APPLICATIONS
Herschel H. Loomis, Jr., Professor
Department of Electrical and Computer Engineering
Sponsor: TRW, Inc.

NAVAL RESERVE SECURITY GROUP (NRSGC) RESEARCH SUPPORT
Herschel H. Loomis, Jr., Professor
Department of Electrical and Computer Engineering
Sponsor: Space and Naval Warfare Systems Command – San Diego

SUMMARY: Naval Reserve Security Group (NRSGC) intelligence/cryptologic analyst support at Southwest Centers.

KEYWORDS: NRSCG, Cryptology

PMW-189 THESIS RESEARCH AND SIGNALS INTELLIGENCE (SIGINT) II COURSE
Herschel H. Loomis, Jr., Professor
Department of Electrical and Computer Engineering
Sponsor: Space and Naval Warfare Systems Command - San Diego

SUMMARY: Explored potential individual thesis research topics and Signals Intelligence II course projects to provide cryptologic support to the U.S. Navy with regard to national/tactical interoperability issues.

ELECTRICAL AND COMPUTER ENGINEERING

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Electronics Warfare, Computers and Software, Sensors

KEYWORDS: Cryptology, Information Operations, Overhead Reconnaissance, Digital Signal Processing, Navigation, Communications, High Power Microwave, Geolocation

SIGNALS INTELLIGENCE TRAVEL SUPPORT
Herschel H. Loomis, Jr., Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School Foundation, Inc.

SUMMARY: This task supported the travel of the National Security Agency Signals Intelligence (SIGINT) Chair Visiting Professor and other SIGINT faculty and students required to develop new signals intelligence systems, components, and algorithms.

KEYWORDS: SIGINT

SPACE AND NAVAL WARFARE SYSTEMS COMMAND (SPAWAR) PMW 189 THESIS RESEARCH SUPPORT
Herschel H. Loomis, Jr., Professor
Department of Electrical and Computer Engineering
Sponsor: Space and Naval Warfare Systems Command

SUMMARY: Provided fiscal year 2003 funding support for Naval Postgraduate School faculty and student research into areas of PMW-189 interest.

KEYWORDS: SPAWAR, PMW-189

TRIPLE-MODULAR-REDUNDANT ARCHITECTURES FOR RELIABLE SPACE-BASED COMPUTING
Herschel H. Loomis, Jr., Professor
Department of Electrical and Computer Engineering
Sponsor: National Reconnaissance Office

SUMMARY: Developed an single-event-upset (SEU)-tolerant space-based computer using commercial, off-the-shelf (COTS) field-programmable gate arrays (FPGA) to demonstrate the feasibility of using triple-modular-redundancy (TMR) to correct errors without resort to system reset. Researchers demonstrated the value of the remote configurability of the FPGA to space computing. Researchers will build and fly a TMR mission computer on NPSSAT, Midstar, and a satellite in a high-radiation orbit.

KEYWORDS: SEU, Space-Based Computing, Redundant Architecture, Midstar, NPSSAT

TRIPLE-MODULAR-REDUNDANT ARCHITECTURES FOR RELIABLE SPACE-BASED COMPUTING
Herschel H. Loomis, Jr., Professor
Department of Electrical and Computer Engineering
Sponsor: National Reconnaissance Office

SUMMARY: This project produced a prototype design of a reconfigurable triple-modular-redundant computer system embedded in a XYLINX Virtex field programmable gate array.

KEYWORDS: Redundant Architecture, XYLINKX Virtex, Space-Based Computing

LOW PROBABILITY OF DETECTION COMMUNICATIONS IN PACKET NETWORKS
John C. McEachen, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: National Security Agency

OBJECTIVE: The goal of this research was to investigate methods of low probability of detection communications as an alternative communications mechanism in packet networks and to characterize delay in a variety of network environments.

SUMMARY: This project was based on the work of B. Verdu (1998) in communicating information using inter-packet delay in data networks. This work was largely classified. Unclassified results included statistical analysis of traffic patterns that indicated high degrees of self-similarity in online game applications. Additionally, loss patterns observed in Internet traffic appeared much less significant than previously reported five years ago.

CONFERENCE PUBLICATIONS:

McEachen, J.C., "Analysis of Self-similarity in an Internet-based Multiplayer Online Game," *Proceedings of the 2003 IEEE International Conference on Computer Communications and Networks (ICCCN 03)*, Dallas, TX, pp. 211-214, October 2003.

McEachen, J.C., "Traffic Analysis of Internet-based Multiplayer Online Games from a Client Perspective," *Proceedings of the 2003 IEEE International Conference on Information, Computers, and Signal Processing*, Singapore, December 2003.

PRESENTATIONS:

McEachen, J.C., "Analysis of Self-similarity in an Internet-based Multiplayer Online Game," 2003 IEEE International Conference on Computer Communications and Networks (ICCCN 03), Dallas, TX, 24 October 2003.

McEachen, J.C., "ARDA Global Infosystems Access Challenge Workshop," U.S. Space and Naval Warfare Command, San Diego, CA, 15 January 2003.

McEachen, J.C., "A Covert Network Channel," Low Probability of Intercept Communications Committee Forum, Monterey, CA, 20 August 2003.

McEachen, J.C., "Traffic Analysis of Internet-based Multiplayer Online Games from a Client Perspective," 2003 IEEE International Conference on Information, Computers, and Signal Processing, Singapore, 17 December 2003.

THESES DIRECTED:

Ballard, J.D., "Error Correction and Synchronization for Delay-based Communications Systems," Master's Thesis, Naval Postgraduate School, June 2003.

Brandes, S.J., "Application and Protocol Implications for Employing Delay-based Communication in Packet-Switched Networks," Master's Thesis, Naval Postgraduate School, September 2003.

Foxworth, E.C., "Timing-based Client Authentication: Evaluation of a Hypertext Transfer Protocol (HTTP) Application Using Time Modulation of Packets," Master's Thesis, Naval Postgraduate School, June 2003.

ELECTRICAL AND COMPUTER ENGINEERING

KEYWORDS: Packet Networks, Information Theory, Steganography

NETWORK ROUTER AND SWITCH LAB
John C. McEachen, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Security Group Command (NSGC)

SUMMARY: Procured computer-network equipment in support of computer operations of interest to CNSG. This funding was used to upgrade the facilities of the Electrical and Computer Engineering Department's advanced networking laboratory (NETLAB), specifically, to procure network equipment in support of lab requirements.

KEYWORDS: NETLAB, CNSG, Router, Switch

PATTERNLESS INTRUSION DETECTION
John C. McEachen, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Engineering Logistics Office

OBJECTIVE: The goal of this research was to develop alternative methods for intrusion detection in computer networks. Specifically, evaluate the effectiveness of real-time patternless intrusion detection software, Therminator, under a variety of network conditions. Examine the use of statistical mechanics in modeling the dynamics of network conversations.

SUMMARY: This interdisciplinary project explored the use of thermodynamic principles to model the flux of conversations across a network boundary. Specifically, the Therminator 2 software program, developed and installed at the U.S. Pacific Command, was evaluated and tested. Formal methodologies for configuration and installation were developed. This work also involved coordination with the University of South Carolina – where a version of Therminator 2 was ported to a Field Programmable Gate Array (FPGA) card – and with LanCope Inc., which has acquired a non-exclusive license to integrate Therminator into its commercial IDS products.

PUBLICATION:

McEachen, J., Zachary, J., and Ford, D., "Therminator: A Transformational Enabler for ForceNet," *CHIPS Magazine*, Vol. 12, No. 1, pp. 18-21, Winter 2004.

CONFERENCE PUBLICATIONS:

Judd, J.D. and McEachen, J.C., "An Architecture for Network Stream Splitting in Support of Intrusion Detection," *Proceedings of the 2003 IEEE International Conference on Information, Computers, and Signal Processing*, Singapore, December 2003.

Judd, J.D., McEachen, J.C., Michael, J.B., and Ettlich, D.W., "Network Stream Splitting for Intrusion Detection," *Proceedings of the 2003 IEEE International Conference on Networks (ICON 03)*, Sydney, Australia, September 2003.

McEachen, J.C., Zachary, J.M., and Ettlich, D.W., "Differentiating Network Conversation Flow for Intrusion Detection and Diagnostics," *IEEE International Symposium on Circuits and Systems*, Vancouver, British Columbia, May 2004, (to appear).

Zachary, J.M., McEachen, J.M., and Ettlich, D.W., "Conversation Exchange Dynamics for Real-time Network Monitoring and Anomaly Detection," *Proceedings of the 2nd IEEE International Information Assurance Workshop*, Charlotte, NC, April 2004, (to appear).

PRESENTATIONS:

Ettlich, D.W., "Network Stream Splitting for Intrusion Detection," 2003 IEEE International Conference on Networks (ICON 03), Sydney, Australia, September 2003.

McEachen, J.C., "An Architecture for Network Stream Splitting in Support of Intrusion Detection," 2003 IEEE International Conference on Information, Computers, and Signal Processing, Singapore, 15 December 2003.

McEachen, J.C., "Therminator," First Fridays, National Reconnaissance Office, Westfields, VA, 4 December 2003.

McEachen, J.C., "Therminator," White House Chief Information Officer, Washington, D.C., 12 August 2003.

McEachen, J.C., "Therminator 2: Real-time Computer Network Situational Awareness and Visualization," Chief of Naval Operations, Monterey, CA, 14 May 2003.

McEachen, J.C., "Therminator 2: Real-time Computer Network Situational Awareness and Visualization," Naval Postgraduate School (NPS) Center for Executive Education (CEE) Research Tours, Monterey, CA, 14 May 2003.

McEachen, J.C., "Therminator 2: Real-time Computer Network Situational Awareness and Visualization," NPS Center for Executive Education (CEE) Research Tours, Monterey, CA, 11 April 2003.

McEachen, J.C., "Therminator 2: Real-time Computer Network Situational Awareness and Visualization," NPS Center for Executive Education (CEE) Research Tours, Monterey, CA, 18 February 2003.

McEachen, J.C., "Therminator 2: Real-time Computer Network Situational Awareness and Visualization," NPS Center for Executive Education (CEE) Research Tours, Monterey, CA, 14 January 2003.

THESES DIRECTED:

Ettlich, D.W., "Therminator: Configuring the Underlying Statistical Mechanics Model," Master's Thesis, Naval Postgraduate School, December 2003, (awarded Space and Naval Warfare Systems Command Award in Electronic Systems Engineering for Distinguished Academic Achievement).

Judd, J.D., "Stream Splitting in Support of Intrusion Detection," Master's Thesis, Naval Postgraduate School, June 2003.

Marinovich, J.M. and Walch, S.L., "Analysis of Initial and Boundary Conditions in Therminator Conversation Exchange Dynamics," Master's Thesis, Naval Postgraduate School, March 2004.

KEYWORDS: Intrusion Detection, Thermodynamics, Statistical Mechanics, High-Speed Networking

SUPPORT TO COMPUTER NETWORK RESEARCH LAB FOR INITIATIVES IN COMPUTER NETWORK OPERATIONS
John C. McEachen, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Engineering Logistics Office

OBJECTIVE: The goal of this research was to initiate research in a variety of areas related to computer network operations of interest to the Naval Engineering Logistics Office (NELO). This research was conducted using the facilities of the Computer Network Research Laboratory (CNRL) and the Electrical

and Computer Engineering Department Advanced Networking Laboratory. Consequently, this effort also served to maintain and upgrade some of the CNRL facilities.

SUMMARY: Interest in portable, high-bandwidth digital communications methods spans the world and presents a formidable challenge to the Department of Defense of the United States. While anxious to use new communications equipment, the armed services are wary of the vulnerabilities they expose. This project examined the vulnerability of control and management functions in a variety of scenarios from wireless local area networks (WLANs) to fiber optic networks. Aspects of this project were classified by the sponsor.

PRESENTATIONS:

McEachen, J.C., "Susceptibility of WiFi Wireless Networks to Denial of Service," Naval Postgraduate School (NPS) Center for Executive Education (CEE) Research Tours, Monterey, CA, 18 February 2003.

McEachen, J.C., "Susceptibility of WiFi Wireless Networks to Denial of Service," NPS Center for Executive Education (CEE) Research Tours, Monterey, CA, 14 January 2003.

THESES DIRECTED:

Babb, J.W. and McGrath, J.R., "System Level Specification for IEEE 802.11a/b Wireless Local Area Network Information Warfare System," Master's Thesis, Naval Postgraduate School, September 2003.

Black-Howell, T.L., "Quantum Key Distribution in a Naval Battlegroup," Master's Thesis, Naval Postgraduate School, September 2003.

Lim, K.S., "Analysis of Network Management Protocols in Optical Networks," Master's Thesis, Naval Postgraduate School, March 2004.

KEYWORDS: 802.11, SONET, SDH, Wireless, LAN, High-Speed Networking

SUPPORT TO NAVAL RESERVE SECURITY GROUP (NRSG) CLASSIFIED RESEARCH AND TEACHING
John C. McEachen, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Reserve Security Group Command (NRSGC)

SUMMARY: Procured computer network test equipment in support of computer network operations and of interest to NRSG. This funding was used to upgrade the facilities of the Electrical and Computer Engineering Department Advanced Networking Laboratory (NETLAB). Specifically, it was used to procure test equipment in support of lab requirements.

KEYWORDS: NRSG, NETLAB

RADIATION TOLERANT ASIC AND VLSI DEVICES FOR SPACE-BASED SYSTEMS
Sherif Michael, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: National Reconnaissance Office

SUMMARY: In this research, a general-purpose digitally programmable very large-scale integrated (VLSI) network for a space-based system was proposed. The design was based on a technique that was developed earlier by the Principal Investigator, and has shown excellent radiation sensitivity performance. The mixed mode signal circuit, using BiCMOS techniques is currently under development. Previously fabricated VLSI application-specific integrated-circuit (ASIC) chips will also be irradiated using the Naval

Postgraduate School linear accelerator (LINAC) for testing its performance under radiation environment. Past experimental results using this technique have shown great improvements in the circuits' radiation performance. Research in incorporating these designs using silicon-in-insulator (SOI) fabrication techniques was also considered.

KEYWORDS: ASIC, VLSI, BiCMOS, LINAC

SPACECRAFT POWER BEAMING USING HIGH ENERGY LASERS
Sherif Michael, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: National Reconnaissance Office

SUMMARY: Satellite lifetime is often limited by degradation of the electrical power subsystem, e.g., radiation-damaged solar arrays or failed batteries. The ability to beam power from terrestrial sites could alleviate this limitation, extending the lifetime of billions of dollars of satellite assets, as well as providing additional energy for electric propulsion that could be used for station-keeping and orbital changes. In addition, laboratory research at the Naval Postgraduate School (NPS) has shown the potential to anneal damaged solar cells using lasers. In this research, an experiment was proposed to demonstrate some of the key technology issues needed to achieve the above goal. The PANSAT, an NPS-built and operated spacecraft, was selected to conduct this experiment. A medium power laser with the proper wavelength was prepared at the Air Force Maui Optical and Supercomputing Site (AMOS), Air Force Research Laboratory (AFRL), where it was proposed to use this satellite for this concept demonstration.

KEYWORDS: Satellite Power, PANSAT, AMOS, AFRL, Terrestrial Beam, Laser

NEAR-FIELD HOLOGRAPHY FOR IMAGING OF ELECTRIC MOTORS AND PUMPS
Michael A. Morgan, Professor
Department of Electrical and Computer Engineering
SPONSOR: OFFICE OF NAVAL RESEARCH

OBJECTIVE: Holographic back-propagation of magnetic fields was investigated for application to electric motors and pumps using measurements from discrete sensors placed on truncated cylindrical surfaces.

SUMMARY: Small imbalances in the magnetic moments for coils or permanent magnets in electric motors are the source for greatly enhanced magnetic fields produced at large distances. These magnetic fields produce "signatures" which are sensed by the detonation mechanisms of magnetic mines. Measurement and mitigation of magnetic signatures (as well as all other signatures) is of paramount importance in warship design.

   This research effort developed software that predicts the magnetic field signature based upon measured fields at sensor locations arrayed on a cylindrical surface that surrounds the motor or other device. In addition, the software can be used to "back-propagate" the measured fields onto a smaller geometrical cylinder, which just encloses the device under test. This surface interrogation can yield the location of the unbalanced sources for the distant signature. The algorithm and initial software was developed during CY2003 and measured data was acquired for a test motor.

PUBLICATIONS:

Morgan, M.A., "Electromagnetic Holography on Cylindrical Surfaces Using K-Space Transformations - Abstract," *Journal of Electromagnetics Waves and Applications*, Vol. 17, No. 11, pp. 1587-1588, 2003.

Morgan, M.A., "Electromagnetic Holography on Cylindrical Surfaces Using K-Space Transformations," *Progress in Electromagnetics Research*, PIER 42, pp. 303-337, 2003.

PRESENTATIONS:

Morgan, M.A., "Magnetic Holography and Steel Tank Effect," Office of Naval Research Program Review, Arlington, VA, 10 September 2003.

Morgan, M.A., "Superresolution in Low-Frequency Electromagnetic Holography," Progress in Electromagnetics Research Symposium, Honolulu, HI, 14 October 2003.

KEYWORDS: Holography, Magnetic Signature, Imaging

OPTIMIZATION OF MAGNETIC FIELD SENSOR PLACEMENTS USING A GENETIC ALGORITHM
Michael A. Morgan, Professor
Department of Electrical and Computer Engineering
Sponsor: Office of Naval Research

OBJECTIVE: Use of a genetic algorithm was investigated for optimizing the placement of sensors for use in predicting the off-board magnetostatic signature of a ferromagnetic object.

SUMMARY: A special genetic algorithm was developed and tested for placing sensors to minimize prediction errors of off-board magnetic signatures for ferromagnetic objects. Testing was performed using fields produced by an axial array of dipoles enclosed within a ferromagnetic spheroidal shell. Genetic algorithm sensor placement optimization was performed for varying numbers of sensors and varying signal to noise ratios for sensor data. The algorithm was shown to quickly search the very large space of possible sensor placement configurations to provide monotonic convergence to a near-optimum configuration.

PRESENTATION:

Morgan, M.A., "Enhanced Off-Board Magnetic Signature Prediction," Office of Naval Research Program Review, Arlington, VA, 24 February 2003.

KEYWORDS: Genetic Algorithm, Optimal Sensor Placement, Magnetic Signature Prediction

SYSTEM PERFORMANCE AND SHIELDING EFFECTIVENESS STUDY
Michael A. Morgan, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Surface Warfare Center - Dahlgren Division

OBJECTIVE: The goal of this task was to investigate the impulse radiation characteristics of specified antennas in the presence of buildings over real earth.

SUMMARY: Wire-grid numerical modeling of antenna and building structures was completed using frequency-stepped calculations of the Numerical Electromagnetics Code (NEC-4). Impulsive near-fields within the modeled building were found using time-domain source modeling and inverse FFT convolution. Computations of transient fields and shielding effectiveness within the structure were created using custom MATLAB programs.

KEYWORDS: Impulse Response, Antenna Modeling, Near-fields, NEC

DIGITAL TARGET IMAGING ARCHITECTURES
Phillip E. Pace, Professor
Douglas J. Fouts, Professor
Department of Electrical and Computer Engineering
Sponsor: Office of Naval Research

OBJECTIVE: The technical objective of this continuing research is threefold. The first objective was to quantify the digital image synthesizer's (DIS) arithmetic rounding and truncation errors and their effects on wideband inverse synthetic aperture radar (ISAR) image quality. The second objective was to build a database of realistic image coefficients using the CRUISE_Missile model outputs. The third objective was to continue constructing the chip and verifying the layout versus schematic in order that the fabricated chip works correctly.

SUMMARY: Using a bit-level simulation of the DIS architecture, the rounding and truncation errors were evaluated based on ISAR image quality. It was determined that using nine bits (or fewer) gave close to infinite resolution image fidelity with no overflow errors created. To build a database of realistic false-target image coefficients, the Fast-RTS model within the CRUISE_Missile engagement simulation (NRL Code 5750) was used to model an ISAR imaging a FFG in a sea multipath environment. The Fast-RTS model was rigorously derived from the Radar Target Signature (RTS) model (NRL Code 5314), which is a first principles, physics-based, radar cross-section prediction code, and the Naval Sea Systems Command (NAVSEA) standard for ship RF signature prediction. The resolution and RF frequency used for the simulation were those of an AN/APS-137. Several examples of the DIS output image were investigated. Operational uses of the DIS for counter-targeting, counter-surveillance, and counter-terminal were examined. The integrated circuit was laid out in a 0.18 um CMOS technology for fabrication.

PRESENTATIONS:

Pace, P.E., "Digital Target Imaging Architectures for Multiple Large Target Generation," ECE Students and Faculty, University of Cincinnati, Cincinnati, OH, 17 January 2003.

Pace, P.E. and Fouts, D.J., "Digital Target Imaging Architecture for Multiple Large Target Generation," Office of Naval Research EW (313) Gathering, Naval Research Laboratory, Washington, D.C., 21 May 2003.

Pace, P.E., Fouts, D.J., Mattox, D., and Adams, C., "Digital Target Imaging Architectures for Multiple Large Target Generation," Office of Naval Research-313, Alexandria, VA, 22 January 2003.

PATENT:

Fouts, D.J. and Pace, P.E., "False Target Radar Image Generator for Countering Wideband Imaging Radars," U.S. 6,624,780, 23 September 2003.

THESES DIRECTED:

Adams, C.N., "Three Dimensional Image Synthesis: Theory and Application," Master's Thesis, Naval Postgraduate School, June 2003.

Kantemir, O., "VHDL Modeling and Simulation of a Digital Image Synthesizer for Countering ISAR," Master's Thesis, Naval Postgraduate School, June 2003.

KEYWORDS: Imaging Decoys, Inverse Synthetic Aperture Radar, Counter-targeting, Counter-terminal, Digital Radio Frequency Memories, DRFM

ELECTRICAL AND COMPUTER ENGINEERING

MATHEMATICAL MODELING FOR SENSOR AND WEAPONS REQUIREMENTS
Phillip E. Pace, Professor
Murali Tummala, Professor
Department of Electrical and Computer Engineering
Sponsor: Missile Defense Agency

OBJECTIVE: The goal of this research was to develop a mathematical model of a boost-phase, ballistic target intercept in order to specify the requirements for the forward based radio frequency (RF) sensors, the space based infrared (IR) sensors, and the sensor fusion architecture used to guide the interceptor. An additional objective was to develop a model for the boost phase kill vehicle (launched by the interceptor) in order to determine its requirements and the resulting probability of kill.

SUMMARY: Researchers developed a 6DOF model of both the ballistic target and the interceptor rocket. The capability to include multiple targets and multiple interceptors was available. Included in the target model were the detailed radar cross-section signature and a simplified model of the plume signature throughout the boost phase. Missile data parameters included total mass, propellant mass, specific impulse, and in-stage burn time. The performance of both a solid propellant and liquid propellant, four-stage thrust vectoring rocket was evaluated for the interceptor and the target. Sensors used to guide the interceptor included two forward-based RF radars and two space-based IR sensors. Signal-to-noise (RF and IR) receiver models and two-state Kalman filters were used to determine the accuracy with which the target can be tracked. The target position derived from each RF sensor was combined with the target position derived by the IR sensors in a data-fusion architecture. Three sensor fusion architectures were evaluated and included: direct fusion of sensor data, representation of sensor data via feature vectors with subsequent fusion of the feature vectors, and processing of each sensor to achieve high-level inferences or decisions that were subsequently combined. The best predicted target position from the sensor fusion (North East Down coordinates) was sent to the interceptor for calculation of the line of sight rates needed for boost-phase guidance. For the end game, the interceptor launched the kill vehicle (single-stage missile) that guided to the target using a dual-mode seeker (both RF and IR). Probability of kill was assessed for an integrated guidance and fusing missile in order to maximize aim point accuracy. Simulation results were used to determine the power-aperture requirements for the forward-based RF sensors, the instantaneous field of view, and the optics arrangement necessary for the space based IR sensors, the specific fusion architecture, and the minimum delay-to-launch interceptor that can be tolerated.

   This research, given that a range of parameters was used in the simulations, will make it possible to answer questions such as the following: Rather than assuming perfect sensor registration and gridlock, what are the tolerable margins of error? How do the target scintillations affect the tracking performance of the sensor? How will exo-atmospheric debris from a previous engagement impact the results?

KEYWORDS: Modeling Sensor Requirements, Weapons Requirements, 6DOF

NAVY SURFACE ANTI-SHIP CRUISE MISSILE THREAT SIMULATOR VALIDATION WORKING GROUP
Phillip E. Pace, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Research Laboratory

OBJECTIVE: The objective of this work was to provide technical leadership to the Navy Surface Anti-Ship Cruise Missile Threat Simulator Validation Working Group (SVWG). Three types of simulations were validated by the SVWG for use in test and evaluation. These included radio frequency missile hardware simulators, infrared missile hardware simulators, and computer models of missile seekers and related electronics.

SUMMARY: The duties for the SVWG chairman included coordinating with the Navy's Simulator Validation Coordinator, the Naval Research Laboratory (NRL) ENEWS Program Manager, and other Navy commands (e.g., Commander Operational Test and Evaluation Force) to prioritize the simulator validations for N912 approval. Additional responsibilities included coordinating with the Office of Naval Intelligence

for threat data review and convening the SVWG as an independent and unbiased reviewer for all of the validation reports. This year we examined the first computer simulation validation report (LIMA), one IR validation report (MIKE) and two RF validation reports (TANGO, ALPHA).

PRESENTATION:

Pace, P.E., "Overview of the N912 Threat Simulator Validation Working Group," Navy Modeling and Simulation Office, Verification, Validation and Accreditation Working Group, Naval Postgraduate School, 4 August 2003.

KEYWORDS: Anti-ship Cruise Missiles, Simulators, Captive-carry, Hardware-in-the-loop

PREDICTING THE EFFECTIVENESS OF OFF-BOARD DECOYS AGAINST ANTI-SHIP CRUISE MISSILES USING LINEAR AND NONLINEAR SIGNAL PROCESSING
Phillip E. Pace, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Research Laboratory

OBJECTIVE: An off-board decoy presents a significant electronic warfare (EW) response to an incoming high-speed anti-ship threat missile. The objective of this proposal was to develop a mathematical model to predict the effectiveness (miss distance) of an off-board decoy using captive-carry field test results where the threat tracks the target in an open-loop scenario.

SUMMARY: A method to calculate the effectiveness of an electronic attack (EA) to an anti-ship cruise missile (ASCM) engagement, using data collected from an open-loop captive carry experiment, was developed and implemented using DT-IIIB test results. The ASCM was a captive-carry INDIA II missile pod on an NP-3D, and the EA was either a NULKA decoy or MK-216 distraction chaff. The EA was shipboard launched from an Aegis class destroyer. From the data, a *relative targeting process* was used to derive the EA response data that corresponded to the track of the decoy or the chaff. To calculate the effectiveness (miss distance) of the EA response using the relative targeting output, an *event mapping* was developed to transform the open-loop track data into closed-loop scenarios that included a digital missile model (DMM). The DMM incorporated the INDIA II characteristics from the INDIA II Validation Report and the Electronic Warfare Reprogramming Database (EWIRDB). The DMM output was the missile's miss distance from the ship that launched the EA response. The significance of this process result was that the EA response's closed-loop effectiveness against a specified threat was predicted using only open-loop data collected on-board a captive-carry platform. The analysis of future network-centric fleet requirements was also investigated.

THESES DIRECTED:

Cunningham, S.P., "Analysis of Future Electronic Warfare Network Centric Requirements (U)," Master's Thesis (SECRET/NOFORN), Naval Postgraduate School, June 2003.

Weber, J.B., "Predicting the Effectiveness of Ship Launched Electronic Attack Against an Anti-Ship Cruise Missile Using Captive Carry Open-Loop DT-IIIB Results," Master's Thesis (SECRET/NOFORN), Naval Postgraduate School, December 2003.

KEYWORDS: Anti-ship Cruise Missiles, Simulators, Captive-carry, Hardware-in-the-loop

ELECTRICAL AND COMPUTER ENGINEERING

MODELING TEMPERATURE DEPENDENCE OF SINGLE EVENT UPSETS
LT Steven G. Plonka, USNR
Department of Electrical and Computer Engineering
Sponsor: Space and Naval Warfare Systems Command - San Diego

SUMMARY: Improved the current methods of modeling a semiconductor in a radiation intense environment. This was accomplished by accounting for absorbed energy in the lattice when a particle impacts a device. The result was a more comprehensive and accurate computer model of a semiconductor device in a radiation intense environment.

KEYWORDS: Semiconductor Modeling, Radiation Environment

FREQUENCY HOPPING SIGNAL RESEARCH
R. Clark Robertson, Professor
Department of Electrical and Computer Engineering
Sponsor: National Security Agency

OBJECTIVE: The objective was to develop a simulation of frequency-hopping signals with multiple frequency-hopping signals active at the same time in order to test precision frequency-hopping signal measurement techniques and to simulate the effects of filtering interference from analog and digital signals.

SUMMARY: The simulation of multiple frequency-hopping signals was used to test precision frequency-hopping signal measurement techniques. This research determined the best method to simulate signals to test these techniques was and whether or not the simulated signals needed to include atmospheric effects. Additionally, simulations of notch filtering effects on analog and digital modulations were done in MATLAB. The notch filters removed unwanted tones from the received signal but caused intersymbol interference in digital data. This effort required the use of several frequency-hopping signal generators to simulate multiple frequency-hopping signals simultaneously active.

KEYWORDS: Spread Spectrum, Frequency-hopping, Narrowband Interference

NATIONAL SECURITY AGENCY (NSA) / APPLIED TECHNOLOGY DIVISION (ATD) CRYPTOLOGIC RESEARCH LABORATORY AND THESIS RESEARCH SUPPORT
R. Clark Robertson, Professor
Department of Electrical and Computer Engineering
Sponsor: National Security Agency

SUMMARY: Supported the Cryptologic Research Laboratory at the Naval Postgraduate School wherein graduate students and faculty performed research in support of the National Security Agency (NSA's) Applied Technology Division.

KEYWORDS: Crytology, NSA ATD

PROPAGATION EFFECTS ON DIGITAL COMMUNICATIONS SIGNALS
R. Clark Robertson, Professor
Department of Electrical and Computer Engineering
Sponsor: Air Force Information Warfare Center

OBJECTIVE: Analysis sections of the 453rd Electronic Warfare (EW) Squadron currently use the Model for Electronic Support and Attack (MESA) for RF propagation of radar and communications signals. The primary analytical output for MESA is received signal strength and the propagation mode assumed to obtain this received signal strength. Signal features and processing are not accounted for in MESA but must be incorporated by hand into an analysis. The objective of this project was to develop an engineering

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methodology to derive the required signal strength from basic equipment parameters to determine if operation of the analyzed equipment was acceptable, degraded, or denied.

SUMMARY: The derivation and compilation of equations, nomographs, and assumptions that incorporate digital communications modulation schema (*M*QAM, various forms of frequency and phase-shift keying, etc.), equalization, diversity, channel coding, speech coding, multiple access techniques and channel characterizations (to name a few) in a detailed, fully documented, and academically and operationally defendable end-to-end link budget analysis was written. This is the engineering methodology that is sufficient to estimate the required signal strength of almost any type of communications equipment encountered. This research is ongoing.

KEYWORDS: Digital Communications, Error Correction Coding, Fading Channels

WIRELESS MULTIPLE-INPUT-MULTIPLE-OUTPUT (MIMO) COMMUNICATIONS RESEARCH
R. Clark Robertson, Professor
Department of Electrical and Computer Engineering
Sponsor: National Security Agency

OBJECTIVE: The principal focus of this research was to investigate the performance of a Multiple-Input-Multiple-Output (MIMO) communication system under various channel and interference conditions. The objective was to develop a flexible software-based simulation architecture that would enable a variety of signal modulation, multiplexing, and space-time coding schemes to be implemented as a MIMO system under various channel conditions and interference scenarios.

SUMMARY: In wireless communications, the use of multiple antennas at both the transmission and receiver locations is an emerging technique known as Multiple-Input-Multiple-Output (MIMO) communications. Although the use of multiple antennas in the wireless communications environment is relatively common, multiple antennas are typically seen at the receive end of the link for the purpose of exploiting spatial diversity or achieving array gain. When multiple transmit antennas are used, recent results from information theory show that significant gains in link capacity can be achieved through the introduction of additional spatial channels (space-time coding). Because the coding is performed across space (transmit antennas) as well as time, MIMO systems can leverage the rich scattering environment that exists in a typical urban multipath channel by using multiple receive antenna elements and relying on the distinct spatial signatures induced through fading. For low signal-to-noise ratio (SNR), the MIMO system capacity can grow linearly with respect to the number of transmit/receive antenna pairs. However, various environmental factors, such as external interference, channel complexity, and channel estimation error, can affect the MIMO system capacity. A MIMO communications system subject to various channel impairments and external interference (cooperative and uncooperative) was modeled and simulated in MATLAB/Simulink. The model was flexible enough to evaluate the link performance of a wide variety of MIMO architectures subject to varying degrees of multipath fading and shadowing effects, channel estimation errors, and external interference scenarios. This research is ongoing.

KEYWORDS: Fading Channels, Multiple-input-multiple-output, MIMO, Space-time Coding

A SPACE-BASED FLEXIBLE DIGITAL DOWNCONVERTER WITHIN A RECONFIGURABLE FIELD PROGRAMMABLE GATE ARRAY (FPGA) ARCHITECTURE FOR SOFTWARE DEFINED RADIO APPLICATIONS
LT Michael Snelling, USN
Department of Electrical and Computer Engineering
Sponsor: Space and Naval Warfare Systems Command – San Diego

SUMMARY: The objective of this project was to research implementations of the digital down-conversion process within a reconfigurable Field Programmable Gate Array (FPGA) architecture for software defined

ratio applications. A basic building block of any all-digital receiver is the down-conversion of a real signal at an IF frequency to complex in-phase and quadrature (I&Q) samples at baseband.

The digital down-converter consists of a complex number controlled oscillator (NCO) that generates digital representations of sampled sine and cosine waveforms. This is the equivalent of a local oscillator (LO) in an analog receiver. Two digital multipliers act as mixers to multiply the incoming signal by the digital LOs and create in-phase (I) and quadrature (Q) signal processing paths. Filtering follows the multipliers to remove the image term in the mixing process and bandlimit the baseband spectrum around the signal of interest.

Filtering is typically performed by a combination of cascaded integrator-comb (CIC) and finite impulse response (FIR) filters. The CIC filters provide an efficient method of reducing the sample rate of over-sampled digital signal. The reduction in sample rate is called decimation. The CIC filters are followed by a FIR filter, which has better control over its frequency response than the CIC filter. The combination of the CIC and FIR filters produces a filtered complex baseband representation of the signal or channel of interest at a sample rate much lower than the input sample rate of the real input signal. This complex baseband signal can be forwarded to carrier and timing recovery circuits such as Phase Locked Loop and Digital-Delay Locked Loop.

KEYWORDS: Field Programmable Gate Array, FPGA, Complex Number Controlled Oscillator, Digital Down-Conversion

INTEGRATED SENSING AND PROCESSING
Charles W. Therrien, Professor
Department of Electrical and Computer Engineering
Sponsor: Defense Advanced Research Projects Agency's Defense Sciences Office/Applied and Computational Mathematics Program via Air Force Office of Scientific Research

OBJECTIVE: This project was part of the integrated sensing and processing (ISP) program under the Defense Acquisition Research Projects Agency (DARPA) DSO/AMCP. It supported faculty and students at the Naval Postgraduate School performing advanced research in sensor processing and fusion. Students who participated in the research were members of the Navy, Army, other services, and civilian employees of the Department of Defense (DoD). A focus of the work was multi-rate statistical signal processing where algorithms were developed for optimal filtering, detection, and classification.

SUMMARY: CY03 Accomplishments - The investigation of multirate statistical methods continued in 2003. The work continued to focus on fundamentals of statistical representation in the time and frequency domains for multi-rate signals and systems and optimal filtering (estimation). Cases of interest occurred when the sensor observations were at a different rate from the desired signal, or sets of sensor observations, sampled at *different* rates, were available (this is a problem in information fusion). Formulae were derived for evaluating the additional information (in the information theoretic sense) that additional sets of observations bring to the estimation problem so that users contemplating the benefits of multiple sensor observations can make informed decisions. A new multi-rate *adaptive* filtering algorithm was developed and tested.

CONFERENCE PUBLICATIONS:

Hawes, A.H. and Therrien, C.W., "LMS Adaptive Filtering with Multirate Observations," *Proceedings of the 37th Asilomar Conference on Signals, Systems, and Computers*, Pacific Grove, CA, pp. 567-570, November 2003.

Kuchler, R.J. and Therrien, C.W., "Optimal Filtering with Multirate Observations," *Proceedings of the 37th Asilomar Conference on Signals, Systems, and Computers*, Pacific Grove, CA, pp. 1208-1212, November 2003.

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PRESENTATIONS:

Therrien, C.W., Kuchler, R. J., and Hawes, A.H., "Multirate Sensor Processing," Defense Acquisition Research Projects Agency (DARPA) DSO/ACMP Program Review, St. Petersburg, FL, October 2003.

Therrien, C.W., Kuchler, R. J., and Hawes, A.H., "Optimal Filtering for Multirate Signals," Air Force Office of Scientific Research (AFOSR) Program Review, Princeton, NJ, June 2003.

THESES DIRECTED:

Hawes, A.H., "Least-Squares and Adaptive Multirate Filtering," Master's Thesis, Naval Postgraduate School, September 2003.

Kuchler, R.J., "Theory of Multirate Statistical Signal Processing and Applications," Ph.D. Thesis (ongoing, title tentative), Naval Postgraduate School.

KEYWORDS: Multirate Signal Processing, Statistical Signal Processing

SIGNAL PROCESSING FOR STRATEGIC SYSTEMS
Charles W. Therrien, Professor
Department of Electrical and Computer Engineering
Sponsor: Strategic Systems Program

OBJECTIVE: This work involved the study of use of jointly-deployed sensors to perform tasks of detection, estimation, and classification for objects of interest. The sensors may be of different types (acoustic, electromagnetic, optical, or other) and are typically characterized by different discrete-time sampling rates.

SUMMARY: Preliminary study of the problem began with a Ph.D. student in the program. Advanced statistical decision methods were studied with a view toward application to the sensor fusion problem.

KEYWORDS: Multirate Signal Processing, Statistical Decision

MODELING AND SIMULATION OF JOINT SERVICE IMAGERY PROCESSING SYSTEM (JSIPS-N) COMMUNICATIONS ARCHITECTURE (JCA)
Murali Tummala, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Aviation Depot, Cherry Point, North Carolina

OBJECTIVE: The goal of this research was to continue the modeling and simulation effort of JSIPS-N concentrator architecture (JCA) for transmission of imagery over packet switched communications networks—both local and wide area segments. This research was initiated during FY2001. Issues addressed in this effort were network performance indicators, assessment of alternate network topologies, and system constraints in terms of capacity limitations and the number of nodes supportable.

SUMMARY: Continuing with the previous year's effort, this work modified and extended the JSIPS-N OPNET model. The model was used to evaluate JCA communications performance against a set of Key Performance Parameters. In this regard, two tasks were satisfied. First, implementation of specific changes to the model, including an upgrade to OPNET 9.0 network simulation software, and inclusion of additional features for satellite modeling. Second, the upgraded model was used to conduct failure and redundancy analysis of the system to gain an improved understanding of the performance capabilities of the JCA model.

The OPNET model was enhanced by incorporating cryptologic devices, a tactical source, a redundant link, and a new client site. Using the enhanced model, simulations were conducted to measure the FTP

response time for different MTU values and file sizes. Also, link utilization and throughput were observed on selected satellite links.

THESES DIRECTED:

Burke, K.W., "Modeling and Simulation of the Joint Services Imagery Processing System-Navy (JSIPS-N) Concentrator Architecture (JCA)," Master's Thesis, Naval Postgraduate School, June 2003.

Laird, P.T., "Modeling and Simulation of the Joint Services Imagery Processing System-Navy (JSIPS-N) Concentrator Architecture (JCA)," Master's Thesis, Naval Postgraduate School, June 2003.

Phan, M.Q., "Modeling and Simulation of the JSIPS-N Concentrator Architecture (JCA) with Added Source and Cryptographic Devices," Master's Thesis, Naval Postgraduate School, September 2003.

Spitale, P.J., "Modeling, Simulation, and Analysis of Full Duplex Communication Capabilities in the JSIPS-N Communications Architecture (JCA)," Master's Thesis, Naval Postgraduate School, March 2003.

KEYWORDS: Wide Area Networks, Local Area Networks, Modeling and Simulation, Image Transmission, Network Performance, OPNET Modeling

SIGNAL PROCESSING OF ELECTROMAGNETIC PULSE (EMP) WAVEFORMS
Murali Tummala, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Air Warfare Center - Aircraft Division

OBJECTIVE: The goal of this research was to investigate the processing of multirate EMP waveforms. The main effort was on the application of wavelet transform to process these waveforms. Additionally, the application of fractional Fourier transform to transient signal processing was studied.

SUMMARY: Naval Air Warfare Center's Aircraft Test Division conducts testing of aircraft against various electromagnetic pulses. With the recent upgrade of a data acquisition and processing suite of equipment, an effort was initiated to develop new signal processing algorithms and enhance processing capabilities. In this effort, researchers developed equalization techniques using the wavelet transform. The new techniques were compared to the currently used techniques. Denoising capabilities of the wavelet algorithms were investigated. The MATLAB code developed was capable of automatically extracting essential portions of a recorded data set and removing the DC bias.

THESIS DIRECTED:

Ardolino, R., "Wavelet-Based Signal Processing of Electromagnetic Pulse Waveforms," Master's Thesis, Naval Postgraduate School, (on extension).

KEYWORDS: Multirate Signal Processing, Electromagnetic Pulse Waveform, Wavelets

DETONATION MERGING ON UNDERWATER BLAST
Donald Wadsworth, Senior Lecturer
Department of Electrical and Computer Engineering
Sponsor: Naval Surface Warfare Center – Indian Head Division

UNDERWATER WARHEAD TECHNOLOGY
Donald Wadsworth, Senior Lecturer
Department of Electrical and Computer Engineering
Sponsor: Office of Naval Research

ELECTRICAL AND COMPUTER ENGINEERING

CONTROLLED LOW TEMPERATURE GROWTH, CHARACTERIZATION AND MODELING FOR GALLIUM NITRIDE
Todd Weatherford, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Silvaco International

OBJECTIVE: The goal of this research was to support an Air Force Small Business Technology Transfer (STTR) with Silvaco and the University of California-Berkeley in developing code to model electrical properties of gallium nitride by virtual growth simulation.

SUMMARY: The Naval Postgraduate School (NPS) modeled the growth and electrical performance of Gallium Nitride (GaN) high electron mobility transistors. Growth of GaN crystal simulations was used to predict point defect type and density. Device simulations utilized the results of the crystal simulations to predict transistor performance. A Cooperative Research and Development Agreement (CRADA) between NPS and Silvaco International was in place for this work.

KEYWORDS: Electronics, Materials, Radiation Effects

FOURTH SYMPOSIUM ON NON-STOICHIOMETRIC III-V COMPOUND SEMICONDUCTORS
Todd Weatherford, Assistant Professor
Andrew Parker, Research Associate
Department of Electrical and Computer Engineering
Sponsors: Air Force Office of Scientific Research, Office of Naval Research

OBJECTIVE: Supported the 4th Symposium on Non-Stoichiometric III-V Compound Semiconductors.

SUMMARY: Support was provided by Air Force Office of Scientific Research (AFOSR) / Office of Naval Research (ONR) to cover invitational travel, conference support, and publications for the Symposium. This was the first U.S. hosting of the Symposium on Non-Stoichiometric III-V Compounds.

PUBLICATIONS:

Weatherford, T.R., "Radiation Effects in High Speed III-V Integrated Circuits," *International Journal for High Speed Electronic Systems*, Vol. 13, No. 1, March 2003, (invited).

Weatherford, T.R. and Anderson, W.T., "Historical Perspective on Radiation Effects in III-V Devices," *IEEE Transactions on Nuclear Science*, NS-51, June 2003, (invited).

KEYWORDS: Electronics, Materials, Radiation Effects

RADIATION EFFECTS STUDIES IN MICROELECTRONICS
Todd Weatherford, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Strategic Systems Program

SUMMARY: Studied ionizing and displacement damage effects in semiconductor microelectronics technologies.

KEYWORDS: Non-Stoichiometric, Semiconductors

SILVACO TOOLS DEVELOPMENT FOR RADIATION EFFECTS
Todd Weatherford, Assistant Professor
Andrew Parker, Research Associate
Department of Electrical and Computer Engineering
Sponsors: Naval Surface Warfare Center – Crane/SSP

OBJECTIVE: The goal of this research was to develop semiconductor simulation tools to improve modeling of radiation effects in semiconductor devices.

SUMMARY: Work in 2003 focused on local heating effects due to radiation. Simulation tools were developed to calculate changes in local lattice temperatures due to particle ionization effects. Results showed that local heating in semiconductors provides a substantial contribution to ionization photocurrents.

THESIS DIRECTED:

Plonka, S., "Analysis and Simulation of Local Heating in Semiconductors Due to Single Event Effects," Master's Thesis, Naval Postgraduate School, June 2003.

KEYWORDS: Electronics, Materials, Processes and Structures, Modeling and Simulation, Silicon-on-Insulator

SUPPORT FOR THE NAVAL POSTGRADUATE SCHOOL (NPS) LINEAR ACCELERATOR (LINAC)
Todd Weatherford, Assistant Professor
Andrew Parker, Research Associate
Department of Electrical and Computer Engineering
Sponsors: Various

OBJECTIVE: The goal of this research was to operate the Naval Postgraduate School (NPS) Linear Accelerator (LINAC) and Flash X-ray facilities.

SUMMARY: In 2003, the Center for Radiation Hardened Electronics supported internal Naval Postgraduate School (NPS) research related to solar cells and radhard electronics for space and strategic systems. Additionally the Center supported NPS classes related to reliability and space systems. Outside researchers from the National Aeronautics and Space Administration, the Naval Research Laboratory, SAIC/Suntronics, Lockheed Martin, and Northrop Grumman used the facilities for radiation effects research in 2003.

PUBLICATIONS:

Clark, K., Ross, A.A., Loomis, H.H., Weatherford, T.R., Fouts, D.J., Buchner, S.P., et al., "Modeling Single-Event Effects in a Complex Digital Device," *IEEE Transactions on Nuclear Science*, NS-47, December 2003, (2003 NRL Alan Berman Award).

Weatherford, T.R., "Radiation Effects in High Speed III-V Integrated Circuits," *International Journal for High Speed Electronic Systems*, Vol. 13, No. 1, March 2003, (invited).

Weatherford, T.R. and Anderson, W.T., "Historical Perspective on Radiation Effects in III-V Devices," *IEEE Transactions on Nuclear Science*, NS-51, June 2003, (invited).

THESIS DIRECTED:

Jones, B., "Radiation Dose Analysis of NPS Flash X-ray Facility Using Silicon PIN Diodes," Master's Thesis, Naval Postgraduate School, September 2003.

ADVANCED RF RECEIVER
Lonnie A. Wilson, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Explosive Ordnance Disposal Technology Division

OBJECTIVE: The goal of this research was to perform device measurements and DSP analysis for potential RF signal database, and develop preliminary system specification of the Advanced RF System.

SUMMARY: New RF threats are encountered in selected geographic regions of the world. These threats cannot be effectively countered using current RF systems. These wireless threats are considered major problems, which must be effectively handled during peace and war situations around the globe.

Numerous wireless devices were evaluated across selected elements of their electronic and technical performance envelopes. Data collection measurements were made for each device characterization, and performance capabilities and performance limitations were identified.

Static and dynamic signal characteristics were measured. Laboratory and local field tests were performed at the Naval Postgraduate School (NPS). Signal analysis was performed using DSP techniques and algorithms to extract important signal characteristics, key signal features and unique parameters for each device. DSP assessments used time domain and frequency domain algorithms.

CONFERENCE PUBLICATIONS:

Wilson, L.A., "Advanced RF Receiver System," April 2003.

Wilson, L.A., "Conceptual Wireless Locations in Generic City," July 2003.

Wilson, L.A., "DSP Analysis of ICOM Amateur Radios – Summary Results," June 2003.

Wilson, L.A., "Electronic Signal ID for Wireless Electronic Products, Radios, and Communication Units," 22 October 2003.

Wilson, L.A., "FMOP Signal Rough Estimate for Wireless Signal Characterization," April 2003.

Wilson, L.A., "Future RF System," September 2003.

Wilson, L.A., "Hacksaw (Wireless Transmitter) Technical Information," April 2003.

Wilson, L.A., "Preliminary RF System Block Diagrams and Technical Considerations," April 2003.

Wilson, L.A., "PT Cruisers (Two Wireless Transmitters) Technical Information," April 2003.

Wilson, L.A., "Razor Blade (Wireless Transmitter) Technical Information," February 2003.

Wilson, L.A., "Shadow Runners (Two Wireless Transmitters) Technical Information," February 2003.

Wilson, L.A., "Shadow Runner Wireless Product: Transmitter and Receiver Characterizations," February 2003.

Wilson, L.A., "Signal Information – Shadow Runner Transmitter Direct Connect," February 2003.

Wilson, L.A., "Situational Awareness, Precision ID, and Potential Tactical Actions for Wireless Signals," May 2003.

Wilson, L.A., "Wireless and EW Deinterleaver Processor," February 2003.

Wilson, L.A., "Wireless Frequencies and Wireless Products," 10 March 2003.

Wilson, L.A., "Wireless Product Information," January 2003.

Wilson, L.A., "Wireless RF Products with Control Devices," April 2003.

Wilson, L.A. and Horning, J., "RF Signal and Data Collection System for 100 MSPS Raw IF to MOP Signals," 12 February 2003.

KEYWORDS: RF Receiver, MOP Signal Extraction, RF Frequencies

ADVANCED RF SYSTEM DEVELOPMENT
Lonnie A. Wilson, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Explosive Ordnance Disposal Technology Division

SUMMARY: Performed device measurements and DSP analysis for potential Rf signal database, and developed preliminary system specification of the advanced Rf system.

KEYWORDS: Digital Signal Processing, DSP, Radio Frequency, Rf Signal Database

AUTOMATIC TARGET DETECTION
Lonnie A. Wilson, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: National University of Singapore

OBJECTIVE: The basic objective was to develop high performance and robust target detection algorithms for Temasek Defence Systems Institute (TDSI) Synthetic Aperture Radar (SAR) sensors.

SUMMARY: The project goal was to develop high performance and robust target detection algorithms for TDSI Synthetic Aperture Radar (SAR) sensors. The automatic target detection processor provided SAR image screening support and potential target detection cueing information to simplify and speed up manual target detection analysis.

Developments included high performance and robust detection algorithms for target detection under various Signal-to-Noise-Ratio (SNR) conditions and background environment conditions associated with the existing TDSI image database. Digital processing architectures and implementations were considered. Software developments included implementation of detection algorithms, software verification testing, and detection algorithm evaluations and trade off assessments.

KEYWORDS: Targets, Radar, Detection

GREEN ACRES PROJECT
Lonnie A. Wilson, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Space and Naval Warfare Systems Command - San Diego

OBJECTIVE: The basic objective was to initiate the Green Acres Project development for unique electronic warfare (EW) and information operations (IO) applications against high performance weapons systems containing modern radar emitters, computer based C3, and high performance missile threats.

DoD KEY TECHNOLOGY AREAS: Surveillance, Targeting, IW, Intelligence

ELECTRICAL AND COMPUTER ENGINEERING

KEYWORDS: Radar, Electronic Warfare, IW, Information Operations

HIGH PERFORMANCE DEINTERLEAVER USING MOP PARAMETERS
Lonnie A. Wilson, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Information Support Center

OBJECTIVE: The basic objective was to develop, evaluate, and demonstrate a high performance deinterleaver using modulation on the pulse (MOP) parameters and preliminary screening using selected classical parameters. This development built on fiscal year 2001 deinterleaver development efforts and previous high performance specific emitter identification (SEI) processor developments and demonstrations.

KEYWORDS: Deinterleaver, Modulation on Pulse, MOP, High Performance Specific Emitter Identification, SEI

HIGHPEAK PROJECT TECHNICAL SUPPORT
Lonnie A. Wilson, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Sea Systems Command

SUMMARY: Provided technical support for the Highpeak Project.

KEYWORDS: Highpeak Project

PMOP STUDY
Lonnie A. Wilson, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: National Reconnaissance Office

OBJECTIVE: The goal of this research was to continue development, evaluation, and demonstration of a high performance deinterleaver using phase-modulation-on-the-pulse (PMOP) parameters and selected classical parameters.

SUMMARY: Emitter deinterleaver problems and sorting ambiguities must be reduced to minimal levels to achieve desired operational capabilities for all electronic environments and conditions. PMOP parameters may emit deinterleaver problems and reduce sorting ambiguities to minimal levels. Also, PMOP parameters resolve split track problems that exist in deinterleavers based on classical parameters.

Algorithm development and software implementation were continued to refine and improve the Deinterleaver Processor and Screening Preprocessor Section performance. Deinterleaving analysis and assessments were successfully performed on the new IF signal database. These refinements included digital signal processing (DSP) algorithms for the Preprocessor and Deinterleaver. Development included parameter and signal extraction algorithms for low signal-to-noise conditions, improved algorithms for interference contamination and multipath signals screening, and integrated algorithms for automated processing.

DSP analysis, deinterleaving processing, and technical assessments were performed using the newly collected digitized IF signal database from the Naval Research Laboratory (NRL). DSP analysis was performed using the improved algorithms to extract signal characteristics and screen contaminated signals, extract key signal features, and provide unique parameters for each emitter.

Deinterleaving processing was performed using PMOP information and specific association metrics. DSP assessments were made using time domain and frequency domain algorithms.

CONFERENCE PUBLICATIONS:

Wilson, L.A., "Cepstrum Analysis for Multipath Processing," National Reconnaissance Office (NRO) Facility, Chantilly, VA, February 2003.

Wilson, L.A., "Deinterleaver Project Summary," National Reconnaissance Office (NRO) Facility, Chantilly, VA, January 2003.

Wilson, L.A., "Deinterleaver Screening: Heavy Filtering of Upper Sideband," National Reconnaissance Office (NRO) Facility, Chantilly, VA, January 2003.

Wilson, L.A., "Deinterleaver Screening: Missing Leading Edge of Pulse," National Reconnaissance Office (NRO) Facility, Chantilly, VA, January 2003.

Wilson, L.A., "EW Deinterleaver Processor," National Reconnaissance Office (NRO) Facility, Chantilly, VA, February 2003.

Wilson, L.A., "PMOP Signal Characterizations for Simulated Multipath Conditions," National Reconnaissance Office (NRO) Facility, Chantilly, VA, March 2003.

Wilson, L.A., "Radar Emitter Groups and PMOP Signals," National Reconnaissance Office (NRO) Facility, Chantilly, VA, May 2003.

Wilson, L.A., "Reference Group Processing and Analysis," National Reconnaissance Office (NRO) Facility, Chantilly, VA, January 2003.

Wilson, L.A., "Tonal Interference Assessment – PMOP and FMOP Signals," National Reconnaissance Office (NRO) Facility, Chantilly, VA, February 2003.

Wilson, L.A., "WJ35100 Superhet Receiver System Summary," National Reconnaissance Office (NRO) Facility, Chantilly, VA, May 2003.

Wilson, L.A., "10 dB Bandwidth Estimate of IF Signal," National Reconnaissance Office (NRO) Facility, Chantilly, VA, January 2003.

Presentation audience included Mr. Mike Regan and Mr. Lou Stielper of the National Reconnaissance Office, and approximately 12 persons from NRO technical staff, Naval Research Laboratory (NRL) SEI technical group, and NRL Data Collection Group. These presentations were at the NRO Facility in Chantilly, Virginia.

KEYWORDS: Sorting, ID, MOP Signal Extraction, Parameter Extractions, SNR, Multipath

MOTION TRACKING USING INERTIAL SENSORS
Xiaoping Yun, Professor
Department of Electrical and Computer Engineering
Sponsors: N6M and Army Research Office (ARO)

OBJECTIVE: The objective of this research was to create a new technology for human body motion tracking in networked virtual environments.

SUMMARY: A new generation of the inertial/magnetic (MARG) motion-tracking system was completed. The new system was capable of tracking multiple human limbs and transmitting motion data to a server wirelessly. The concept of the control-interface unit (CIU) was introduced, designed, prototyped, and tested. Additionally, a network-based realistic avatar was developed for visualizing human motions tracked

by the MARG sensors. The avatar was developed using the X3D graphic language and following the H-Anim standards.

CONFERENCE PUBLICATIONS:

Bachmann, E.R., Yun, X., and McGhee, R.B., "Sourceless Tracking of Human Posture Using Small Inertial/Magnetic Sensors," *Proceedings of 2003 IEEE International Symposium on Computational Intelligence in Robotics and Automation*, Kobe, Japan, July 2003.

Bachmann, E.R., Yun, X., McKinney, D., McGhee, R.B., and Zyda, M.J., "Design and Implementation of MARG Sensors for 3-DOF Orientation Measurement of Rigid Bodies," *Proceedings of 2003 IEEE International Conference on Robotics and Automation*, Taipei, Taiwan, September 2003.

Yun, X., Lizarraga, M., Bachmann, E.R., and McGhee, R.B., "An Improved Quaternion- Based Kalman Filter for Real-Time Tracking of Rigid Body Orientation," *Proceedings of 2003 IEEE/RSJ International Conference on Intelligent Robots and Systems*, Las Vegas, NV, October 2003.

THESIS DIRECTED:

Sicura, D.L., "Physical Based Modeling and Simulation of a Ship in Open Water 3-D Virtual Environment," Master's Thesis, Naval Postgraduate School, September 2003.

KEYWORDS: Motion Tracking, MARG Sensors, Human Avatar, Wireless LAN

REDUCED CREW SIZE METROLOGY USING WIRELESS LOCAL AREA NETWORKS (LAN) AND WEARABLE PERSONAL COMPUTERS
Xiaoping Yun, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Sea Systems Command - Corona

OBJECTIVE: The objective of the project was to develop a closed-loop wireless calibration system for calibrating shipboard pressure sensors.

SUMMARY: A prototype calibration system was developed. It was capable of calibrating analog and digital pressure sensors. The system operated in a completely wireless environment, where sensor data were delivered to the user's personal computer (PC) using an IEEE 802.11b-compliant wireless local-area network (LAN), and calibration standard data were transmitted using the Bluetooth wireless communication protocol. The prototype system was demonstrated at the 13th International Ship Control Systems Symposium held in Orlando, Florida, on 7-9 April 2003.

CONFERENCE PUBLICATION:

Rupnow, R., Walden, J., Yun, X., Greaves, D., and Click, H., "New Calibration Standards for Next Generation Ship's Monitoring Systems," *Proceedings of the Thirteenth International Ship Control Systems Symposium*, Orlando, FL, April 2003.

THESES DIRECTED:

Perchalski, S.J., "Shipboard Sensor Closed-loop Calibration Using Wireless LANs and Data Socket Transport Protocols," Master's Thesis, Naval Postgraduate School, June 2003.

Silva, E.P., "Network-Based Control, Monitoring, and Calibration of Shipboard Sensors," Master's Thesis, Naval Postgraduate School, September 2003.

KEYWORDS: Metrology, Wireless LAN, Wearable Computer

SUBMARINE WIRELESS LOCAL AREA NETWORKING
Xiaoping Yun, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Sea Systems Command

OBJECTIVE: The goal of this project was to conduct assessment of new wireless local area network (LAN) technologies and standards, to test and evaluate the IEEE 802.11a/b/g compliant wireless LAN components, and to continue the investigation of wireless LAN EMI issues.

SUMMARY: The performance of the 802.11g wireless LAN components was evaluated in comparison with the 802.11b components. In particular, data throughput and communication range under various operating conditions were studied. A maximum data rate of 8.37 Mbps was achieved, whereas the data rate specification for the 802.11g was 54 Mbps. A maximum range of 120m was achieved, which was in line with specification. The performance of Bluetooth wireless components from five different vendors was also tested. The maximum data rate was determined to be about 400 Kbps, and the maximum range was about 17 m. EMI compliance of the 802.11g products was investigated, following the MILSTD-461E standards.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications

KEYWORDS: Damage Control, Wireless Computer Networks

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

2003
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and Presentations

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McEachen, J., Zachary, J., and Ford, D., "Therminator: A Transformational Enabler for ForceNet," *CHIPS Magazine*, Vol. 12, No. 1, pp. 18-21, Winter 2004.

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Jenn, D.C. and Chua, E.-H., "Two-port Hybrid Ring Dipole with Simultaneous Sum and Difference Element Patterns," *IEE Electronics Letters*, Vol. 39, No. 12, p. 892, 12 June 2003.

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Michael, S.N., "Advantages of Spacecraft Power Beaming Using High-Energy Lasers Experimental Verification," *Proceedings of the Sixth Annual Directed Energy Symposium*, Albuquerque, NM, October 2003.

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DEPARTMENT OF
APPLIED MATHEMATICS

MICHAEL S. MORGAN
CHAIR

APPLIED MATHEMATICS

OVERVIEW:

The Naval Postgraduate School (NPS) Applied Mathematics Department is committed to excellence. Our purpose is to provide an exceptional mathematical education focused on the unique needs of our students, to produce relevant research for our sponsors, and to provide quality service to the community. We further are committed to maintenance of a well-designed curriculum and a supportive environment for our students.

CURRICULA SUPPORTED:

- The majority of the departmental effort is devoted to the service courses offered which support a variety of curricula.

DEGREES GRANTED:

- Master of Science in Applied Mathematics
- Doctor of Philosophy

RESEARCH THRUSTS:

- Scientific Computation
- Control Theory
- Approximation
- Numerical Modeling

RESEARCH PROGRAM (Research and Academic)-FY2003:

The Naval Postgraduate School's sponsored program exceeded $71 million in FY2003. Sponsored programs include both research and educational activities funded from an external source. A profile of the sponsored program for the Department of Applied Mathematics is provided below.
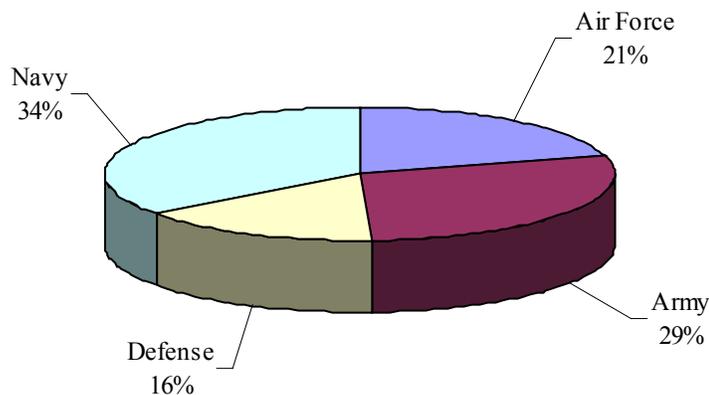
Size of Program: **$507K**

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APPLIED MATHEMATICS

MODELING THE SPREAD OF BIOLOGICAL INFECTIONS IN A FUNCTIONING MILITARY UNIT
C. F. Borges, Associate Professor
Department of Mathematics
Sponsor: Unfunded

OBJECTIVE: To develop models that can be used to study the spread of biological infections in functioning military units. To use these models to better understand the implications of a bio-warfare attack on a forward operating military unit, and to develop strategies for minimizing the effects of such attacks.

SUMMARY: This unfunded effort was a continuing research project. CAPT Ryan Paterson, USMC, performed Master's thesis work centered on various methods investigated by the Principal Investigator for modeling the spread of biological infections in functioning military units. CAPT Paterson implemented a computer model that allowed one to investigate the impact of a biological warfare attack on a single Marine battalion operating in a combat area. This model was quite general and was used to further investigate vaccination and quarantine strategies and other aspects critical to operating in a bio-warfare environment where the specific agents can generate contagious illnesses (secondary infections). This was the first model of its kind.

KEYWORDS: Biological Warfare, Biological Terrorism

TOTAL LEAST SQUARES FITTING OF ORDERED DATA WITH POLYNOMIAL SPLINES
C. F. Borges, Associate Professor
Department of Mathematics
Sponsor: Unfunded

OBJECTIVE: To develop fast and numerically stable algorithms for fitting polynomial splines to ordered data with minimal error in the total least-squares sense.

SUMMARY: This unfunded effort was a continuing research project. The idea was to fit parametric polynomial spline curves to ordered data to get the best possible fit. Unlike traditional least-squares methods, researchers assumed that errors might occur in both the x and y directions. Moreover, the data used was allowed to be completely general - in particular, it did not have to be functional in nature, it could overlap itself or change directions without restriction. All that was required was an ordered set of points in the plane. The Principal Investigator investigated a variety of different approaches and developed some very fast and robust algorithms for solving the problem for a single Bezier curve. These algorithms were extended to work with B-spline curves with general knot sequences. A first paper on this work appeared last year and the algorithms described therein have come into widespread use in other fields.

KEYWORDS: Curve Fitting, Data Compression, Approximation Theory

THERMOCAPILLARY EFFECTS IN WELDING
David Canright, Associate Professor
Department of Mathematics
Sponsor: Unfunded

OBJECTIVE: To analyze the thermocapillary feedback mechanism in the "cold corner" region of weld pools, and to develop an accurate model of this process for numerical simulation of welding.

SUMMARY: This unfunded project extended previously funded work. At the edge of a weld pool, where hot liquid meets relatively cool solid, thermocapillary effects may locally dominate the flow of fluid and of heat, which can affect the quality of the resulting weld. In this case, the length scales of this concentrated flow were extremely small relative to the pool size, imposing severe resolution constraints for numerical simulations. The current work used an earlier scaling analysis to develop a boundary-layer model that

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exploits the even smaller length scales of viscous boundary layers in the corner. The resulting corner model compared well with careful numerical simulations, and can be integrated into a global simulation to relieve the severe resolution constraints. This year work began on developing a consistent higher-order model for the cold corner.

DoD KEY TECHNOLOGY AREA: Scientific Computation

KEYWORDS: Thermocapillary Flow, Materials Processing, Boundary-Layer Theory

BUCKLING OF SHIP GRILLAGES WITH BULB FLAT STIFFENERS
D.A. Danielson, Professor
Department of Mathematics
Sponsor: Naval Surface Warfare Center – Carderock Division

OBJECTIVE: Use analytical formulas and finite element models to calculate the buckling loads of ship grillages with bulb flat stiffeners.

SUMMARY: There is currently great interest in understanding the benefits of using bulb flat, rather than T or angle, stiffeners in plate structures. Use of bulb flat stiffeners will reduce the cost of construction and maintenance of Navy ships. This year, analytical formulas and finite element models were developed for the buckling loads of bulb flat stiffened plates. The formula predictions were less than 4% higher than finite element results. During a visit with the sponsors at the Naval Surface Warfare Center, Carderock, researchers saw that one of the experimentally tested ship grillages buckled with the load and mode predicted by this theory.

THESIS DIRECTED:

Wilmer, A., "Analytic Expression of the Buckling Loads for Stiffened Plates with Bulb Flat Flanges," Ph.D. Thesis, Naval Postgraduate School, June 2003.

KEYWORDS: Structure, Ship, Grillage, Stiffener, Buckling

COMPUTATIONAL MATHEMATICS PROGRAM
Fariba Fahroo, Associate Professor
Department of Mathematics
Sponsor: Air Force Office of Scientific Research

OBJECTIVE: To manage the computational math program at the Air Force Office of Scientific Research in Arlington, Virginia.

SUMMARY: This program involved managing a multi-million dollar basic research effort at the university and Air Force labs level to develop improved numerical and mathematical modeling and simulation capabilities for Air Force needs.

The program also supported the national Air Force program in high performance computing. Duties involved managing the portfolio by knowing the latest trends in computational algorithm developments (as related to the Air Force), visiting the Principal Investigators (PI), holding program review meetings, maintaining inter-agency and inter-service contacts with other Department of Defense (DoD) funding agencies, and increasing the portfolio's exposure internally and externally to attract more funding for more research programs.

KEYWORDS: numerical modeling and simulation, computational algorithms

DEVELOPMENT OF ON-LINE FOOTPRINT GENERATION ALGORITHMS FOR SPACE ACCESS VEHICLES WITH CONTROL FAILURES
Fariba Fahroo, Associate Professor
Department of Mathematics
Sponsor: Air Force Research Laboratory

OBJECTIVE: To develop fast and accurate numerical methods for determining the largest reachable set (footprint) for a reusable launch vehicle under actuator failure.

SUMMARY: This research project continued work performed at the Air Force Research Laboratory (AFRL) in 2002. The ultimate goals of this research were to develop advanced guidance and control algorithms for hypersonic and reusable launch vehicles. One application was in the area of determining reachable regions by a reentry or un-powered hypersonic vehicle experiencing control effector failures. This problem was formulated as a parameter dependent, optimal control problem. The problem was solved using a numerical package developed at the Naval Postgraduate School (NPS) by Mike Ross and the Principal Investigator (PI). Future goals of the project will involve designing an adaptive reconfigurable control system for the X-40A vehicle to support a flight-test demonstration of an integrated adaptive guidance and control system.

CONFERENCE PUBLICATIONS:

Fahroo, F., Doman, D., and Ngo, A., "Footprint Generation for Reusable Launch Vehicles Using a Direct Pseudospectral Method," *Proceedings of the American Control Conference,* Denver, CO, June 2003.

Fahroo, F., Doman, D., and Ngo, A., "Modeling Issues in Footprint Generation for Reusable Launch Vehicles," *Proceedings of the 2003 IEEE Aerospace Conference,* Big Sky, MT, March 2003.

PRESENTATION:

Fahroo, F. and Doman, D., "A Direct Method for Approach and Landing Trajectory Reshaping with Failure Effect Estimation," 2004 AIAA Conference on Guidance, Navigation and Control, Providence, RI, August 2004, (to be presented).

DoD KEY TECHNOLOGY AREA: Space Vehicles

KEYWORDS: Trajectory Optimization, Guidance, Footprint Generation, Reusable Launch Vehicles, Pseudospectral Methods

REAL-TIME COMPUTATION OF TRAJECTORIES FOR HYPERSONIC LAUNCH VEHICLES
Fariba Fahroo, Associate Professor
Department of Mathematics
Sponsor: Naval Postgraduate School

OBJECTIVE: To develop numerical algorithms for computing trajectories for re-entry launch vehicle in real-time and to study the numerical properties, such as convergence and stability, of these algorithms.

SUMMARY: In this project, computational methods for generating optimal trajectories for re-entry vehicles subject to three DOF nonlinear dynamics were considered. Mathematically the problem was formulated within the framework of nonlinear and possibly non-smooth optimal control theory. Issues such as numerical stability and convergence of a class of numerical methods, pseudospectral methods, were considered. In addition, real-time implementation of the methods was also studied.

PUBLICATIONS:

Ross, I. M. and Fahroo, F., "Legendre Pseudospectral Approximations of Optimal Control Problems," *Lecture Notes in Control and Information Sciences*, Vol. 295, pp. 327-342, New York: Springer-Verlag, 2003.

Ross, I. M. and Fahroo, F., "Pseudospectral Knotting Methods for Solving Optimal Control Problems," *Journal of Guidance, Control and Dynamics,* September 2003, (accepted to appear).

Ross, I. M. and Fahroo, F., "Pseudospectral Methods for Optimal Motion Planning of Differentially Flat Systems," *IEEE Transactions on Automatic Control,* April 2003, (accepted after revision).

CONFERENCE PUBLICATIONS:

Fahroo, F., "Optimizing the Decay Rate in the Damped Wave Equation: a Numerical Study," *Proceedings of the American Control Conference*, Denver, CO, June 2003.

Ross, I. M., D'Souza, C., Fahroo, F., and Ross, J. B., "A Fast Approach to Multi-Stage Vehicle Trajectory Optimization," *Proceedings of the AIAA Guidance, Navigation and Control Conference*, Austin, TX, 5-8 August 2003.

Ross, I. M. and Fahroo, F., "A Unified Framework for Real-Time Optimal Control," *Proceedings of the IEEE Conference on Decision and Control,* Maui, HI, December 2003.

Ross, I. M., Fahroo, F., and Strizzi, J., "Adaptive Grids for Trajectory Optimization by Pseudospectral Methods," *Proceedings of the AAS/AIAA Space Flight Meeting, Paper AAS 03-142*, Ponce, Puerto Rico, February 2003.

DoD KEY TECHNOLOGY AREA: Space Vehicles

KEYWORDS: Trajectory Optimization, Guidance, Pseudospectral Methods

PROBLEMS IN PROBABILITY AND HEAT TRANSFER
Chris Frenzen, Associate Professor
Department of Mathematics
Sponsor: Unfunded

OBJECTIVE: The enumeration of the number of independent subsets on a finite sample space with a uniform probability distribution was completed. Also, work was performed to determine the monotonicity of the heat transferred between two conducting spheres of unit radius, as a function of their separation distance.

SUMMARY: The number of probabilistically independent subsets on a finite sample space with a uniform probability distribution depends on the cardinality of the sample space. For example, if the cardinality is a prime number, then only the empty set and the whole sample space are independent. Researchers have enumerated the maximum number of independent subsets on the sample space as a function of the prime factorization of the cardinality of the subspace. Also, research continued on a heat transfer problem involving the monotonicity of the heat transferred between two conducting spheres of unit radius as a function of their separation distance. This problem, unsolved for over twenty five years, involved a rather delicate analysis of an infinite series involving hyperbolic sine functions. Though much progress has been made, the conjecture that the heat transferred decreases with increasing radius has not yet been rigorously proved.

KEYWORDS: Probabability, Heat Transfer, Monotonicity of Heat Transfer, Conducting Spheres

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**ADVANCED ALGORITHMS AND SOFTWARE ENVIRONMENT DEVELOPMENT FOR
RECONFIGURABLE PLATFORMS**
Douglas J. Fouts, Professor
Department of Electrical and Computer Engineering
David Canright, Associate Professor
Department of Mathematics
Sponsor: National Security Agency

OBJECTIVE: To establish various libraries of open-source functions for a computer with a reconfigurable architecture. To use these libraries to benchmark and compare the performance and correctness of a computer with a reconfigurable architecture against a typical workstation. To study and experiment with the programming languages, methodologies, environments, and applications to move reconfigurable computing closer to the typical programming environment already familiar to most applications developers**.**

SUMMARY: Three different algorithms were successfully ported to the SRC-6e reconfigurable computer. The first was a false radar target image synthesis algorithm for countering imaging inverse synthetic aperture radar. The second algorithm was based on the well-known CORDIC algorithm and was used for extracting the phase of a complex signal. The third algorithm was a 64-bit encryption algorithm. Together, these three applications created an excellent suite for benchmarking and evaluating the SRC-6e. The suite was executed on both the SRC-6e and on personal computers (PC) with standard architectures. Performance measurements were taken and documented.

PRESENTATIONS:

Duren, R., Fouts, D.J., and Zulaica, D., "Performance Comparison of CORDIC Implementations on the SRC-6e Reconfigurable Computer," 2003 Military Applications of Programmable Logic Devices Conference, Washington, D.C., 9-11 September 2003.

Fouts, D.J., Duren, R., and Zulaica, D., "Algorithm and Programming Considerations for Embedded Reconfigurable Computers," 2003 High Performance Embedded Computing Workshop, MIT Lincoln Laboratory, 22-25 September 2003.

THESIS DIRECTED:

Macklin, K.R., "Performance Evaluation of a Reconfigurable Computer for Image Synthesis Applications," Master's Thesis, Naval Postgraduate School, September 2003.

DoD KEY TECHNOLOGY AREAS: Computers and Software, Electronics

KEYWORDS: Reconfigurable Computing, Computer Performance Evaluation, Computer Architecture, Parallel Processing

ANALYSIS OF DATA FROM THE MULTI-CENTER VALIDATION PROJECT
Toke Jayachandran, Professor
Department of Mathematics
**Sponsor: Defense Intelligence Agency Central Measurement and Signature Intelligence (MASINT)
Organization**

OBJECTIVE: To perform statistical analyses of data collected by the Armed Forces Institute of Pathology (AFIP) on behalf of the Central Measurement and Signature Intelligence (MASINT) organization. The goal was to assess the effectiveness of the rapid thermal cycler in detecting the presence of biological/chemical agents such as anthrax and other agents, and to set standards and guidelines for laboratory analyses of samples containing suspect material.

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SUMMARY: AFIP provided the raw data collected from the primary experiment using synthesized samples contaminated with differing levels of anthrax and analyzed at seven different laboratories. After several extensive discussions with the scientists at AFIP, the data was reformatted so as to be amenable to statistical analyses. Several statistical procedures were applied to determine the threshold level of the contaminant that has high probability of detection and also to identify the performance differences in the laboratories participating in the experiment. AFIP suggested that it would be useful to generate Receiver Operating Characteristic (ROC) curves for the data; ROC curves are often used by drug companies in support of new drugs for which FDA approval is sought. Relevant information on the procedure for generating ROC curves was collected through an Internet search and applied to the AFIP data. Because the data did not report any false positive results (necessary for generating a meaningful ROC curve), the resulting graphs turned out to be primarily straight lines.

An informal report on the results of the analysis was submitted to both AFIP and the sponsor. AFIP is continuing the experiment with several other chemical/biological threat agents and agreed to provide the new data in a format ready for statistical analysis; the project has been on hold pending the arrival of the data.

REPORT: "Statistical Analysis of AFIP Data," informal report sent to AFIP and the sponsor.

KEYWORDS: Armed Forces Institute of Pathology (AFIP), Central Measurement and Signature Intelligence (MASINT), anthrax, Rapid Thermal cycler, biological/chemical agents

COOPERATIVE DECISION MAKING WITH PARTIAL INFORMATION AND COMMUNICATION RESTRICTIONS
Wei Kang, Associate Professor
Department of Mathematics
Sponsor: U.S. Air Force Research Laboratory

OBJECTIVE: The objective of the project was to develop cooperative controllers for multiple UAV's with communication restrictions. Specifically, the objectives included: developing algorithms and criteria for decision making based on partial information; developing algorithms to improve communication situation awareness of UAV formations; and formation reconfiguration to improve the robustness of the communication topology.

SUMMARY: Task assignment for cooperative control of multiple UAV's was studied. A model of linear programming was developed for multiple-tour assignment, and both terminal and non-terminal tasks were included in the set of tasks. Although the problem is NP-hard, simulations show the possibility of real time computation for problems with a small number of tasks. A MATLAB based software program was developed to numerically compute the optimal task assignment. It was also proven that the size of the linear programming problem was determined by the number of tasks, independent of the number of UAV's. Partial results were achieved for multiple-tour assignment with timing.

PUBLICATIONS:

Hamzi, B. and Kang, W., "Resonant Terms and Bifurcations of Nonlinear Control Systems with One Uncontrollable Mode," *Systems and Control Letters*, Vol. 49 (4), pp. 267-278, 2003.

Hamzi, B., Kang, W., and Barbot, J.-P., "Analysis and Control of Hopf Bifurcations," *SIAM Journal on Control and Optimization*, (to appear).

Kang, W., Xiao, M., and Tall, I., "Controllability and Local Accessibility—A Normal Form Approach," *IEEE Transactions on Automatic Control*, Vol. 48, No. 10, pp. 1724-1736, 2003.

Krener, A.J. and Kang, W., "Locally Convergent Nonlinear Observers," *SIAM Journal on Control and Optimization*, Vol. 42, No. 1, pp. 155-177, 2003.

Krener, A.J., Kang, W., and Chang, D., "Control Bifurcations," *IEEE Transactions on Automatic Control*, (to appear).

CONFERENCE PUBLICATIONS:

Hamzi, B., Kang, W., and Krener, A.J., "Control of Center Manifolds," *Proceedings of the IEEE Conference on Decision and Control*, December 2003.

Kang, W. and Sparks, A., "Modeling and Computation of Optimal Task Assignment for Cooperative Control," *Proceedings of the IEEE Conference on Decision and Control*, December 2003.

Kang, W. and Sparks, A., "Task Assignment in the Cooperative Control of Multiple UAV's," *Proceedings of the AIAA Guidance, Navigation, and Control Conference*, August 2003.

PRESENTATIONS:

Kang, W., Shanghai International Symposium on Nonlinear Science and Applications, Shanghai, China, June 2003, (invited).

Kang, W., Summer School, International Summer School in Automatic Control of Lille, France, 8-12 September 2003, (invited).

Kang, W., "Topics in Nonlinear Dynamics," 2nd International Summer School, Siena, Italy, 9-11 July 2003, (invited).

BOOK CHAPTERS:

Kang, W. and Krener, A.J., "On the Convergence of Normal Forms for Analytic Control Systems," *Open Problems in Mathematical Systems and Control Theory*, V. Blondel and A. Megretski (Eds.), Princeton University Press, 2003.

Xiao, M. and Kang, W., "Control of Hopf Bifurcations for Infinite-dimensional Nonlinear Systems," *New Trends in Nonlinear Dynamics and Control, and Their Applications*, W. Kang, M. Xiao, and C. Borges (Eds.), Springer, 2003.

KEYWORDS: UAV, cooperative controller, linear programming, MATLAB

NEW TRENDS IN NONLINEAR DYNAMICS AND CONTROL
Wei Kang, Associate Professor
C. F. Borges, Associate Professor
Department of Applied Mathematics
Sponsor: U. S. Air Force Office of Scientific Research

OBJECTIVE: To organize a two-day symposium "`New Trends in Nonlinear Dynamics and Control, and Their Applications" at the Naval Postgraduate School (NPS), and to publish a book by Springer on closely related topics.

SUMMARY: The Symposium on "New Trends in Nonlinear Dynamics and Control, and Their Applications" was held 18-19 October 2002 at NPS in Monterey, California. Leading researchers in nonlinear control attended the conference. A book on trends in nonlinear dynamics and control was published by Springer.

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BOOK:

W. Kang, M. Xiao, and C. Borges (Eds.), *New Trends in Nonlinear Dynamics and Control, and Their Applications*, Springer, 2003.

KEYWORDS: Nonlinear dynamics and control, symposium

DEVELOPMENT OF JOINT CAMPAIGN FEDERATION OF MODELS FOR WEAPONS OF MASS DESTRUCTION
B. Neta, Professor
Department of Mathematics
Sponsor: Defense Threat Reduction Agency

SUMMARY: Used knowledge of existing and future combat and other constructive simulations and mathematical models to investigate how to play the effects of weapons of mass destruction (WMD) in a campaign context. Investigated the feasibility of using a federation of computer-based models to capture these modeled plays.

KEYWORDS: model, weapons of mass destruction, WMD

A STUDY OF LATERAL BOUNDARY CONDITIONS FOR THE NAVAL RESEARCH LABARATORY (NRL'S) COUPLED OCEAN/ATMOSPHERE MESOSCALE PREDICTION SYSTEM (COAMPS)
B. Neta, Professor
Department of Mathematics
Sponsors: Office of Naval Research, Naval Postgraduate School

OBJECTIVE: The treatment of lateral boundaries in regional models has been a perennial problem since the early days of numerical weather prediction. In a limited-area model the lateral edges are not physical boundaries of the flow but constitute artificial constraints imposed by computational considerations. Hence, they do not have a physical counterpart. Conditions must be imposed at these artificial boundaries in order to solve the problem in an efficient and accurate manner. This work continued research on high order non-reflecting boundary conditions for the dispersive Klein-Gordon equation. Researchers intended to extend new schemes to the nonlinear shallow water equations.

PUBLICATIONS:

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

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

Givoli, D. and Neta, B., "High-Order Non-Reflecting Boundary Conditions for Dispersive Wave Problems," *Journal of Computational and Applied Mathematics*, 158, 49-60, 2003.

Givoli, D., Neta, B., and Patlashenko, I., "Finite Element Analysis of Time-Dependent Semi-Infinite Wave-Guides with High-Order Boundary Treatment," (accepted for publication).

Navon, I.M., Neta, B., and Hussaini, M.Y., "A Perfectly Matched Layer Approach to the Linearized Shallow Water Equations Models," *Monthly Weather Review*, (accepted for publication).

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

van Joolen, V., Neta, B., and Givoli, D., "A Stratified Dispersive Wave Model with High-Order Non-Reflecting Boundary Conditions," *Computers and Mathematics with Applications*, (accepted for publication).

CONFERENCE PUBLICATION:

van Joolen, V., Neta, B., and Givoli, D., "High-Order Non-Reflecting Boundary Conditions for Dispersive Wave Problems in Stratified Media," *Proceedings of the Sixth International Conference on Computer Modeling and Experimental Measurements of Seas and Costal Regions*, Cadiz, Spain, C. A. Brebbia, D. Almorza, and F. Lopez-Aguayo (Eds.), pp. 73-82, 23-25 June 2003.

DoD KEY TECHNOLOGY AREA: Software

KEYWORDS: Mesoscale, Limited-area Model, Perfectly Matched Layers, COAMPS

MATHEMATICAL MODELS OF TERRORISM AND LOW-INTENSITY CONFLICT
Guillermo Owen, Professor
Department of Mathematics
Sponsor: Naval Postgraduate School

OBJECTIVE: Professors McCormick and Owen have developed game-theoretic models for the problem of counter-proliferation; on this topic, one article was submitted for publication. They have also developed models of low-intensity conflict, and particularly, civil war. One article was submitted and accepted for publication. They are currently studying the problem of state sponsors of terrorism. An article is in preparation.

PUBLICATION:

McCormick, G. and Owen, G., "Factionalism, Violence, and Bargaining in Civil Wars," *Homo Oeconomicus*, 2004.

KEYWORDS: mathematical model, counter-proliferation, terrorism, low-intensity conflict

THEORY OF GAMES AND APPLICATIONS
Guillermo Owen, Professor
Department of Mathematics
Sponsor: Unfunded

OBJECTIVE: This was an unsponsored project on which Professor Owen worked with mathematicians at the Complutense University in Madrid, Spain, and at the University of Hamburg in Germany. An article dealing with centrality in social networks was published and a second article was submitted for publication. An article on reduced games and consistent values was also submitted and accepted for publication.

PUBLICATIONS:

Holler, M. and Owen, G., "On the Present and Future of Power Measures," *Homo Oeconomicus*, 281-295, 2002; republished as "Present and Future of Power Measures," *Group Decisions and Voting*, J. Kacprzyk and D. Wagner (Eds.), Warsaw: Academicka Oficyna Wydawnicza, 31-46, 2003.

Manuel, C., Gonzalez, E., Gomez, F., del Pozo, M., Owen, G., and Tejada, J., "Centrality in Social Networks: A Game Theoretic Approach," *Mathematical Social Sciences*, 27-54, 2003.

Manuel, C., Gonzalez, E., Gomez, F., del Pozo, M., Owen, G., and Tejada, J., "Splitting Graphs when Calculating the Myerson Value," *Mathematical Methods of Operations Research*, 2004, (to appear).

Owen, G., "Consistency in Values," *International Game Theory Review*, 2004, (to appear).

Owen, G. and Gambarelli, G., "The Coming of Game Theory," *Essays in Cooperative Games*, G. Gambarelli (Ed.), Kluwer, 2004, (to appear).

CONFERENCE PRESENTATIONS:

Owen, G., "The Coming of Game Theory," 15th Italian Conference in Game Theory, Urbino, Italy, 9 July 2003.

Owen, G., "Consistency in Values," 7th Annual Festival on Game Theory, Stony Brook, NY, 29 July 2003.

BOOK REVIEW:

Owen, G., "Handbook of Game Theory with Economic Applications, Volume 3," *Journal of Economic Literature*, R. J. Aumann and S. Hart (Eds.), 1274-1275, 2003.

KEYWORDS: Complutense University, Hamburg, centrality, social networks

MODELING TARGET ACQUISITION, TRACKING, AND LOSS IN MILITARY OPERATIONS IN URBAN TERRAIN (MOUT) USING GRAPHS
Craig Rasmussen, Associate Professor
Department of Mathematics
Sponsor: TRADOC Analysis Center, Monterey

OBJECTIVE: The objective of this project was to model target detection, tracking, and loss in urban areas using graphs so that analytic methods associated with graph theory and random graphs can be applied to the models to provide insights to support OF/Future Combat Systems and to suggest aggregate models for future simulation and analysis. The scope of the research was limited to developing graph models and exploring analytic techniques that might provide insights using these models.

PRESENTATIONS:

Mlakar, J., "Aggregate Models for Target Acquisition in Urban Terrain," Military Operations on Urban Terrain (MOUT) FACT In-Progress Review (IPR) and Integration Meeting, Orlando, FL, 4 December 2003.

Mlakar, J., "Aggregate Models for Target Acquisition in Urban Terrain," ACQSIM Conference, TRADOC Analysis Center (TRAC), Monterey, CA, 10 December 2003.

Phillips, D., "Modeling Target Acquisition, Tracking, and Loss in MOUT Using Graphs," MOUT M&S Summit III, Aberdeen Proving Ground, 17 September 2003.

THESIS DIRECTED:

Mlakar, J., "Aggregate Models for Target Acquisition in Urban Terrain," Master's Thesis, Naval Postgraduate School, June 2004.

KEYWORDS: Urban Target Acquisition, Military Operations in Urban Terrain, MOUT

FINITE ELEMENT MODELING OF HIGH FREQUENCY ACOUSTICS
Clyde L. Scandrett, Professor
Department of Mathematics
Sponsor: Office of Naval Research

SUMMARY: Initiated research and development of the finite element (FE) code ProPHLEX for use in numerical modeling of acoustic propagation in ocean sediments. The work included collaboration with researchers at Supreme Allied Commander, Atlantic Undersea Research Center (SACLANTCEN) and members of an experimental research team working on sediment-acoustics experiment SAX04 in fiscal year 2004.

KEYWORDS: High-Frequency Acoustics, Numerical Modeling, SACLANTCEN, SAX04, ProPHLEX

NAVAL POSTGRADUATE SCHOOL (NPS) MINE AND UNDERSEA WARFARE PROGRAM
Clyde L. Scandrett, Professor
Department of Mathematics
Sponsor: Program Executive Office, Mine and Undersea Warfare

OBJECTIVE: Oversee work performed by the Mine Warfare Chair, and assist where necessary in the performance of his/her duties. The general requirements of the Mine Warfare Chair include: 1) facilitating student visits to mine warfare commands and research activities; 2) planning and executing mine warfare workshops and symposia; 3) serving as curator of the Menneken Lecture Series on Mine Warfare, and 4) acting as the liaison between the PEO, the Naval Postgraduate School (NPS), and Navy Labs.

SUMMARY: Some of the accomplishments that occurred this past year included:
- Coordinated the NATO Mine Warfare Emerging Technologies Conference in Oostend, Belgium, in October.
- Hired a new Director for the Undersea Warfare Research Center – retired VADM Roger Bacon and former Assistant Chief of Naval Operations for Undersea Warfare.
- Preparing for an upcoming Sixth International Symposium on Technology and the Mine Problem that will be held at Naval Postgraduate School (NPS) in May 2004.
- Through the National Naval Responsibility Program (NNRP), sponsored by the Office of Naval Research (ONR), two Navy Lab students graduated in 2003. One student was from CSS and the other from the Naval Undersea Warfare Center (NUWC).
- Purchased Global Command-and-Control Systems, Maritime (CCS-M) and trained an officer in its use for Contech wargaming.
- Helped organize a suite of courses for a certificate program in Undersea Warfare for the Third Fleet.

PUBLICATIONS:

Proceedings of the Third Symposium on Technology and the Mine Problem, 1998.

Proceedings of the Fourth Symposium on Technology and the Mine Problem, 2000.

Proceedings of the Fifth Symposium on Technology and the Mine Problem, 2002.

* The above proceedings were put into print and mailed during the 2003 calendar year with funds from the fifth symposium.

DoD KEY TECHNOLOGY AREAS: Sensors, Electronics, Battlespace Environments and Weapons

DEPARTMENT OF
APPLIED MATHEMATICS

2003
Faculty Publications
and Presentations

APPLIED MATHEMATICS

PUBLICATIONS

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

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

Givoli, D. and Neta, B., "High-Order Non-Reflecting Boundary Conditions for Dispersive Wave Problems," *Journal of Computational and Applied Mathematics*, 158, 49-60, 2003.

Givoli, D., Neta, B., and Patlashenko, I., "Finite Element Analysis of Time-Dependent Semi-Infinite Wave-Guides with High-Order Boundary Treatment," *International Journal Numerical Methods in Engineering*, 58, pp. 1955-1983, 2003.

Hamzi, B. and Kang, W., "Resonant Terms and Bifurcations of Nonlinear Control Systems with One Uncontrollable Mode," *Systems and Control Letters*, Vol. 49 (4), pp. 267-278, 2003.

Holler, M. and Owen, G., "On the Present and Future of Power Measures," *Homo Oeconomicus*, 281-295, 2002; republished as "Present and Future of Power Measures," *Group Decisions and Voting*, J. Kacprzyk and D. Wagner (Eds.), Warsaw: Academicka Oficyna Wydawnicza, 31-46, 2003.

Kang, W., Borges, C., and Xiao, M., "Symposium on New Trends in Nonlinear Dynamics and Control and Their Applications," *IEEE Control System Magazine*, pp. 99-100, 2003.

Kang, W., Xiao, M., and Tall, I., "Controllability and Local Accessibility - A Normal Form Approach," *IEEE Transactions on Automatic Control*, Vol. 48, No. 10, pp. 1724-1736, 2003.

Krener, A.J. and Kang, W., "Locally Convergent Nonlinear Observers," *SIAM Journal on Control and Optimization*, Vol. 42, No. 1, pp. 155-177, 2003.

Manuel, C., Gonzalez, E., Gomez, F., del Pozo, M., Owen, G., and Tejada, J., "Centrality in Social Networks: A Game Theoretic Approach," *Mathematical Social Sciences*, 27-54, 2003.

Neta, B. and Lipowski, Y., "A New Scheme for Trajectory Propagation," *Journal of Astronautical Sciences*, 50, pp. 255-268, 2003.

Ross, I.M. and Fahroo, F., "Legendre Pseudospectral Approximations of Optimal Control Problems," *Lecture Notes in Control and Information Sciences*, New York: Springer-Verlag, Vol. 295, pp. 327-342, 2003.

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

CONFERENCE PUBLICATIONS

Fahroo, F., "Optimizing the Decay Rate in the Damped Wave Equation: a Numerical Study," *Proceedings of the American Control Conference*, Denver, CO, June 2003.

Fahroo, F., Doman, D., and Ngo, A., "Footprint Generation for Reusable Launch Vehicles Using a Direct Pseudospectral Method," *Proceedings of the American Control Conference,* Denver, CO, June 2003.

Fahroo, F., Doman, D., and Ngo, A., "Modeling Issues in Footprint Generation for Reusable Launch Vehicles," *Proceedings of the 2003 IEEE Aerospace Conference,* Big Sky, MT, March 2003.

Hamzi, B., Kang, W., and Krener, A.J., "Control of Center Manifolds," *Proceedings of the IEEE Conference on Decision and Control*, December 2003.

Kang, W. and Sparks, A., "Modeling and Computation of Optimal Task Assignment for Cooperative Control," *Proceedings of the IEEE Conference on Decision and Control*, December 2003.

Kang, W. and Sparks, A., "Task Assignment in the Cooperative Control of Multiple UAV's," *Proceedings of the AIAA Guidance, Navigation, and Control Conference*, August 2003.

Ross, I.M., D'Souza, C., Fahroo, F., and Ross, J.B., "A Fast Approach to Multi-Stage Vehicle Trajectory Optimization," *Proceedings of the AIAA Guidance, Navigation, and Control Conference*, Austin, TX, 5-8 August 2003.

Ross, I.M. and Fahroo, F., "A Unified Framework for Real-Time Optimal Control," *Proceedings of the IEEE Conference on Decision and Control,* Maui, HI, December 2003.

Ross, I.M., Fahroo, F., and Strizzi, J., "Adaptive Grids for Trajectory Optimization by Pseudospectral Methods," *Proceedings of the AAS/AIAA Space Flight Meeting, Paper AAS 03-142*, Ponce, Puerto Rico, February 2003.

van Joolen, V., Neta, B., and Givoli, D., "High-Order Non-Reflecting Boundary Conditions for Dispersive Wave Problems in Stratified Media," *Proceedings of the Sixth International Conference on Computer Modeling and Experimental Measurements of Seas and Costal Regions*, C. A. Brebbia, D. Almorza, and F. Lopez-Aguayo (Eds.), pp. 73-82, Cadiz, Spain, 23-25 June 2003.

PRESENTATIONS

Duren, R., Fouts, D.J., and Zulaica, D., "Performance Comparison of CORDIC Implementations on the SRC-6e Reconfigurable Computer," 2003 Military Applications of Programmable Logic Devices Conference, Washington, D.C., 9-11 September 2003.

Fahroo, F. and Doman, D., "A Direct Method for Approach and Landing Trajectory Reshaping with Failure Effect Estimation," 2004 AIAA Conference on Guidance, Navigation and Control, Providence, RI, August 2004.

Fouts, D.J., Duren, R., and Zulaica, D., "Algorithm and Programming Considerations for Embedded Reconfigurable Computers," 2003 High Performance Embedded Computing Workshop, MIT Lincoln Laboratory, 22-25 September 2003.

Mlakar, J., "Aggregate Models for Target Acquisition in Urban Terrain," Military Operations on Urban Terrain (MOUT) FACT In-Progress Review (IPR) and Integration Meeting, Orlando, FL, 4 December 2003.

Mlakar, J., "Aggregate Models for Target Acquisition in Urban Terrain," ACQSIM Conference, TRADOC Analysis Center (TRAC), Monterey, CA, 10 December 2003.

Owen, G., "The Coming of Game Theory," 15th Italian Conference in Game Theory, Urbino, Italy, 9 July 2003.

Owen, G., "Consistency in Values," 7th Annual Festival on Game Theory, Stony Brook, NY, 29 July 2003.

Phillips, D., "Modeling Target Acquisition, Tracking, and Loss in MOUT Using Graphs," Military Operations on Urban Terrain (MOUT) M&S Summit III, Aberdeen Proving Ground, MD, 17 September 2003.

APPLIED MATHEMATICS

BOOK CHAPTERS

Kang, W. and Krener, A.J., "On the Convergence of Normal Forms for Analytic Control Systems," *Open Problems in Mathematical Systems and Control Theory*, V. Blondel and A. Megretski (Eds.), Princeton University Press, 2003.

Xiao, M. and Kang, W., "Control of Hopf Bifurcations for Infinite-dimensional Nonlinear Systems," *New Trends in Nonlinear Dynamics and Control, and Their Applications*, W. Kang, M. Xiao, and C. Borges (Eds.), Springer 2003.

BOOK REVIEW

Owen, G., "Handbook of Game Theory with Economic Applications, Volume 3," *Journal of Economic Literature*, R.J. Aumann and S. Hart (Eds.), 1274-1275, 2003.

DEPARTMENT OF MECHANICAL ENGINEERING

TERRY R. MCNELLEY
CHAIR

MECHANICAL ENGINEERING

OVERVIEW:

The mission of the Department of Mechanical Engineering is to increase the combat effectiveness of U.S. and Allied armed forces and to enhance the security of the United States through advanced education that focuses on the ability to identify, formulate and solve technical and engineering problems in areas related to mechanical engineering and that spans issues of research, design, development, procurement, operation, maintenance and disposal of components and systems for Naval platforms.

RESEARCH MISSION:

The research mission of the Department of Mechanical Engineering is to increase the combat effectiveness of U.S. and Allied armed forces and to enhance the security of the United States through research in areas related to mechanical engineering and that spans the field from basic phenomena to engineering design, development, operation, maintenance and disposal of components and systems for Naval platforms.

CURRICULA SERVED:

The Mechanical Engineering Department serves the Naval and Mechanical Engineering Curriculum (570) and the Mechanical and Reactors Engineering Curriculum (571). Both curricula are in support of Navy needs for individuals having advanced technical education in mechanical engineering and related fields. The 570 Curriculum provides the educational component for the Engineering Duty Officer program and the research program in the Department is designed to support the requirement for Officers having the ability to identify, formulate and solve technical and engineering problems in areas related to mechanical engineering.

DEGREES GRANTED:

- Master of Science in Mechanical Engineering
- Mechanical Engineer
- Doctor of Philosophy
- Doctor of Engineering

RESEARCH THRUSTS:

There are five different disciplines of research thrusts such as Fluid Dynamics, Heat Transfer and Turbomachinery; Dynamics Systems, Controls and Robotics; Solid Mechanics, Vibrations, and Shock; Materials Science and Engineering; Total Ship Systems Engineering

FACULTY EXPERTISE:

- Fluid Dynamics, Heat Transfer and Turbomachinery:
  Distinguished Professor Turgut Sarpkaya, Professor Matthew Kelleher, Associate Professor Knox Millsaps, Jr., Associate Professor Ashok Gopinath
- Dynamics Systems, Controls and Robotics:
  Professor Anthony Healey, Professor Morris Driels, Associate Professor Fotis Papoulias
- Solid Mechanics, Vibration, and Shock:
  Professor Young Shin, Professor Young Kwon, Associate Professor Joshua Gordis
- Materials Science and Engineering:
  Professor Terry McNelley, Professor Alan Fox, Associate Professor Indranath Dutta
- Total Ship Systems Engineering:
  Professor Charles Calvano

RESEARCH FACILITIES:

The Mechanical Engineering Laboratories are designed as complements to the educational mission and research interests of the department. In addition to extensive facilities for the support of student and faculty research, a variety of general use equipment is available. This includes equipment and facilities for the investigation of problems in engineering mechanics; a completely equipped materials science laboratory, including advanced scanning electron microscopes, an Auger microprobe, a transmission electron microscope and X-ray diffractometers; an oscillating water tunnel, a unique underwater towing tank and a low turbulence water channel; a vibration analysis laboratory; a fluid power controls laboratory; a robotics and real-time control laboratory; facilities for experimentation with low velocity air flows; equipment for instruction in thermal transport phenomena; a laser doppler velocimeter; nuclear radiation detection equipment and an interactive CAD/CAE computer graphics laboratory. Experimentation is further enhanced by a broad selection of analog and digital data acquisition and processing equipment and instrumentation.

RESEARCH PROGRAM (Research and Academic)-FY2003:

The Naval Postgraduate School's sponsored program exceeded $71 million in FY2003. Sponsored programs include both research and educational activities funded from an external source. A profile of the sponsored program for the Department of Mechanical Engineering is provided below.

Size of Program: **$1,593K**
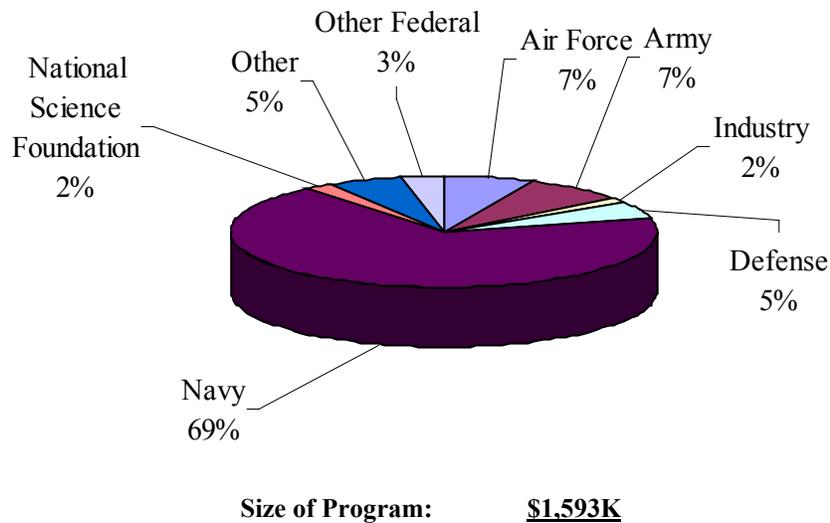
MECHANICAL ENGINEERING

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MECHANICAL ENGINEERING

ADVANCED TOTAL SHIP SYSTEMS ENGINEERING AND OPTIMIZATION
Charles N. Calvano, Professor
Department of Mechanical Engineering
Sponsor: Advanced Technology Institute

SUMMARY: The purpose of this collaborative effort was to educate American youth about career opportunities in naval architecture and marine engineering (NA&ME) through a pre-college program for ship design.

KEYWORDS: Naval Architecture, Marine Engineering, Career

TOTAL SHIP SYSTEMS ENGINEERING IN SUPPORT OF NAVAL SEA SYSTEMS COMMAND (NAVSEA) CONTRACT DESIGN
Charles N. Calvano, Professor
Department of Mechanical Engineering
Sponsor: Naval Sea Systems Command

SUMMARY: This program was intended to support the ongoing Total Ship Systems Engineering (TSSE) program, which, in turn, worked with and supported Naval Sea Systems Command (NAVSEA) and NAVSEA activities in the performance of ship concept design studies and in the evaluation of ship designs. In addition to the general areas of effort described in the associated Memorandum of Understanding (MOA), the 2002 effort included examination of the potential role and utility of a joint command and control ship, such as that considered by the joint-command ship (JCC[X]) program office. TSSE and other campus design projects supported by TSSE included an examination of the capabilities and potential contributions of the JCC(X) to the expeditionary warfare cross discipline problem. Work performed as part of this program supported student design education and was used to ensure that classroom material continues to be relevant to ongoing Navy ship-related technology developments.

KEYWORDS:TSSE, JCC(X), expeditionary warfare, cross-discipline

ATTEND JOINT MUNITIONS EFFECTIVENESS MANUAL (JMEM) CONFERENCE
Morris Driels, Professor
Department of Mechanical Engineering
Sponsor: Aeronautical Systems Command (ASC)

SUMMARY: Attended Joint Munitions Effectiveness Manual (JMEM) conference in Seoul, Republic of Korea.

KEYWORDS: Joint Munitions Effectiveness Manual (JMEM), Seoul

MISCELLANEOUS AIR-TO-SURFACE TASKS
Morris Driels, Professor
Department of Mechanical Engineering
Sponsor: ASC

SUMMARY: This proposal covered several tasks of interest to the Joint Technical Coordinating Group (JTCG) including: review and consolidation of methodologies for predicting the accuracies of GPS/INS guided weapons; updating the Joint Air-to-Surface Weaponeering System (JAWS) target acquisition program and manual; obtaining aircraft error budget data and incorporating them into the Joint Delivery Accuracy (JDAP) program; and documenting air-to-surface and surface-to-surface methodologies in the derivations manual.

KEYWORDS: Joint Technical Coordinating Group, JTTG, GPS, INS, JAWS target acquisition

MECHANICAL ENGINEERING

MISCELLANEOUS AIR-TO-SURFACE TASKS
Morris Driels, Professor
Department of Mechanical Engineering
Sponsor: U.S. Army Materiel Systems Analysis Activity

GOALI: CREEP AND MICROSTRUCTURAL COARSENING OF LEAD FREE SOLDERS IN MICRO-ELECTRONIC PACKAGING APPLICATIONS
Indranath Dutta, Associate Professor
Department of Mechanical Engineering
Sponsor: National Science Foundation

INTERFACIAL CREEP IN MULTI-COMPONENT MATERIALS SYSTEMS
Indranath Dutta, Associate Professor
Department of Mechanical Engineering
Sponsor: National Science Foundation

SUMMARY: This GOALI (Grant Opportunities for Academic Liaison with Industry) research was a comprehensive investigation of diffusionally accomodated interfacial sliding (interfacial creep) in multi-component materials systems, with a view to obtaining a fundamental understanding of the operative mechanism and its dependence on interfacial structure. The goal of this research was to develop experimental and analytical approaches to study interfacial creep in both bulk and thin film materials systems; develop mechanistic insight into interfacial sliding by correlating the sliding kinetics with the interfacial morphology, structure and chemistry; generate sliding kinetics data for selected interfaces of practical importance; and evaluate the impact of sliding on the performance of two engineering systems of importance (fibrous composites and film-substrate systems).

KEYWORDS: Air To Surface, GOALI, Solder, Micro-Electronic Packaging, Interfacial Creep, Interfacial Sliding, Interface, Fibrous Composite, Film Substrate

MINIATURIZED IMPRESSION CREEP TEST FOR BGA AND FC SOLDER JOINTS
Indranath Dutta, Associate Professor
Department of Mechanical Engineering
Sponsor: Semiconductor Research Corporation

THERMO-MECHANICAL BEHAVIOR OF ADAPTIVE LEAD-FREE SOLDERS FOR ELECTRONIC PACKAGING APPLICATIONS
Indranath Dutta, Associate Professor
Department of Mechanical Engineering
Sponsor: U.S. Army Research Office

SUMMARY: The purpose of this research was to develop adaptive pb-free solders that can respond intelligently to externally applied loads so as to minimize the inelastic strain induced in the solder during thermo-mechanical cycling. The 95.5Sn3.8Ag0.7Cu solder, reinforced with a small volume fraction of shape-memory alloy (SMA) whiskers, was fabricated and tested under creep and thermo-mechanical cycling conditions, with the goal of obtaining a mechanistic understanding of the contribution of SMA to the inelastic strain response of the solder.

DoD KEY TECHNOLOGY AREA: Materials and Processes

KEYWORDS: Solder, Creep, Thermo-Mechanical Cycling, Electronic Packaging

FIRST PRINCIPLES PREDICTION OF X-RAY IMPULSE
Ashok Gopinath, Associate Professor
Department of Mechanical Engineering
Sponsor: Strategic Systems Program

OBJECTIVE: The goal of this research was to develop a first-principles based physics model for predicting the impulse induced on selected surfaces by an X-ray burst in space and to validate the model and numerical hydrocode predictions with available underground test data and other experimental data.

SUMMARY: This objectives of this multi-year project were to: i) gather and archive key data relevant to predicting vulnerability of an RB aeroshell to an X-Ray burst in space, ii) compare the capabilities of existing commercial physics-based hydrocodes to predict blow-off impulse and damage to various RB composite materials, iii) modify a selected code to improve fidelity, and iv) modify the existing code against existing UGT data.

The work performed in calendar year 2003 was a continuation of a previous thesis research investigation, in which the response of graphite to cold X-ray deposition was modeled using a 1-D version of the Sandia CTH Eulerian code. In this work, the capabilities of the Century Dynamics AUTODYN code were explored. A simulated blackbody radiation source and associated energy deposition function were implemented into a 1-D model of instantaneous change in internal energy. Rapid material heating and shock formation, sublimation and surface layer blow-off, and impulsive loading stresses were analyzed and compared with previous results. The findings suggested that AUTODYN is a menu-driven simulation technique that requires less training than CTH, can be adapted to a certain degree, and may be a more suitable tool for short term parametric investigations.

This was a collaborative effort involving faculty in the Naval Postgraduate School (NPS) Space Systems Academic Group and the departments of physics (PH), mechanical engineering (ME), and electrical and computer engineering (ECE).

PUBLICATIONS:

Hamilton, L.J. and Gopinath, A., "Numerical Analysis of the Performance of a Staggered Cross Flow Pin Fin Array Heat Exchanger," *AIAA Journal of Thermophysics and Heat Transfer,* (to appear).

Hamilton, L.J. and Gopinath, A., "Numerical Analysis of Pin Fin Array Heat Exchangers with Variable Axial Pitch and Fin Height Ratios," *ASME Journal of Heat Transfer,* (to appear).

THESIS DIRECTED:

Sylvester, C.A., "Cold X-Ray Radiation Absorption and Material Response: Numerical Model to Predict Blow-Off and Impulsive Loading in Re-Entry Vehicles," Master's Thesis, Naval Postgraduate School, December 2003.

DoD KEY TECHNOLOGY AREA: Other (Nuclear Weapons)

KEYWORDS: X-Ray, Impulse, Blow Off, Weapons Effects

MODELING OF HEAT TRANSFER IN A ROCKET ENGINE COMBUSTION CHAMBER
Ashok Gopinath, Associate Professor
Department of Mechanical Engineering
Sponsor: Air Force Research Laboratory

OBJECTIVE: To model and predict the flow and heat transfer behavior in a rocket engine combustion chamber, and its influence on the characteristics of the exhaust plume and its resulting signature.

SUMMARY: A numerical study was conducted to predict the combined convective and radiative heat transfer rates on the walls of a small aspect ratio cylinder representative of the scaled model of a rocket

engine combustion chamber. A high-temperature, high-pressure environment was simulated in the cylinder, with gas velocities at low subsonic levels typical of the conditions leading to the entrance of the nozzle section of a rocket engine. The thrust of the study was to determine the heat transfer rate from the hot radiatively participating chamber gases to the cooler supercritical fuel film layer that is swirl injected onto the chamber walls. This effort evaluated the effectiveness of the fuel layer in achieving a reduced heat flux to the chamber wall under varying emission/absorption conditions. This was related directly to the tendency of the hydrocarbon fuel to produce soot precipitates at temperatures above 550 K that affects the resulting optical properties of the fuel layer on the wall, as well as the exhaust plume. The results from the numerical model were corroborated with data obtained by the ongoing experimental effort by the Principal Investigator.

The calculations were carried out using the commercial CFD package CFDACE, and were first benchmarked against known results in the literature for the simpler case of gray chamber walls and a gray participating medium. The composition of the gases in the cylinder was determined from the TEP program for the burning of rocket fuel at typical values of the O/F ratio. The non-gray computations were subsequently carried out using gas absorption coefficient values obtained from the exponential wide band model with the help of the fire-modeling program, RADCAL.

THESES DIRECTED:

Goh, S.-H., "A Numerical Study of the Effect of the Fuel Film on Heat Transfer in a Rocket Engine Combustion Chamber," Master's Thesis, Naval Postgraduate School, December 2003.

Rochford, F.D., "Heat Transfer Characteristics of a Film Cooled Uni-Element Rocket Engine," Master's Thesis, Naval Postgraduate School, June 2003.

KEYWORDS: Missile, Propulsion, Signature, Infrared, IR, Soot

THERMOPHOTOVOLTAIC (TPV) POWER SYSTEMS
Ashok Gopinath, Associate Professor
Department of Mechanical Engineering
Sponsor: Unfunded

OBJECTIVE: To model the large radiative energy transfer rates in micro-thermophotovoltaic (TPV) devices and to carry out a design study of the parameters that influence its performance.

SUMMARY: TPV technology is of great interest to Naval Reactors as a potential solution for direct energy conversion for submarine propulsion in the future. The device works by transfer of thermal energy by radiation from a high temperature emitter to a semiconductor collector placed in close proximity in which it is converted to electrical energy. When the gap between emitter and collector in a TPV device is of the order of the wavelength of radiation, the so-called Micro-TPV device can yield very large power densities. The modeling work of a Micro-TPV device to determine the radiative transfer rates from emitter to collector, as well as the resulting electrical power density and efficiency, was continued in calendar year 2003. Different emitter materials and temperatures, various collector band gap levels, and a range of (micron and sub-micron) level spacings between emitter and collector surfaces were considered. An experimental phase of the project was also started to demonstrate high heat flux removal techniques, such as spray cooling, that are required for the back-end cooling of high power-density MTPV devices. Low cost commercially available industrial nozzle and spray components were used to study the role of water mass flux and droplet size on the removal of heat fluxes as large as 100 W/cm^2.

The Principal Investigator was on sabbatical leave at the Fraunhofer Institute of Solar Energy Systems (ISE) in Freiburg, Germany, where he was involved in the development of a full scale TPV system. The principal challenge was to design and successfully integrate the complex mix of the advanced technological sub-systems that make up the whole system. The second half of 2003 was spent on this project, and work will continue into 2004.

PUBLICATION:

Gopinath, A. and Hebling, C., "Micro-TPV Devices for Large Power Densities," *PowerMEMS 2003*, Tokyo, Japan, 3-5 December 2003.

THESIS DIRECTED:

Cryer, M.A., "An Experimental Study of High Heat Flux Removal Using Micro-Droplet Spray Cooling," Master's Thesis, Naval Postgraduate School, June 2003.

KEYWORDS: Thermophotovolatic, TPV, Micro-TPV, Emitter, Collector, Receiver, Radiation, Quantum Efficiency, Fill Factor, Dark Current, Power Density

TURBINE CONVECTIVE COOLING CONCEPTS EVALUATION
Ashok Gopinath, Associate Professor
Department of Mechanical Engineering
Sponsors: Naval Air Systems Command / Naval Air Warfare Center

OBJECTIVE: To provide support and validatory analyses of ongoing work in a new MEMs-based micro-heat exchanger turbine cooling concept.

SUMMARY: This project was ongoing from 2001. The primary thrust of the project was to develop a multi-physics computational analysis of the proposed heat exchanger design. The micro-heat exchanger was based on the concept of the use of pin fins in the narrow gap of a shroud enclosed turbine blade to obtain a large volumetric density of heat transfer area. A finite element numerical analysis based on the package ANSYS was used to predict the fully 3-D flow and heat transfer characteristics of such a micro pin fin heat exchanger. Various pin configurations and flow Reynolds numbers were studied, and the resulting heat transfer and pressure drop behavior were used to make predictions of optimal designs. The numerical project supported the work of one Ph.D. student (in part), and two Master's thesis students.

The experimental phase of the project was also developed and a complete experimental test rig was built to corroborate the numerical predictions. Using a modular design, various pin shapes and configurations were tested in a wind tunnel type arrangement that was instrumented to obtain heat transfer and pressure drop data. Extensive data was obtained and supported the work of 2 M.S. thesis students.

CONFERENCE PUBLICATIONS:

Hamilton, L.J. and Gopinath, A., "Numerical and Experimental Study of Pin-Fin Array Heat Exchangers," *2003 ASME International Mechanical Engineering Congress and Exposition*, Washington, D.C., 16-21 November 2003.

Lind, E.K., Hamilton, L.J., and Gopinath, A., "Analysis of Turbulence Models in a Cross Flow Staggered Array Pin Fin Heat Exchanger," 6th *ASME-JSME Thermal Engineering Joint Conference*, Kona, HI, 16-20 March 2003.

THESES DIRECTED:

Boulares, J., "Numerical and Experimental Study of the Performance of a Drop-Shaped Pin Fin Heat Exchanger," Master's Thesis, Naval Postgraduate School, June 2003.

Choo, J.-S., "Numerical Analysis of the Performance of Staggered Pin-Fin Micro Heat Exchangers," Master's Thesis, Naval Postgraduate School, December 2003.

Hamilton, L.J., "Numerical and Experimental Analysis of the Performance of Staggered Short Pin-Fin Heat Exchangers," Doctoral Dissertation, Naval Postgraduate School, June 2003.

Ramthun, D.L., "An Experimental Study of a Pin Fin Heat Exchanger," Master's Thesis, Naval Postgraduate School, June 2003.

Summers, J.W., "An Empirical Study of a Pin Fin Heat Exchanger in Laminar and Turbulent Flow," Master's Thesis, Naval Postgraduate School, December 2003.

KEYWORDS: Pin Fin Array, Compact Heat Exchanger, Micro Heat Exchanger, Turbine Blade Cooling

AERODYNAMIC INVESTIGATION AND OPTIMIZATION OF LIGHT TRUCK ACCESSORIES
Joshua H. Gordis, Associate Professor
Department of Mechanical Engineering
Sponsor: Army Tank Automotive and Armaments Command (TACOM)

OBJECTIVE: The purpose of this research was to develop and quantify optimal light truck canopy designs using computational fluid dynamics (CFD). Time permitting, other accessories, such as front and side skirts, may be investigated. The focus of the shape optimization was on minimizing drag while attempting to maintain the maximum enclosed volume.

KEYWORDS: Light Truck, Canopy, CFD, Computational Fluid Dynamic

DEVELOPMENT OF AN ACTIVE MOTION COMPENSATION SYSTEM FOR ROLL-ON/ROLL-OFF (RORO) OPERATIONS IN ELEVATED SEA STATES
Joshua H. Gordis, Associate Professor
Department of Mechanical Engineering
Sponsor: Naval Surface Warfare Center – Carderock Division

SUMMARY: To develop two concepts for motion compensation between stern roll-on/roll-off (RORO) ramps and barges, to allow RORO operations in elevated sea states while maintaining the structural integrity of the ramps.

KEYWORDS: RORO, Roll On, Roll Off, Motion Compensation

NUMERICAL ANALYSIS OF HEAT-EXCHANGER PERFORMANCE FOR A STAGGERED SHORT PIN-FIN ARRAY
CDR Leonard Hamilton, USN
Department of Mechanical Engineering
Sponsor: Space and Naval Warfare Systems Command - San Diego

SUMMARY: Conducted and experimentally validated numerical simulations modeling the heat transfer characteristics of a short, staggered pin-fin array heat exchanger that would be used for meeting the high heat dissipation requirements anticipated in cutting edge computing systems.

KEYWORDS: Heat Transfer, Numerical Simulation, Pin-Fin Array, Heat Dissipation

DEVELOPMENT OF AUTONOMOUS UNDERWATER VEHICLES (AUV) TECHNOLOGIES
Anthony J. Healey, Professor
Department of Mechanical Engineering
Sponsor: National University of Singapore

SUMMARY: The project was a joint effort between the National University of Singapore (NUS) collaborating scientists/engineers and Naval Postgraduate School (NPS) faculty in the Center for

Autonomous Underwater Vehicles (AUV) Research in the development of control algorithms and verification of AUV dynamic behavior as well as in the conceptual design of the next generation AUV.

KEYWORDS: AUV, Autonomous Underwater Vehicle, Singapore

NAVAL POSTGRADUATE SCHOOL ARIES FORWARD LOOK SONAR INTEGRATION AND TESTING
Anthony J. Healey, Professor
Department of Mechanical Engineering
Sponsor: Office of Naval Research

SUMMARY: The Naval Postgraduate School (NPS) worked with the Applied Physics Lab-University of Washington (APL-UW) to perform research and development on forward look sonars (FLS) for autonomous underwater vehicles (AUV). Specifically, in fiscal year 2003, a developmental blazed array was temporarily integrated into the NPS *ARIES* vehicle for the purpose of initial data gathering. The focus of the overall research effort was gathering and displaying sonar data for use by the research community. The data was made available via password protected internet data server.

KEYWORDS: ARIES, Sonar Integration, FLS

PARTICIPATION IN AUTONOMOUS OCEAN SAMPLING NETWORK (AOSN) II
Anthony J. Healey, Professor
Department of Mechanical Engineering
Sponsor: Office of Naval Research

TACTICAL DECISION AIDS AND RELATED TECHNOLOGIES
Anthony J. Healey, Professor
Department of Mechanical Engineering
Sponsor: Office of Naval Research

TACTICAL DECISION AIDS USING MODELING AND SIMULATION TOOLS
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Department of Mechanical Engineering
Sponsor: Office of Naval Research

SUMMARY: This was a proposal for a multi-year program started to provide enhancements to modeling and simulation tools and provide usable VSW tactical decision in performing very shallow water mine countermeasures operations with autonomous vehicles. The program expanded modeling and simulation efforts already underway at the Naval Postgraduate School (NPS), Florida Atlantic University (FAU), and Old Dominion University (ODU). Leveraging from other ongoing programs, these enhancements provided the Navy VSW Detachment, San Diego, with tactical decision aids for using AUVs.

KEYWORDS: AOSN, Autonomous Ocean Sampling Network, Tactical Decision Aids, Florida Atlantic University, Old Dominion University

MECHANICAL ENGINEERING

DETAIL TO OFFICE OF NAVAL RESEARCH INTERNATIONAL FIELD OFFICE, LONDON
Matthew D. Kelleher, Professor
Department of Mechanical Engineering
Sponsor: Office of Naval Research

SUMMARY: The objective of this proposal was to provide support for Professor Kelleher to carry out the duties of Associate Director for Ship Systems at the Office of Naval Research International Field Office, London.

KEYWORDS: Naval Research International Field Office, London

DAMAGE IN PARTICULATE COMPOSITES: MOLECULAR DYNAMICS AND MICROSTRUCTURAL STUDY
Young W. Kwon, Professor
Department of Mechanical Engineering
Sponsor: Air Force Research Laboratory

SUMMARY: This was a continuing research project from the past several years, during which a numerical modeling and simulation technique was developed and evaluated against experimental results. The developed method was called a micro/macro approach. This year's effort focused on the study of the effects of microstructures on local damage initiation and growth, its interaction, and global effect, and the molecular dynamics modeling for micro-structural variation of strain fields.

KEYWORDS: Particulate Composites, Molecular Dynamics Modeling, Microstructure

MODELING AND SIMULATION OF DAMAGE AND CRACKS IN PARTICULATE COMPOSITE MATERIALS: EFFECTS OF MICROSTRUCTURES
Young W. Kwon, Professor
Department of Mechanical Engineering
Sponsor: Air Force Research Laboratory

SUMMARY: This was a continuing research project from the past several years, during which a numerical modeling and simulation technique was developed and evaluated against experimental results. The developed method was called a micro/macro approach. This year's effort focused on the study of the effects of microstructures on local damage initiation and growth, its interaction, and global effect.

KEYWORDS: Particulate Composite Materials, Microstructures, Cracks

THE MECHANICAL AND MICROSTRUCTURAL CHARACTERIZATION OF COMMERCIAL AA5083 MATERIALS
Terry R. McNelley, Professor
Department of Mechanical Engineering
Sponsors: University of Texas at Austin, General Motors Corporation

OBJECTIVE: The objective of this program was to determine the mechanisms of elevated temperature deformation and the conditions for transition from grain boundary sliding to solute-drag controlled dislocation creep. Also, the mechanisms associated with failure by cavity formation and growth during superplastic deformation were clarified.

SUMMARY: Superplastic forming of aluminum alloys has become an established technology for aerospace systems and is being used increasingly in transportation and other applications. The commercial alloy AA5083 is an aluminum-magnesium-manganese that provides a combination of superplastic forming characteristics, corrosion resistance, weldability, and post-forming mechanical properties that make it

suitable for a wide range of aerospace, marine, and automotive applications. There are two particular difficulties: empirically developed methods for production of fine-grained AA5083 sheet material result in high cost and available sheet materials often exhibit widely different ductility values at elevated temperature, even when their grain sizes, textures, and grain boundary characteristic are essentially identical. In this research program, newly developed orientation imaging microscopy and related microtexture methods were employed to investigate grain size refinement during thermomechanical processing and transitions from grain boundary sliding to dislocation deformation mechanisms. Of particular concern were the relationships among alloy constitution, deformation mechanism, and failure by the formation and coalescence of cavities. The influence of stress state was also considered by including materials deformed under balanced biaxial tension and plane strain conditions as well as under uniaxial tension.

PUBLICATIONS:

Kulas, M.A., Krajewski, P.E., McNelley, T.R., and Taleff, E.M., "Deformation and Failure Mechanisms in Commercial AA5083 Materials," *Hot Deformation of Aluminum Alloys III*, Z. Jin, et al. (Eds.), Warrendale, PA: TMS, pp. 499-509, 2003.

McNelley, T.R. and Swisher, D.L., "Deformation Processing, Recrystallzation, and Grain Boundaries in Superplastic Aluminum Alloys," *Materials Science Forum*, Vols. 447-448, pp. 373-380, 2003.

Peréz-Prado, M.T., McNelley, T.R., Swisher, D.L., González-Doncel, G., and Ruano, O.A., "Texture Analysis and the Transition from Slip to Grain Boundary Sliding in a Continuously Recrystallized Superplastic Aluminum Alloy," *Materials Science and Engineering A*, Vol. A342, pp. 216-230, 2003.

CONFERENCE PUBLICATION:

McNelley, T.R. and Swisher, D.L., "Processing, Recrystallization and Grain Boundaries in Superplastic Aluminum Alloys," ICSAM2003 International Conference on Superplasticity in Advanced Materials, Oxford, England, 30 July 2003, (invited paper).

CONFERENCE PRESENTATIONS:

Kulas, M.A., Krajewski, P.E., McNelley, T.R., and Taleff, E.M., "Deformation and Failure Mechanisms in Commercial AA5083 Materials," Symposium on Hot Deformation of Aluminum, 132nd TMS Annual Meeting, San Diego, CA, 5 March 2003.

McNelley, T.R. and Swisher, D.L., "Processing, Recrystallization and Grain Boundaries in Superplastic Aluminum Alloys," ICSAM2003 International Conference on Superplasticity in Advanced Materials, Oxford, England, 30 July 2003.

THESIS DIRECTED:

Boydon, Jr., J.F., "Study of Cavitation and Failure Mechanisms of Superplastic 5083 Aluminum Alloy," Master's Thesis, Naval Postgraduate School, September 2003.

Orellano, R., "Grain Size Control in AA5083 by Thermomechanical Processing (TM): The Role of Dispersed Particles," Master's Thesis, Naval Postgraduate School, September 2003.

KEYWORDS: Aluminum, Superplasticity, Recrystallization, Grain Boundaries, Thermomechanical Processing

MICROSTRUCTURE EVOLUTION AND CONTROL DURING FRICTION STIR PROCESSING (FSP) OF CAST NAVAL BRONZE MATERIALS

Terry R. McNelley, Professor
Department of Mechanical Engineering
Sponsor: Defense Advanced Research Projects Agency

OBJECTIVE: The objective of this program was to determine the effect of friction stir processing (FSP) on the microstructure and properties of a cast nickel-aluminum bronze (NAB) material utilizing various micro-analytical methods as well as conventional mechanical testing. Of particular concern was to determine the mechanisms of microstructure refinement during FSP and the temperature distributions associated with this process.

SUMMARY: NAB materials are copper-based alloys that are widely used to produce cast components for marine applications due to excellent corrosion resistance, good fracture toughness combined with moderate strength, low coefficients of friction and good wear characteristics, non-sparking behavior, high damping capacity, and good fatigue resistance. Many cast components produced in NAB involve thick sections and the slow cooling rates contribute to coarse microstructures and reduced physical and mechanical properties. Porosity is a particular problem. In many NAB applications it would be desirable to have a means to reduce the porosity, as well as alternative methods available to selectively strengthen the surface layers of cast components. During FSP, friction between a rotating tool and the surface of the material results in a "stirring" action that, in turn, produces adiabatic heating and local softening. The tool rotation results in very large deformations in the softened regions, and thus microstructure refinement and homogenization leading, in turn, to improved strength and ductility in processed material. FSP may also result in closure of porosity and redistribution of inclusions thus conferring improved corrosion resistance. The influence of FSP on NAB materials was examined by various methods, including conventional scanning electron microscopy, orientation imaging microscopy, transmission electron microscopy, and related characterizations of the physical and mechanical properties of processed materials.

PUBLICATIONS:

Meyers, M.A., Xu, Y.B., Xue, Q., Pérez-Prado, M.T., and McNelley, T.R., "Microstructural Evolution in Adiabatic Shear Localization in Stainless Steel," *Acta Materialia*, Vol. 51, pp. 1307-25, 2003.

Oh-Ishi, K., Cuevas, A.M., Swisher, D.L., and McNelley, T.R., "The Influence of Friction Stir Processing on Microstructure and Properties of a Cast Nickel-Aluminum Bronze Material," *Materials Science Forum*, Vols. 426-432, pp. 2885-2890, 2003.

Oh-ishi, K. and McNelley, T.R., "Microstructural Modification of As-Cast NiAl Bronze by Friction Stir Processing," *Metallurgical and Materials Transactions A*, (submitted).

CONFERENCE PRESENTATIONS:

Oh-ishi, K., Cuevas, A.M., Park, C., and McNelley, T.R., "The Influence of Friction Stir Processing on Microstructure and Properties of a Cast Nickel Aluminum Bronze Material," THERMEC2003 International Conference on Processing and Manufacturing of Advanced Materials, Madrid, Spain, 8 July 2003.

Oh-Ishi, K. and McNelley, T.R., "Friction Stir Processing of As-Cast Nickel-Aluminum Bronze," Workshop on Friction Stir Welding and Processing, 132nd TMS Annual Meeting, San Diego, CA, 4 March 2003.

THESES DIRECTED:

Faires, K.B., "Characterization of Microstructure and Microtexture in Longitudinal Sections From Friction Stir Processed Nickel-Aluminum Bronze," Master's Thesis, Naval Postgraduate School, June 2003.

Nabach, W.A., "The Effects of Isothermal Annealing and Deformation on the Microstructure of Nickel-Aluminum Bronze Propeller Material," Master's Thesis, Naval Postgraduate School, June 2003.

Vazquez, D.K., "The Effects of Isothermal Deformation and Annealing on the Microstructure of Nickel-Aluminum Bronze in Relation to Friction Stir Processing," Master's Thesis, Naval Postgraduate School, December 2003.

Walton, C.F., "Microtextural Characterization of Shear Textures in the Thermomechanically Affected Zone of Friction Stir Processed Nickel Aluminum Bronze," Master's Thesis, Naval Postgraduate School, June 2003.

DoD KEY TECHNOLOGY AREA: Materials and Processes

KEYWORDS: Nickel Aluminum Bronze, Friction Stir Processing, Castings, Propellers, Stir Zone, Thermomechanically Affected Zone, Shear Deformation

ULTRA-FINE AND NANO-GRAIN MICROSTRUCTURES BY SEVERE PLASTIC DEFORMATION
Terry R. McNelley, Professor
Department of Mechanical Engineering

OBJECTIVE: The goal of this program was to determine mechanisms by which ultra-fine grain structures form in severely deformed materials, such as those processed by equi-channel angular (ECA) pressing.

SUMMARY: Ultra-fine grain sizes in the sub-micrometer or even nanometer range can be achieved in metallic materials by imposing extremely large plastic strains during deformation processing. Such grain refinement will result in drastic improvements in strength/toughness combinations for structural applications, as well as in improved ductility during elevated temperature forming. Methods such as ECA pressing are required in order to impart stains large enough to produce such refinement. ECA pressing is accomplished by pressing a billet of material through a die having two channels, of equal cross-section, that intersect at an angle. In such a circumstance, the billet experiences simple shear without change in cross-sectional area and so the process is amenable to repetition. Billet rotation between successive pressing operations allows the shear plane orientation to be changed in order to achieve further control of microstructural refinement. The characteristics of the grain structures and, especially, the nature of the grain boundaries produced by such processing have remained in question. However, grain-to-grain misorientations may be readily determined by newly developed computer-aided electron backscatter pattern (EBSP) analysis methods.

CONFERENCE PUBLICATION:

McNelley, T.R. and Swisher, D.L., "Grain Refinement Mechanisms During Equi-Channel Angular Pressing," *LiMAT2003 International Conference on Light Metals for Transportation Systems*, E.-W. Lee and N.-J. Kim (Eds.), Korea Metals Society, 2003, (in press).

CONFERENCE PRESENTATIONS:

McNelley, T.R. and Swisher, D.L., "The Evolution of Microstructure During ECAP of Pure Aluminum," U.S.-Korea Workshop on Advances in Metallic Structural Materials, Kihei, Maui, HI, 21 January 2003.

McNelley, T.R. and Swisher, D.L., "Processing and Microtexture During ECAP of Pure Aluminum," LiMAT2003, Honolulu, HI, 5 November 2003.

MECHANICAL ENGINEERING

DISSERTATION DIRECTED:

Swisher, D.L., "Deformation Banding and Grain Refinement in FCC Materials," Ph.D. Dissertation, Naval Postgraduate School, March 2003.

DoD KEY TECHNOLOGY AREA: Materials and Processes

KEYWORDS: Aluminum, Grain Refinement, Nano-Grain Materials, Recrystallization, Grain Boundaries, Materials Processing

ADVANCED MARINE GAS TURBINE TECHNOLOGY PROGRAMS
Knox T. Millsaps, Associate Professor
Department of Mechanical Engineering
Sponsor: Naval Surface Warfare Center – Carderock Division

SUMMARY: The objective of this work was to support the Advanced Technology Group Manager (Code 91) in the Marine Gas Turbine Branch of the Naval Surface Warfare Center - Carderock Division, for the life cycle support of the ship service and main propulsion gas turbines. This work included providing analysis and methodologies for the detection and localization of compressor fouling for condition based maintenance (CBM) of the Allison 501 and to support the International Gas Turbine Institute (IGTI) Marine Committee.

KEYWORDS: Gas Turbine, Code 91, Compressor, Fouling

PRELIMINARY DESIGN STUDY FOR REDUCED GAS TURBINE EXHAUST TEMPERATURES FROM THE LHAR II PROPULSION ENGINES
Knox T. Millsaps, Associate Professor
Department of Mechanical Engineering
Sponsor: Naval Surface Warfare Center – Carderock Division

SUMMARY: Performed a preliminary design study and proposed options for reducing the impact of the gas turbine exhaust on heating surrounding structures and reducing infrared plume signature.

KEYWORDS: Gas Turbine, Exhaust, Infrared Plume, LHAR II

ROBUST DISTRIBUTED CONTROL OF SHIPBOARD SYSTEMS
Fotis A. Papoulias, Associate Professor
Department of Mechanical Engineering
Sponsor: Office of Naval Research

SUMMARY: This project supported work performed for the Office of Naval Research by Nutech Solutions, Inc., on robust distributed control of shipboard systems utilizing a multi-agent approach.

KEYWORDS: Nutech Solutions, Multi-agent, Distributed Control

ROBUST DISTRIBUTED CONTROL OF SHIPBOARD SYSTEMS
Fotis A. Papoulias, Associate Professor
Department of Mechanical Engineering
Sponsor: Office of Naval Research

SUMMARY: This project supported fiscal year 2002 work performed for the Office of Naval Research by Biosgroup, Inc., on robust distributed control of shipboard systems utilizing a multi-agent approach.

DoD KEY TECHNOLOGY AREAS: Surface Vehicles, Modeling and Simulation

KEYWORDS: Distributed Control, IPS, Intelligent Agent Control

SECURING AND FENDERING FOR SKIN TO SKIN REPLENISHMENT
Fotis A. Papoulias, Associate Professor
Joshua H. Gordis, Associate Professor
Department of Mechanical Engineering
Sponsor: Advanced Design Consultants, Inc.

SUMMARY: This project supported a Small Business Technology Transfer (STTR) performed by Advanced Design Consultants, Inc., and funded by the Office of Naval Research.

DoD KEY TECHNOLOGY AREAS: Surface Vehicles, Modeling and Simulation

KEYWORDS: Roll-on-roll-off, Ramp Dynamics, Finite Element Methods, Hydrodynamics

WIRELESS CONTROL OF SHIPBOARD SYSTEMS
Fotis A. Papoulias, Associate Professor
Department of Mechanical Engineering
Sponsor: Naval Sea Systems Command

SUMMARY: This project supported work performed by the Naval Postgraduate School (NPS) on wireless control and sensors of shipboard systems presented at the 2003 Ship Control Systems Symposium.

KEYWORDS: Wireless Shipboard Systems, Ship Control

BOW WAVES AND SHIP WAKES
T. Sarpkaya, Distinguished Professor
Department of Mechanical Engineering
Sponsor: Office of Naval Research

OBJECTIVE: This continuing basic research was an experimental investigation of the formation of bow waves on destroyers. The objective was to understand enough of the hydrodynamics of the effect of bow shape on the jet separation in order to minimize the spray generation and resistance. In addition, the effect of the contaminants on the decay of turbulence in the wake of the destroyer was studied extensively.

SUMMARY: Measurements of bow waves were made with several high-speed imagers, a pulsating laser, and a Digital Particle Image Velocimeter (DPIV) system. The measurements were analyzed through the use of appropriate software. The Reynolds number ranged from 2.4×10^4 to 4×10^4, the Froude number from 15 to 30, and the Weber number from 1,500 to 3,000. The characteristics of the separated sheet were evaluated for a large number of bow motions and their combinations: heave, pitch, and yaw in calm seas. Additional work involved the effect of waves on the heave and pitch of the test models (scale model of an actual destroyer).

PUBLICATION:

Markle, H.B. and Sarpkaya, T., "Bow Waves on a Free-Running, Heaving and/or Pitching Destroyer," *Naval Hydrodynamics, National Academy of Sciences*, Washington, D.C., pp. 1-15, 2002.

CONFERENCE PUBLICATION:

Markle, H.B. and Sarpkaya, T., "Bow Waves on a Free-Running, Heaving and/or Pitching Destroyer," *Proceedings of the 24th Naval Hydrodynamics Symposium*, Fukuoka, Japan, 7-13 July 2002.

THESIS DIRECTED:

Markle, H.B., "An Experimental Investigation of the Bow Wave on *USS COLE* (DDG-67)," Master's Thesis, Naval Postgraduate School, September 2001.

KEYWORDS: Hydrodynamics, Drop Formation, Spray

FLOW-INDUCED VIBRATIONS
T. Sarpkaya, Distinguished Professor
Department of Mechanical Engineering
Sponsor: Office of Naval Research

OBJECTIVE: To compose an inspired review of the best in the works of the past century on flow-induced vibrations for the next generation of researchers and engineers. Everything important, from the fundamental phenomena to new directions for research, from theory and numerical simulations to experiments, were covered in a seminal journal paper.

SUMMARY: Flow-induced vibrations occur in many engineering situations, such as bridges, stacks, transmission lines, offshore structures, heat exchangers, marine cables, flexible risers in petroleum production, and other hydrodynamic and hydro-acoustic applications. During the past century, a great deal of work has been done on flow-induced vibrations and fluid elastic instability. The number of contributions has increased exponentially. Thus, the amount of time required for any one researcher to comprehend the literature and to plow through the empirical morass became an increasingly larger fraction of his research time. Clearly, to move forward and make contributions that shape the art and science of flow-induced vibrations in the new century, one must know and fully understand the essence of the work done during the past century. The safe guiding as well as safeguarding hand of the understanding of existing theoretical, experimental, numerical, and empirical evidence must be periodically re-energized and marshaled for new discoveries and applications. This requires a comprehensive review at least every 25 years.

PUBLICATION:

Sarpkaya, T., "A Critical Review of the Intrinsic Nature of Vortex-Induced Vibrations," *Journal of Fluids and Structures,* (in press).

CONFERENCE PUBLICATION:

Sarpkaya, T., "A Compendious Review of Vortex Induced Vibrations," *International Union of Theoretical and Applied Mechanics Congress*, Rutgers University, NJ, 2-6 June 2002.

TECHNICAL REPORT:

Sarpkaya, T., "A Critical Review of the Intrinsic Nature of Vortex-Induced Vibrations," Naval Postgraduate Technical Report, NPS-ME-03-002, 16 June 2003.

KEYWORDS: Flow-induced Vibratons, Comprehensive Review

MECHANICAL ENGINEERING

MODEL OF DYNAMICS AND DECAY OF WAKE VORTICES IN PARALLEL RUNWAYS
T. Sarpkaya, Distinguished Professor
Department of Mechanical Engineering
Sponsor: National Aeronautics and Space Administration-Langley Research Center

OBJECTIVE: The purpose of the investigation was threefold. One, to enhance the new vortex decay model for the prediction of the descent of aircraft trailing vortices subjected to realistic environmental conditions (stratification, turbulence, cross wind, headwind, shear effects, and ground effect). Two, to apply the model to field data obtained with Lidar in the Memphis and Dallas–Fort Worth airports. Three, to extend the results to parallel runways, wake transport between runways, vortex bouncing and lofting, and other decay phenomena.

SUMMARY: A robust and relatively simple physics-based vortex decay model was devised. It did not violate any hydrodynamical principles, had only one model constant, used the turbulence eddy dissipation rate in conjunction with a theoretical model (as verified by experiments and numerical simulations), and required no cumbersome algorithms to account for the ground effects. Acquisition of better and more detailed field data (vortex velocities and positions; wind, shear, and their gradients; better temperature, humidity, and eddy dissipation profiles), the quantification of the consequences of unstable stratification, and the optimization of the new model parameters constitute the essence of this continuing research of vital international importance. The model was successfully tested at the Dallas-Fort Worth airport in September 2001. It was recast for the prediction of landings on parallel runways.

PUBLICATION:

Sarpkaya, T., Robins, R.E., and Delisi, D.P., "Wake-Vortex Eddy-Dissipation Model Predictions Compared with Observations," *Journal of Aircraft, AIAA*, Vol. 38, No. 4, pp. 687-692, July-August 2003.

KEYWORDS: Trailing Vortices, Aircraft Wakes, Wake Hazard

FORCE PROTECTION IN THREAT ENVIRONMENTS: WEAPONS EFFECTS ON TARGET AND DAMAGE MODELS
Young S. Shin, Professor
Department of Mechanical Engineering
Sponsor: Defense Threat Reduction Agency

SUMMARY: The objective of this research was to analyze the details of integrated munitions effects on targets (structural systems) and, as a result, to identify the critical technology needs, to apply the IMEA software system to model weapon effects on integrated structure system, and to develop additional features in IMEA modules, weapons effects, and damage models.

KEYWORDS: Integrated Munitions, Target Models, Damage Models

SHIP DAMPING STUDIES FOR ENERGY DISSIPATION IN SHIP STRUCTURE SYSTEM
Young S. Shin, Professor
Young W. Kwon, Professor
Department of Mechanical Engineering
Sponsor: Naval Surface Warfare Center – Carderock Division

OBJECTIVE: The objective of this research was to investigate ship damping mechanisms for energy dissipation in ship structure system. The scopes of the tasks performed included a state-of-the-art literature survey for ship damping; UNDEX test data analysis for identification of energy dissipation sources; simple laboratory tests and simulations to explain the identified elements; ship damping studies for distribution of energy dissipation and parametric studies using ship shock simulations; and development of an implementation strategy within DYNA module in DYSMAS code.

DoD KEY TECHNOLOGY AREA: Others (Ship Damping in Ship Structure System)

KEYWORDS: Ship Damping, Energy Dissipation, Underwater Explosion

SHOCK AND VIBRATION ANALYSIS IN SUPPORT OF DDG-81 CLASS SHOCK FOLLOW-ON ACTIONS
Young S. Shin, Professor
Department of Mechanical Engineering
Sponsor: Naval Sea Systems Command

SUMMARY: The objective was to perform shock and vibration analysis in support of DDG-81 class shock follow-on actions including DDG-81 flight IIA ship shock modeling and simulation. The results were compared with ship shock trial test data (shots one and two) to identify potential problem areas and to investigate damage potential from the standpoint of survivability and vulnerability of a ship system.

KEYWORDS: Shock, Vibration Analyis, DDG-81, IIA Ship Shock

DEPARTMENT OF MECHANICAL ENGINEERING

2003
Faculty Publications
and Presentations

MECHANICAL ENGINEERING

PUBLICATIONS

Kulas, M.A., Krajewski, P.E., McNelley, T.R., and Taleff, E.M., "Deformation and Failure Mechanisms in Commercial AA5083 Materials," *Hot Deformation of Aluminum Alloys III*, Z. Jin, et al. (Eds.), Warrendale, PA: TMS, pp. 499-509, 2003.

Markle, H.B. and Sarpkaya, T., "Bow Waves on a Free-Running, Heaving and/or Pitching Destroyer," *Naval Hydrodynamics, National Academy of Sciences*, Washington, D.C., pp. 1-15, 2002.

Markle, H.B. and Sarpkaya, T., "Bow Waves on a Free-Running, Heaving and/or Pitching Destroyer," *Journal of the Japan Society of Marine Engineering*, Vol. 24, pp. 1-15, 2003.

McNelley, T.R. and Swisher, D.L., "Deformation Processing, Recrystallzation and Grain Boundaries in Superplastic Aluminum Alloys," *Materials Science Forum*, Vols. 447-448, pp. 373-380, 2003.

Meyers, M.A., Xu, Y.B., Xue, Q., Pérez-Prado, M.T., and McNelley, T.R., "Microstructural Evolution in Adiabatic Shear Localization in Stainless Steel," *Acta Materialia*, Vol. 51, pp. 1307-25, 2003.

Oh-Ishi, K., Cuevas, A.M., Swisher, D.L., and McNelley, T.R., "The Influence of Friction Stir Processing on Microstructure and Properties of a Cast Nickel-Aluminum Bronze Material," *Materials Science Forum*, Vols. 426-432, pp. 2885-2890, 2003.

Peréz-Prado, M.T., McNelley, T.R., Swisher, D.L., González-Doncel, G., and Ruano, O.A., "Texture Analysis and the Transition from Slip to Grain Boundary Sliding in a Continuously Recrystallized Superplastic Aluminum Alloy," *Materials Science and Engineering A*, Vol. A342, pp. 216-230, 2003.

Sarpkaya, T., Robins, R.E., and Delisi, D.P., "Wake-Vortex Eddy-Dissipation Model Predictions Compared with Observations," *Journal of Aircraft, AIAA*, Vol. 38, No. 4, pp. 687-692, July-August 2003.

CONFERENCE PUBLICATIONS

Gopinath, A. and Hebling, C., "Micro-TPV Devices for Large Power Densities," *PowerMEMS 2003*, Tokyo, Japan, 3-5 December 2003.

Hamilton, L.J. and Gopinath, A., "Numerical and Experimental Study of Pin-Fin Array Heat Exchangers," *2003 ASME International Mechanical Engineering Congress and Exposition*, Washington, D.C., 16-21 November 2003.

Lind, E.K., Hamilton, L.J., and Gopinath, A., "Analysis of Turbulence Models in a Cross Flow Staggered Array Pin Fin Heat Exchanger," *6th ASME-JSME Thermal Engineering Joint Conference*, Kona, HI, 16-20 March 2003.

Markle, H.B. and Sarpkaya, T., "Bow Waves on a Free-Running, Heaving and/or Pitching Destroyer," *Proceedings of the 24th Naval Hydrodynamics Symposium*, Fukuoka, Japan, 7-13 July 2002.

McNelley, T.R. and Swisher, D.L., "The Evolution of Microstructure During ECAP of Pure Aluminum," *U.S.-Korea Workshop on Advances in Metallic Structural Materials*, Kihei, Maui, HI, 21 January 2003.

McNelley, T.R. and Swisher, D.L., "Processing, Recrystallization and Grain Boundaries in Superplastic Aluminum Alloys," *ICSAM2003 International Conference on Superplasticity in Advanced Materials*, Oxford, England, 30 July 2003, (invited paper).

McNelley, T.R. and Swisher, D.L., "Processing and Microtexture During ECAP of Pure Aluminum," *LiMAT2003*, Honolulu, HI, 5 November 2003.

Oh-ishi, K., Cuevas, A.M., Park, C., and McNelley, T.R., "The Influence of Friction Stir Processing on Microstructure and Properties of a Cast Nickel Aluminum Bronze Material," *THERMEC2003 International Conference on Processing and Manufacturing of Advanced Materials*, Madrid, Spain, 8 July 2003.

Oh-Ishi, K. and McNelley, T.R., "Friction Stir Processing of As-Cast Nickel-Aluminum Bronze," *Workshop on Friction Stir Welding and Processing, 132nd TMS Annual Meeting*, San Diego, CA, February 2003.

Sarpkaya, T., "A Compendious Review of Vortex Induced Vibrations," *Proceedings of the International Union of Theoretical and Applied Mechanics Congress*, Rutgers University, NJ, 2-6 June 2002.

CONFERENCE PRESENTATIONS

Kulas, M.A., Krajewski, P.E., McNelley, T.R., and Taleff, E.M., "Deformation and Failure Mechanisms in Commercial AA5083 Materials," Symposium on Hot Deformation of Aluminum, 132nd TMS Annual Meeting, San Diego, CA, 5 March 2003.

McNelley, T.R. and Swisher, D.L., "The Evolution of Microstructure During ECAP of Pure Aluminum," U.S.-Korea Workshop on Advances in Metallic Structural Materials, Kihei, Maui, HI, 21 January 2003.

McNelley, T.R. and Swisher, D.L., "Processing and Microtexture During ECAP of Pure Aluminum," LiMAT2003, Honolulu, HI, 5 November 2003.

Oh-ishi, K., Cuevas, A.M., Park, C., and McNelley, T.R., "The Influence of Friction Stir Processing on Microstructure and Properties of a Cast Nickel Aluminum Bronze Material," THERMEC2003 International Conference on Processing and Manufacturing of Advanced Materials, Madrid, Spain, 8 July 2003.

Oh-Ishi, K. and McNelley, T.R., "Friction Stir Processing of As-Cast Nickel-Aluminum Bronze," Workshop on Friction Stir Welding and Processing, 132nd TMS Annual Meeting, San Diego, CA, 4 March 2003.

Sarpkaya, T., "A Compendious Review of Vortex Induced Vibrations," International Union of Theoretical and Applied Mechanics Congress, Rutgers University, NJ, 2-6 June 2003.

Sarpkaya, T. and Markle, H.B., "Quantification of the Bow Waves and Spray Sheets," Pasadena, CA, April 2002, (ONR-invited presentation).

Sarpkaya, T. and Markle, H.B., "Quantification of the Bow Waves and Spray Sheets," University of California, San Diego, CA, September 2002, (ONR-invited presentation).

TECHNICAL REPORT

Sarpkaya, T., "A Critical Review of the Intrinsic Nature of Vortex-Induced Vibrations," Naval Postgraduate Technical Report, NPS-ME-03-002, 16 June 2003.

DEPARTMENT OF METEOROLOGY

CARLYLE WASH
CHAIR

METEOROLOGY

OVERVIEW:

The Department of Meteorology provides graduate-level instruction in the science of meteorology and its application in support of military operations. To maintain expertise and provide support to student theses, the faculty performs research in the Navy-relevant areas of synoptic and dynamic meteorology, remote sensing, numerical modeling, tropical meteorology, boundary layer meteorology, and environmental effects.

Over 40 years ago, the Naval Postgraduate School (NPS) was responsible for the establishment and flourishing of a Navy operational command on its campus. In 1959, the Naval Oceanographic Command moved its numerical prediction center to Monterey as a new operational command, the Fleet Numerical Weather Central (now, Fleet Numerical Meteorology and Oceanography Center-FNMOC). The Navy chose to move FNMOC to Monterey to take advantage of the presence of NPS with its large assembly of science faculty who are intimately familiar with Navy operational problems in meteorology and oceanography. For similar reasons, the Navy Environmental Prediction Research Facility (now the Marine Meteorology Division of the Naval Research Laboratory (NRL) Monterey), moved to Monterey in 1971. This further augmentation of meteorological and oceanographic scientists in Monterey has made it the center of Naval environmental science.

The consequences of these moves are the substantial involvement of NPS faculty in research projects at NRL Monterey and the enhancement of operational capabilities at FNMOC. Furthermore, personnel from the latter two organizations are able to take advanced courses at NPS, and officer-students at NPS can engage in thesis research on "real-life" applications relating environmental parameters to Naval operations.

CURRICULA SERVED:

- Meteorology
- Meteorology and Physical Oceanography
- Space Systems Operations
- Space Systems Engineering
- Electronic Warfare

DEGREES GRANTED:

- Master of Science in Meteorology
- Master of Science in Meteorology and Physical Oceanography
- Doctor of Philosophy in Meteorology

RESEARCH THRUSTS:

- Synoptic, Mesoscale, and Coastal Meteorology:
  Distinguished Professor Russell Elsberry, Associate Professor Wendell Nuss, Professor Carlyle Wash, Research Assistant Professor Douglas Miller, Research Associate Professor Patrick Harr
- Numerical Weather Prediction (NWP):
  Professor Roger Williams, Research Associate Hway-Jen Chen, Research Assistant Professor Kevin Cheung, Research Assistant Professor Douglas Miller
- Environmental Analysis and Visualization:
  Research Associate Mary Jordan
- Air-Sea Interactions:
  Professor Kenneth Davidson, Professor Robert Haney, Research Associate Paul Frederickson
- Satellite and Ground Based Remote Sensing:
  Professor Phillip Durkee, Research Associate Kurt Nielsen
- Tropical Meteorology:
  Professor Chih-Pei Chang, Research Associate Hway-Chen, Research Associate Professor Patrick Harr, Research Assistant Professor Kevin Cheung

- ▪ Tropical Cyclone Motion:
  Distinguished Professor Russell Elsberry, Research Assistant Professor Kevin Cheung, Research Associate Professor Patrick Harr
- ▪ Boundary Layer Meteorology:
  Professor Kenneth Davidson, Associate Professor Qing Wang
- ▪ Climate Dynamics:
  Professor Chih-Pei Chang, Professor Roger Williams, Research Associate Hway-Jen Chen, Senior Lecturer Tom Murphee
- ▪ Atmospheric Factors in EM/EO Propagation:
  Professor Kenneth Davidson, Research Associate Professor Peter Guest, Research Associate Paul Fredrerickson
- ▪ Polar Meteorology:
  Research Associate Professor Peter Guest

RESEARCH FACILITIES:

- ▪ **IDEA Laboratory:** The Interactive Digital Environmental Analysis (IDEA) laboratory has Silicon Graphics workstations specifically designed and funded for instruction. The lab computers are used to analyze and display real-time satellite data and numerical model output.
- ▪ **Tactical Laboratory:** The Tactical Lab operates an SMQ-11 DMSP satellite receiver that collects and processes classified environmental data and runs military tactical decision aids used to support operations.
- ▪ **Synoptic Analysis and Forecasting Laboratory:** The Synoptic Analysis and Forecasting Lab uses a suite of computers and advanced display devices to provide local and global real-time meteorological data and numerical products for instruction and research in operational weather forecasting.
- ▪ **Atmospheric Boundary Layer Measurements Laboratory:** The Measurements Lab provides information from a special near-coastal observation site at Fort Ord in support of instruction and research in boundary layer and coastal meteorology. Present instrumentation includes two radar wind profilers, an automatic surface weather station, and rawinsonde systems.

RESEARCH PROGRAM (Research and Academic)-FY2003:

The Naval Postgraduate School's sponsored program exceeded $71 million in FY2003. Sponsored programs included both research and educational activities funded from an external source. A profile of the sponsored program for the Department of Meteorology is provided below:
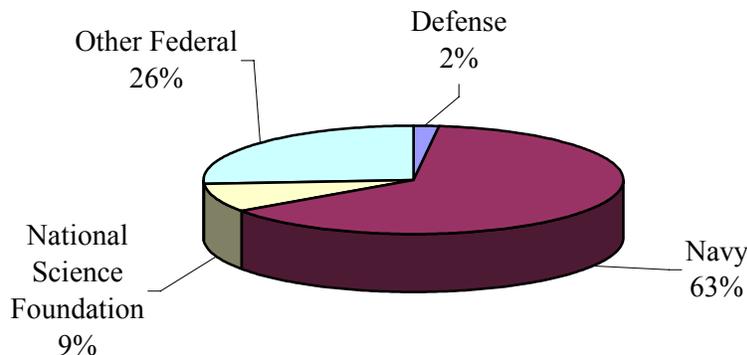
Size of Program: $2,534K

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METEOROLOGY

TRANSITION OF REVISED DYNAMICAL MODEL TRACK PREDICTION EVALUATION EXPERT SYSTEM

Mark A. Boothe, Meteorologist
Department of Meteorology
Sponsor: National Oceanic and Atmospheric Administration

OBJECTIVE: The objective was the transition of a revised operational expert system to the National Hurricane Center (NHC) that will improve the track forecasts of tropical storms and hurricanes.

SUMMARY: Since the 2001 hurricane season, the United States Weather Research Program has funded the Joint Hurricane Testbed. The goal of the Joint Hurricane Testbed is to expedite forecasting tools from research to operations at NHC. The Dynamical Model Evaluation System (DYMES) has been funded since 2001, and the version utilized during 2003 was revised from the previous two years. The DYMES provides guidance to a hurricane forecaster for scenarios when computer forecast models suggest different possible tracks. Based upon the orientation of the forecast tracks and a knowledge base of previous errors of the models, DYMES suggested which models may be potentially degraded, and why, for the current scenario. From mid-July 2003 through the remainder of the hurricane season, DYMES was operated at the Naval Postgraduate School (NPS) every weekday morning on Atlantic and eastern Pacific storms. Notable differences in the structure of the TC (even at analysis) from model to model were seen, and these had important consequences on subsequent motion. Also, a surprisingly high number of cases involved obvious tracker problems in which the tracker jumped to another circulation. Results from the 2003 season and program modifications were presented at the 58th Interdepartmental Hurricane Conference in March 2004 and the American Meteorological Society's 25th Conference on Hurricanes and Tropical Meteorology in May 2004. Training material was produced during April and delivered in May before the 2004 hurricane season starts. Three major projects were also planned prior to mid-May: incorporating DYMES output into a format used at the National Hurricane Center; displaying height fields to help the forecaster determine the relative strength of other features affecting the storm; and displaying field differences to help the forecaster more easily see how one model differs from another.

PRESENTATION:

Boothe, M.A., Elsberry, R.L., and Salvador, L., "Beta Test of a Prototype Dynamical Model Track Prediction Evaluation System for the Atlantic and Eastern Pacific," 57th Interdepartmental Hurricane Conference, Miami, FL, 10-14 March 2003.

KEYWORDS: Dynamical Model Track Prediction, Hurricane, NHC, Joint Hurricane Testbed

FORECAST OF CLOUD PROBABILITY IN SOUTHEAST ASIA

Chih-Pei Chang, Professor
Department of Meteorology
Sponsor: Naval Sea System Command (collaboration with Ministry of Defense, Republic of Singapore)

OBJECTIVE: The objective was to analyze historical GMS satellite blackbody temperature data, airport surface station cloud data, and gridded Numerical Weather Prediction (NWP) analyzed wind data to derive empirical forecast tools for the probability of cloud cover in the vicinity of Singapore.

SUMMARY: Additional forecast tools were developed for several airports. They were of the synoptic type and were applicable for northern winter when the large-scale influence to the cloud development is significant. These were based on low level NWP wind analysis from the National Centers for Environmetal Prediction (NCEP) and the Navy Operational Global Atmospheric Prediction System (NOGAPS). In one of the synoptic models, the predictors were the relative position of two low centers, one in the South China Sea and the other in the southern Bay of Bengal. In another synoptic model, the predictor was the development of a cold surge in the northern South China Sea. Work is continuing to evaluate the feasibility

of using the synoptic low centers (or cyclonic circulation centers) in the South China Sea and eastern Indian Ocean in other seasons as predictors.

PUBLICATION:

Statistical and synoptic model reports to Ministry of Defense, Republic of Singapore.

KEYWORDS: Cloud probability, Tropical Meteorology, Monsoon, Southeast Asia, China Seas

MONSOON DISTURBANCES OVER SOUTHEAST ASIA AND ADJACENT SEAS
Chih-Pei Chang, Professor
Department of Meteorology
Sponsors: Office of Naval Research, Naval Postgraduate School

OBJECTIVE: The objectives of this research were twofold. One objective was to study the structure and the dynamic and thermodynamic properties of the disturbances in the vicinity of the Southeast and East Asian monsoon region, which stretches from the Indian Ocean to the tropical western Pacific and includes the South China Sea and the Yellow Sea. These are of particular interest to naval operations. The second objective was to study the ability and sensitivity of Navy operational numerical models in analyzing and predicting these disturbances.

SUMMARY: The formation of Typhoon Vamei on 27 December 2001 near 1.5N in the equatorial South China Sea was studied. Observational evidence suggested that Vamei formed as a result of an interaction between two well-known features of the Asian winter monsoon: a weak Borneo vortex that drifted into, and remained in, the southern tip of the South China Sea and a strong and persistent cold surge that created the large background cyclonic vorticity at the equator. The development was compared to the work by Lim and Chang (1981), who showed that an equatorial cyclongenesis process can be demonstrated using the equatorial wave theory. In the theory, geostrophic adjustment and potential vorticity conservation following a cross-equatorial surge spin up counterclockwise rotation to the east of the surge axis, where in the real world the Borneo vortex is located. By analyzing Navy Operational Global Atmospheric Prediction System (NOGAPS), National Centers for Environmetal Prediction (NCEP), and QuikSCAT data, researchers postulated that Vamei developed because the durations of the intense cold surge in the equatorial South China Sea and the Borneo circulation remaining over water were both significantly longer than normal, which allowed the interaction to continue for nearly a week until the storm formed. Researchers estimated the probability for an equatorial development from similar conditions to be about once in a century or longer. This estimate appeared consistent with historical observations. However, it was not known whether other near-equatorial developments occurred but were not observed during the pre-satellite era.

Researchers expanded the study of the cold surge–Borneo vortex interaction in the equatorial South China Sea during boreal winter by starting on composite studies of the convection and circulation fields over the region, using long term NCEP reanalysis and Japanese GMS satellite data. The research focused on the possible interactions between the cold surges, the Borneo vortex, and the different phases of MJO.

PUBLICATIONS:

Chang, C.-P., Harr, P.A., McBride, J., and Hsu, H.H., "Maritime Continent Monsoon. East Asian Monsoon," *World Scientific Series on Meteorology of East Asia*, Vol. 2, 2004, (in press).

Chang, C.-P., Liu, C.H., and Kuo, H.C., "Typhoon Vamei: An Equatorial Tropical Cyclone Formation," *Geophysical Research Letters*, 30, 50 1-4, 2003.

Chen, J.M., Chang, C.-P., and Li, T., "Annual Cycle of the South China Sea Surface Temperature Using the NCEP/NCAR Reanalysis," *Journal of the Meteorological Society of Japan*, 81, 879-884, 2003.

KEYWORDS: Numerical Weather Prediction, Tropical Meteorology, Monsoon, Southeast Asia, Indonesia, Malaysia, China Seas

METEOROLOGY

MONSOON–ENSO INTERACTIONS
Chih-Pei Chang, Professor
Department of Meteorology
Sponsor: National Oceanic and Atmospheric Administration

OBJECTIVE: To study the structure of the interannual variations of the Asian-Australian monsoon and its relationship with El Nino–Southern Oscillations (ENSO).

SUMMARY: Two papers were revised: "A Theory for the Indian Ocean Dipole Mode" and "On the Relationship between Western Maritime Continent Monsoon Rainfall and ENSO During Northern Winter." In the second paper, additional surface station data was used to confirm the Maritime Continent rainfall-ENSO relationship and the decadal changes identified from the analysis data. New research was initiated to document the seasonal march, including both annual and semiannual cycles, of rainfall over the Maritime Continent and surrounding regions using station rainfall and Tropical Rainfall Measuring Mission (TRMM) data. Strong wind-terrain interactions that seem to play a crucial role in the seasonal march were identified.

PUBLICATIONS:

Chang, C.-P., Wang, Z., Ju, J., and Li, T., "On the Relationship between Western Maritime Continent Monsoon Rainfall and ENSO During Northern Winter," *Journal of Climate*, 17, 665-672, 2004.

Chen, J.M., Chang, C.-P., and Li, T., "Annual Cycle of the South China Sea Surface Temperature Using the NCEP/NCAR Reanalysis," *Journal of the Meteorological Society of Japan*, 81, 879-884, 2003.

Li, T., Wang, B., Chang, C.-P., and Zhang, Y., "A Theory for the Indian Ocean Dipole Mode," *Journal of Atmospheric Science*, 60, 2119–2135, 2003.

CONFERENCE PRESENTATION:

Wang, Z., Wang, B., and Chang, C.-P., "Great Plain Summer Rainfall Variability," U.S. Climate Variability and Predicability (CLIVAR) Pan American Workshop, Boulder, CO, 16-18 September 2003.

KEYWORDS: Monsoon, El Nino, ENSO, Climate Variations, Southeast Asia, Tropical Meteorology

TROPICAL VORTICES IN NORTHWEST PACIFIC MONSOON
Chih-Pei Chang, Professor
Roger Terry Williams, Professor
Department of Meteorology
Sponsor: National Science Foundation

OBJECTIVE: To study the interactions between Asia/Australian monsoon and tropical disturbances, particularly the dynamics of the formation and intensification of tropical disturbances in the monsoon confluence region in the Northwest Pacific.

SUMMARY: Researchers studied the formation of Typhoon Vamei on 27 December 2001 near 1.5N in the equatorial South China Sea. The development was compared to the work by Lim and Chang (1981) who showed that an equatorial cyclongenesis process can be demonstrated using the equatorial wave theory. In the theory, geostrophic adjustment and potential vorticity conservation following a cross-equatorial surge spin up counterclockwise rotation to the east of the surge axis, where in the real world the Borneo vortex is located. By analyzing Navy Operational Global Atmospheric Prediction System (NOGAPS), National Centers for Environmetal Prediction (NCEP), and QuikSCAT data, researchers postulated that Vamei developed because the durations of the intense cold surge in the equatorial South China Sea and the Borneo circulation remaining over water were both significantly longer than normal, which allowed the interaction

to continue for nearly a week until the storm formed. Researchers estimated the probability for an equatorial development from similar conditions to be about once in a century or longer.

Research continued on the concentric eye structure of tropical cyclones using a nondivergent barotropic model with additional experiments in parameter spaces. It was demonstrated that concentric vorticity structures result from the interaction between a small and strong inner vortex (the tropical cyclone core) and neighboring weak vortices (the vorticity induced by the moist convection outside the central vortex of a tropical cyclone). The results highlighted the pivotal role of the vorticity strength of the inner core vortex in maintaining itself, and in stretching, organizing, and stabilizing the outer vorticity field.

PUBLICATIONS:

Chang, C.-P., Harr, P.A., McBride, J., and Hsu, H.H., "Maritime Continent Monsoon. East Asian Monsoon," *World Scientific Series on Meteorology of East Asia*, Vol. 2, 2004, (in press).

Chang, C.-P., Liu, C.H., and Kuo, H.C., "Typhoon Vamei: An Equatorial Tropical Cyclone Formation," *Geophysical Research Letters,* 30, 50 1-4, 2003.

Kuo, H.C., Lin, L.Y., Chang, C.-P., and Williams, R.T., "The Formation of Concentric Vorticity Structures in Typhoons," *Journal of Atmospheric Science,* 2004, (submitted)

KEYWORDS: West Pacific, Typhoons, Tropical Meteorology, Tropical Cyclones

STUDIES IN TROPICAL CYCLONE FORMATION
Kevin K. W. Cheung, Research Assistant Professor
Russell L. Elsberry, Professor
Department of Meteorology
Sponsor: Office of Naval Research

OBJECTIVE: To understand the physics of tropical cyclone formation and improve the skill of tropical cyclone formation forecasts using numerical weather prediction models.

SUMMARY: Numerical simulations were performed on Typhoon Robyn (1993) in the western North Pacific (WNP) using the PSU/NCAR MM5 model. This case was chosen because of availability of observations from two intensive observational periods during the Tropical Cyclone Motion (TCM-93) field experiment, and one of the hypotheses of the experiment was that mesoscale convective systems contributed to the formation of Robyn. Detailed diagnostics of the sensitivity experiments in MM5 identified an appropriate model configuration that simulates the case of Typhoon Robyn well and also some potential problems in the model (e.g., generation of spurious vortices) when different physics is adopted. A manuscript summarizing the results was submitted to the *Monthly Weather Review* (Cheung and Elsberry 2004). Short-term future work included high-resolution simulations on the same case to enable diagnosing the interactions among several mesoscale systems. Long-term work will involve model comparison with the Navy Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) concerning TC formation predictions, since COAMPS is the operational model within the Fleet Numerical Meteorology and Oceanography Center.

Although the basic large-scale environmental conditions for TC formations are well-known, detailed information on some of the dynamical parameters associated with TC formations is not well documented. This is especially true for the WNP, where there exist a number of different formation patterns. Several parameters closely related to TC formations were examined for cases in the 1990–2001 time period. These parameters included sea-surface temperature (SST), vertical wind shear, relative humidity, convective available potential energy (CAPE), and mid-to-upper-level moisture content. They were computed from the National Centers for Environmetal Prediction (NCEP) reanalyses and GMS-5 satellite imagery. The distributions of these parameters for all TC formation cases in the 12-year period were obtained. Then a potential formation area (PFA) concept was introduced to identify areas in which the large-scale environmental parameters are favorable for TC formations. It was found that among the six parameters, the vertical zonal shear and CAPE play important roles in affecting the meridional change of formation

positions within a year, as indicated in their respective climatologies. The sensitivity tests that ignored one of the parameters in determining the PFA also indicated that the zonal shear and relative humidity determine, to a large extent, the zonal distribution of the PFA. This concept of PFA was utilized in the TC formation expert system for identifying potential formation cases. A manuscript summarizing these results was published in the *Journal of Climate* (Cheung 2004).

PUBLICATIONS:

Cheung, K.K.W., "Large-Scale Environmental Parameters Associated with Tropical Cyclone Formations in the Western North Pacific," *Journal of Climate*, Vol. 17, pp. 466–484, 2004.

Cheung, K.K.W. and Elsberry, R.L., "Numerical Simulations of the Formation of Typhoon Robyn (1993): Part I: Model Sensitivities," *Monthly Weather Review*, 2004, (submitted).

DoD KEY TECHNOLOGY AREA: Battlespace Environment

KEYWORDS: Tropical Cyclone Formation, Cyclogenesis, Numerical Modeling and Simulation

COMBATANT CRAFT METEOROLOGY AND OCEANOGRAPHY (METOC) MEASUREMENTS FOR RADAR DETECTABILITY
Kenneth L. Davidson, Professor
Department of Meteorology
Sponsor: Space and Naval Warfare Systems Command

SUMMARY: Provided field test guidance for and evaluation of airflow and surface measurements for use on combatant craft to estimate radar detectability.

KEYWORDS: Combatant Craft, METOC, Radar Detectability

DESIGN OF REFRACTIVITY PROFILE COLLECTION DURING VESSEL SIGNATURE TESTS
Kenneth L. Davidson, Professor
Department of Meteorology
Sponsor: Naval Surface Warfare Center – Carderock Division

SUMMARY: Performed preparation by component shipment and acquisition for collection of meteorology and oceanography (METOC) data that was used to estimate vertical profiles of temperature and humidity along the Rf path during vessel signature tests. The tests took place in Dam Neck, Virginia, and San Clemente Island, California, during July and September.

KEYWORDS: METOC, Rf Path, Temperature, Humidity

AN INTEGRATED MODEL FOR OPERATIONAL ASSESSMENT OF RF/IR PROPAGATION AND APPLICATION TO TACTICAL DECISION AIDS (TDA) FOR FORCE DEFENSE
Kenneth L. Davidson, Professor
Department of Meteorology
Sponsor: Space and Naval Warfare Systems Command

SUMMARY: Performed immediate tasks to improve atmospheric descriptions for propagation assessment tactical decision aids (TDA) in order to improve the warfighter's ability to predict Rf/Ir detection of specific threats, to optimize sensor performance for the current environment, and to assist in tactical decision making for force defenses.

KEYWORDS: TDA, Rf/IR, Propogation Assessment, Atmospheric Description

LONG-TERM FLUX-BUOY MEASUREMENTS AT WALLOPS ISLAND: MEAN METEOROLOGY AND OCEANOGRAPHY (METOC), TURBULENCE, NEAR-SURFACE SCALAR PROFILES, AND SURFACE WAVES
Kenneth L. Davidson, Professor
Department of Meteorology
Sponsor: Naval Surface Warfare Center – Dahlgren Division

SUMMARY: Obtained near-surface atmospheric and surface data that enabled gradients of the radar/radio wave refractivity and wave conditions to be estimated for interpretation of near-horizon EM propagation.

KEYWORDS: Flux-buoy, Wallops Island, METOC, Turbulence, Waves, Scalar Profile, EM Propogation

NAVAL POSTGRADUATE SCHOOL SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM
Kenneth L. Davidson, Professor
Department of Meteorology
Sponsor: Office of Naval Research

PARAMETERIZATION OF NEAR-SURFACE REFRACTIVITY PROFILES OVER THE OCEAN AND THEIR EFFECTS ON IR/RF PROPAGATION
Kenneth L. Davidson, Professor
Department of Meteorology
Sponsor: Office of Naval Research

SUMMARY: Evaluated mid-path atmospheric and surface wave descriptions in infrared to interpret and describe measured RF/EO (radio-frequency and electro-optical) propagation. Described the applicability of and modified Monin-Obukhov surface-layer scaling over the ocean to estimate mean profiles and turbulent properties and their impact on RF/EO.

KEYWORDS: RF/EO, IR, Monin-Obukhov, Near-Surface Refractivity

REFRACTIVITY PROFILE COLLECTION DURING VESSEL SIGNATURE TESTS: SAN CLEMENTE ISLAND, CALIFORNIA, OCTOBER 2002
Kenneth L. Davidson, Professor
Department of Meteorology
Sponsor: Naval Surface Warfare Center – Carderock Division

SUMMARY: Collected meteorology and oceanography (METOC) data to estimate vertical profiles of temperature and humidity along radar paths during vessel signature tests. The data was interpreted for METOC influences on s- and x-band radar detection range of NSW platforms. The tests were at San Clemente Island, California (October 2002).

KEYWORDS: METOC, Vertical Profiles, Radar, Vessel Signatures, S-band, X-band, San Clemente

METEOROLOGY

REFRACTIVITY PROFILE COLLECTION DURING VESSEL SIGNATURE TEST: SAN CLEMENTE ISLAND, CALIFORNIA, JUNE 2003
Kenneth L. Davidson, Professor
Department of Meteorology
Sponsor: Naval Surface Warfare Center – Carderock Division

SUMMARY: Collected meteorology and oceanography (METOC) data to estimate vertical profiles of temperature and humidity along radar paths during vessel signature tests. The data was interpreted for METOC influences on s- and x-band radar detection range of Naval Surface Warfare (NSW) platforms. The tests took place in San Clemente Island, California in June 2003.

KEYWORDS: METOC, Vertical Profiles, Radar, Vessel Signatures, S-band, X-band, San Clemente

REFRACTIVITY PROFILE COLLECTION DURING VESSEL SIGNATURE TESTS: DAM NECK, VIRGINIA, AND SAN CLEMENTE ISLAND, CALIFORNIA
Kenneth L. Davidson, Professor
Department of Meteorology
Sponsor: Naval Surface Warfare Center – Carderock Division

SUMMARY: Collected meteorology and oceanography (METOC) data to estimate vertical profiles of temperature and humidity along radar paths during vessel signature tests. The data was interpreted for METOC influences on s- and x-band radar detection range of Naval Surface Warfare (NSW) platforms. The tests took place in Dam Neck, Virginia (July-August 2002), and San Clemente Island, California (October-November 2002).

KEYWORDS: METOC, Vertical Profiles, Radar, Vessel Signatures, S-band, X-band, San Clemente, Dam Neck, Virginia

SHIPBOARD METEOROLOGICAL AND OCEANOGRAPHIC OBSERVING SYSTEM (SMOOS) PERFORMANCE EVALUATION
Kenneth L. Davidson, Professor
Department of Meteorology
Sponsor: Space and Naval Warfare Systems Command

SUMMARY: Supported development of Shipboard Meteorological and Oceanographic Observing System (SMOOS) (R) acquisition specifications by providing meteorology and oceanography (METOC) system validation, verification, and integration and providing guidance for meteorological instrumentation and data processing.

KEYWORDS: Shipboard Meteorological and Oceanographic Observing System, SMOO, METOC

ADVANCES IN METOC REMOTE SENSING
Philip A. Durkee, Professor
Department of Meteorology
Sponsor: Navy Meteorology and Oceanography Professional Development Center

METEOROLOGY

SATELLITE-DERIVED MARINE ATMOSPHERIC BOUNDARY LAYER AND ELECTROMAGNETICM/ELECTRO-OPTICAL PROPERTIES

Philip A. Durkee, Professor
Mary S. Jordan, Research Associate
Department of Meteorology
SPONSOR: SPACE AND NAVAL WARFARE SYSTEMS COMMAND

OBJECTIVE: To develop an automated computer method to estimate the location and strength of elevated ducts in coastal and open ocean regions using satellite imagery received on U.S. Navy ships and regional Meteorology and Oceanography (METOC) centers. This project supports development of boundary layer analysis techniques using satellite radiances. The output from this method will be input for radar propagation assessment programs to improve force protection and Naval Fires/Strike objectives.

SUMMARY: This project was a satellite remote sensing tool to estimate the height of the marine boundary layer and elevated duct strength and depth in coastal and open-ocean regions. It will be an input to radar propagation assessment tools, or other tactical aids. The project provided computer software to run on the standard shipboard/regional center METOC satellite receiver/processing computer. Marine stratus clouds were identified in National Oceanic and Atmospheric Administration (NOAA) polar orbiter (AVHRR) imagery and the cloud-top height was estimated. The existence of an elevated duct, and information about the duct strength and depth, was estimated from the satellite imagery and, possibly, external information. The duct information was provided in output forms suitable for radar propagation assessment programs and/or other tactical aids. It may be possible to modify the technique to work with geostationary satellite imagery.

In FY03, the physical assumptions of the technique were explored and refined. In FY04, error estimates will be made based on case studies and an elevated duct strength estimation algorithm will be developed and added to the automation process.

CONFERENCE PUBLICATION:

Jordan, M.S. and Durkee, P.A., "Marine Boundary Layer Cloud-top Altitude Analysis from Satellite Measurements," *Proceedings of the Battlespace Atmospheric and Cloud Impacts on Military Operations (BACIMO) Conference*, Monterey, CA, 9-11 September 2003.

CONFERENCE PRESENTATION:

Jordan, M.S. and Durkee, P.A., "Marine Boundary Layer Cloud-top Altitude Analysis from Satellite Measurements," Battlespace Atmospheric and Cloud Impacts on Military Operations (BACIMO) Conference, Monterey, CA, 9-11 September 2003.

DoD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Satellite, Remote Sensing, Clouds, Marine Atmospheric Boundary Layer, Elevated Duct

TARGET AREA METEOROLOGY AND OCEANOGRAPHY (METOC) MERIT SUPPORT

Philip A. Durkee, Professor
Department of Meteorology
Sponsor: National Reconnaissance Office

SUMMARY: This research supported preparation of algorithms for the target area meteorology /oceanography (TAM) MERIT program. TAM is also known under Navy Tactical Exploitation of National Capabilities (TENCAP) as Radian Sleet. Two primary algorithms were developed, tested, and validated: atmospheric visibility and near surface air temperature. Monthly reports were provided to meet the MERIT program requirements.

KEYWORDS: METOC, TAM, MERIT, TENCAP, Radian Sleet

METEOROLOGY

AIR-OCEAN INTERFACE AND BOUNDARY PROCESSES AT THE INTERNATIONAL WORKSHOP ON TROPICAL CYCLONES
Russell L. Elsberry, Professor
Department of Meteorology
Sponsor: Office of Naval Research - International Field Office

SUMMARY: Provided travel funds for an international group of experts to attend the Fifth International Workshop on Tropical Cyclones (IWTC-V) for the purpose of assessing scientific knowledge of air-ocean interface and boundary processes in tropical cyclones and to formulate collaborative research programs in these fields.

KEYWORDS: Workshop on Tropical Cyclones, IWTC-V

MODELING TROPICAL CYCLONE STRUCTURE AND TRACK
Russell L. Elsberry, Professor
Department of Meteorology
SPONSOR: SPACE AND NAVAL WARFARE SYSTEMS COMMAND

SUMMARY: This research demonstrated the feasibility of creating knowledge-based expert system modules that will allow the Joint Typhoon Warning Center (JTWC) forecasters make more accurate and consistent forecasts of tropical cyclone formations, outer wind structure, and inner wind structure.

KEYWORDS: Joint Typhoon Warning Center, JTWC, Tropical Cyclone, Forecast

PREDICTING TROPICAL CYCLONE FORMATION AND STRUCTURE CHANGE
Russell L. Elsberry, Professor
Department of Meteorology
Sponsor: Office of Naval Research

SUMMARY: This research demonstrated the feasibility of creating knowledge-based expert system modules that will allow the Joint Typhoon Warning Center (JTWC) forecasters make more accurate and consistent forecasts of tropical formation, outer wind structure, and inner wind structure (intensity).

KEYWORDS: Joint Typhoon Warning Center, JTWC, Tropical Cyclone, Forecast

PREDICTION OF TROPICAL CYCLONE FORMATION
Russell L. Elsberry, Professor
Department of Meteorology
Sponsor: Office of Naval Research - International Field Office

SUMMARY: Documented the ability of numerical weather prediction models to forecast tropical cyclone formation in the southern hemisphere and then produced guidance products for the Joint Typhoon Warning Center forecasters utilizing those outputs for five-day forecasts.

KEYWORDS: Numerical Weather Prediction Model, Joint Typhoon Warning Center, JTWC, Tropical Cyclone, Forecast

THE STRUCTURAL CHANGES OF TROPICAL CYCLONES UPON INTERACTION WITH VERTICAL WIND SHEAR
Russell L. Elsberry, Professor
Department of Meteorology
Sponsor: National Aeronautics and Space Administration

SUMMARY: A combined observational and modeling study of the effects of vertical wind shear on the core structure and intensity of a tropical cyclone was conducted. The observational phase was based on the CAMEX-4 field program and was designed to identify physical processes in the tropical cyclone core that occur during interaction with vertical wind shear. The overall objective was to define the role of environmental vertical wind shear in developing asymmetries in the core structure of the tropical cyclone, and to assess how the intensity of the tropical cyclone increases/decreases. A synthesis of the observational and numerical simulations was used to develop a conceptual model of the structural evolution and intensity change of the tropical cyclone structure as it interacts with vertical wind shear.

KEYWORDS: Wind Shear, CAMEX-4

SUPPORT FOR U.S. WEATHER RESEARCH PROGRAM (USWRP) HURRICANE SCIENCE COORDINATOR
Russell L. Elsberry, Professor
Department of Meteorology
Sponsor: Office of Naval Research

SUMMARY: This project supported Professor Elsberry as the Science Coordinator (Hurricane Landfall) for the U.S. Weather Research Program, which was sponsored by the Office of Naval Research. Professor Elsberry carried out the duties of the Science Coordinator (Associate Lead Scientist) as described in the terms of reference dated January 1999.

KEYWORDS: Hurricane Landfall, U.S. Weather Research Program, Elsberry

SYSTEMATIC APPROACH TO TROPICAL CYCLONE TRACK FORECASTING
Russell L. Elsberry, Professor
Department of Meteorology
Sponsor: Space and Naval Warfare Command

SUMMARY: This project provided Joint Typhoon Warning Center, Pearl Harbor, with the complete version of the systematic approach to tropical cyclone track forecasting. This project continued extension of the systematic approach to the other tropical cyclone basins, especially the Southern Hemishpere, eastern/central Pacific, and the Atlantic regions.

DoD KEY TECHNOLOGY AREAS: Tactical Environmental Support, Atmospheric Effects

KEYWORDS: Tropical Cyclone Track Prediction, Tactical Decision Aids

TRANSITION OF DYNAMICAL MODEL TRACK PREDICTION EVALUATION EXPERT SYSTEM
Russell L. Elsberry, Professor
Department of Meteorology
Sponsor: National Oceanic and Atmospheric Administration

SUMMARY: Continued second-year research with a pre-operational implementation test of the Dynamical Model Evaluation System (DYMES) for Atlantic hurricanes in conjunction with the Joint Hurricane Testbed.

METEOROLOGY

KEYWORDS: Dynamical Model Evaluation System, DYMES, Atlantic, Joint Hurricane Testbed

USING THE SHEBA FLUX DATA TO IMPROVE REGIONAL AND GLOBAL CLIMATE MODELS

Peter Guest, Research Associate Professor
Department of Meteorology
Sponsor: National Science Foundation

OBJECTIVE: This was a collaborative effort to use the atmospheric surface layer data collected during the Surface Heat Budget of the Arctic field program to develop ice-atmosphere exchange algorithms for local, regional, and global ice-atmosphere models of the Arctic.

SUMMARY: This continued an analysis of data collected during a field program that was performed from September 1997 to September 1998. The data set obtained represented the most comprehensive information on surface-layer properties ever obtained in the central Arctic. The project involved analysis of factors affecting the surface heat and momentum fluxes, including snow drifting, melting of the ice surface, radiation and cloud effects, and the effects of nearby leads. These results were incorporated into various models that simulated Arctic air-ice-sea interactions and their effects on regional and global climate.

PUBLICATIONS:

Andreas, E.L., Fairall, C.W., Persson, P.O.G., and Guest, P.S., "Probability Distributions for the Inner Scale and the Refractive Index Structure Parameter and Their Implications for Flux Averaging," *Journal of Applied Meteorology*, 42, 2003, 1316-1329.

Andreas, E.L., Fairall, C.W., Persson, P.O.G., and Guest, P.S., "Probability Distributions for the Inner Scale and the Refractive Index Structure Parameter and Their Implications for Flux Averaging," Cold Regions Research and Engineering Laboratory, *ERDC/CRREL TR-03-24*, 2003, 55 pages.

Grachev, A.A., Fairall, C.W., Persson, P.O.G., Andreas, E.L., and Guest, P.S., "Stable Boundary-Layer Scaling: The SHEBA Data," *Boundary-Layer Meteorology*, 2004, (in press).

CONFERENCE PRESENTATIONS:

Andreas, E.L., Fairall, C.W., Grachev, A.A., Guest, P.S., Horst, T.W., Jordan, R.E., et al., "Turbulent Transfer Coefficients and Roughness Lengths Over Sea Ice: The SHEBA Results," *Seventh Conference on Polar Meteorology and Oceanography and Joint Symposium on High-Latitude Climate Variations*, American Meteorological Society, Hyannis, MA, 12-16 May 2003.

Grachev, A.A., Fairall, C.W., Persson, P.O.G., Andreas, E.L., and Guest, P. S., "Turbulence Decay in the Stable Arctic Boundary Layer," *Seventh Conference on Polar Meteorology and Oceanography and Joint Symposium on High-Latitude Climate Variations,* American Meteorological Society, Hyannis, MA, 12-16 May 2003.

Guest, P.S., Andreas, E.L., Fairall, C.W., Grachev, A.A., Jordan, R.E., and Persson, P.O.G., "Modeling Surface Interactions in the Arctic Ocean: Accuracy vs. Computational Cost," *Seventh Conference on Polar Meteorology and Oceanography and Joint Symposium on High-Latitude Climate Variations,* American Meteorological Society, Hyannis, MA, 12-16 May 2003.

Jordan, R.E., Andreas, E.L., Fairall, C.W., Grachev, A.A., Guest, P.S., and Persson, P.O.G., "Modeling Surface Exchange and Heat Transfer for the Shallow Snow Cover at SHEBA," *Seventh Conference on Polar Meteorology and Oceanography of the American Meteorological Society and Joint Symposium on High-Latitude Climate Variations*, American Meteorological Society, Hyannis, MA, 12-16 May 2003.

Persson, P.O.G., Andreas, E.L., Fairall, C.W., Grachev, A.A., Guest, P.S., and Perovich, D.K., "Pack Ice Surface Energy Changes at SHEBA Initiated by Late Summer Synoptic Forcing," *Seventh Conference on Polar Meteorology and Oceanography and Joint Symposium on High-Latitude Climate Variations*, American Meteorological Society, Hyannis, MA, 12-16 May 2003.

DoD KEY TECHNOLOGY AREAS: Other (Meteorology)

KEYWORDS: Polar Meteorology, Air-Sea-Ice Interactions, Surface Fluxes

OBJECTIVE AND AUTOMATED ASSESSMENT OF OPERATIONAL GLOBAL FORECAST MODEL PREDICTIONS OF TROPICAL CYCLONE FORMATION AND LIFE CYCLE
Patrick A. Harr, Associate Professor
Department of Meteorology
Sponsor: National Oceanic and Atmospheric Administration

SUMMARY: The objective of this project was to transition an operational product to the National Hurricane Center that will extend the utility of operational global model forecasts of tropical cyclone formation.

KEYWORDS: National Hurricane Center, Global Model Forecast, Weather

NOWCAST FOR THE NEXT GENERATION NAVY
John McCarthy, Research Professor
Department of Meteorology
Sponsor: Naval Research Laboratory

OBJECTIVE: The broad objective of this research was to continue guidance and advocacy for the NOWCAST program, to provide senior leadership for Naval Research Laboratory (NRL) technology efforts, and to foster more collaboration between NRL Monterey and the Naval Postgraduate School.

DoD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Mesoscale Forecasting, COAMPS, TAMS-RT

DEVELOPMENT AND VALIDATION OF A PREDICTIVE MODEL TO ASSESS THE IMPACT OF COASTAL OPERATIONS ON URBAN SCALE AIR QUALITY
Douglas K. Miller, Associate Research Professor
Department of Meteorology
Sponsor: Strategic Environmental Research and Development Program

SUMMARY: Routinely generated mesoscale analyses and forecasts for the southern California region to be used as input for an atmospheric dispersion model at the Desert Research Institute. This model will be used to provide guidance and reduce the impact of Department of Defense (DoD) operations on urban scale air quality.

KEYWORDS: Mesoscale Analysis, Forecast, Southern California, Atmospheric Dispersion, Desert Research Institute, Air Quality

METEOROLOGY

DISTANCE LEARNING SUPPORT
Tom Murphree, Senior Lecturer
Department of Meteorology
Sponsors: Chief, Naval Education and Training, Distributed Learning Resource Center, Naval Postgraduate School

OBJECTIVE: The objective of this project was to develop an online course that enables military personnel to more effectively use meteorological and oceanographic information to improve the planning, conduct, and assessment of military operations.

SUMMARY: The development of this course, *Meteorology, Oceanography, and Military Operations* (MR2230), was completed in 2003. The first course offering is planned for 2004. In this course, students will develop: (1) a conceptual understanding of the major concepts of meteorology and oceanography and their application to the wide range of environments in which the military operates; and (2) a basic ability to use meteorology and oceanography (METOC) concepts, analyses, and forecasts to assess the impacts of atmospheric and oceanic variations on military operations. The course examines basic patterns and processes of the atmosphere and ocean, and their effects on the planning and conduct of military operations. The course topics include: METOC and military planning; wind, waves, and ship operations; coastal processes and amphibious operations; clouds, visibility, and aviation operations; electromagnetic radiation and tactical warfare; forecasting; and special operations. Special emphasis is placed on understanding the atmospheric and oceanic environment in regions of military significance. Case studies from military history are used extensively. Major METOC technologies and products that aid in planning and conducting military operations are introduced.

COURSE MATERIALS:

Martin, B., Murphree, T., and Hinz, J., "Assessing and Managing METOC Risks in RHIB Operations," Revised training module prepared for Naval Postgraduate School (NPS) online course, MR2230, and for Department Head Program of Surface Warfare Officers School, 125 pages.

Murphree, T., "Meteorology, Oceanography, and Military Operations, MR2230," course materials for a new NPS online course, 2003. Publicly accessible pages for this course are available online: http://online.nps.navy.mil/vu_cc/MR2230.htm. Course materials are also available online: http://nps.blackboard.com/.

DoD KEY TECHNOLOGY AREAS: Environmental Effects, Environmental Processes, Environmental Monitoring, Environmental Modeling

KEYWORDS: Distributed Learning, Education, Online Education, Training, Meteorology, Oceanography, Military Operations, Environmental Effects

GLOBAL OCEAN ECOSYSTEMS DYNAMICS (GLOBEC) - NORTHEAST PACIFIC CLIMATE CHANGE MECHANISMS
Tom Murphree, Senior Lecturer
Department of Meteorology
Sponsor: National Oceanic and Atmospheric Administration

OBJECTIVE: This project analyzed long term weather and climate variations in the North Pacific – North American atmosphere and ocean, and the mechanisms that produce these variations. This work supports the development of medium and long-range weather and climate forecasts.

SUMMARY: This project was part of the U.S. Global Ocean Ecosystems Dynamics (GLOBEC) research program, funded by the National Science Foundation and the National Oceanic and Atmospheric Administration (NOAA). These projects were conducted in collaboration with researchers in the Department of Oceanography at the Naval Postgraduate School (NPS) and at the Pacific Fisheries Environmental Laboratory

(PFEL) of NOAA in Pacific Grove, California. The goal was to improve the analysis and modeling of intraseasonal to decadal variations of the atmosphere and ocean in the North Pacific – North American (NPNA) region. Work emphasized the identification and modeling of the mechanisms that govern these variations (e.g., teleconnections form remote regions and their impacts on wind stress curl (WSC) and coastal ocean circulation). This research involved dynamical analyses of observed, analyzed, and modeled atmospheric and oceanic fields. During 2003, the focus of this research was" 1) dynamical analyses of intraseasonal to decadal variations of WSC and WSC-forced changes in upper ocean structure and circulation; 2) simulation of these variations in ocean circulation models; 3) identification of dynamic similarities in climate change processes operating on intraseasonal to decadal scales; and 4) identification of atmospheric and oceanic mechanisms that link the California and Alaska current systems, and that link the northeast Pacific to the northwest Atlantic.

PUBLICATIONS:

Murphree, T., Bograd, S., Schwing, F., and Ford, B., "Large Scale Atmosphere-Ocean Anomalies in the Northeast Pacific During 2002 and Their Impacts on the California Current System," *Geophysical Research Letters*, 30, 8026-8029, 2003.

Murphree, T., Ford, B., Schwing, F., and Bograd, S., "Dynamic Similarity in North Pacific – North American Climate Variations: Characteristic Relationships and Mechanisms," 2003, (in preparation).

Murphree, T., Green-Jessen, P., Schwing, F., and Bograd, S., "The Seasonal Cycle of Wind Stress Curl and its Relationship to Subsurface Ocean Temperature in the Northeast Pacific," *Geophysical Research Letters*, 30, 1469-1472, 2003.

CONFERENCE PRESENTATIONS:

Murphree, T., Ford, B., Schwing, F., Bograd, S., and Mendelssohn, R., "Dynamic Similarity in Large Scale Climate Variations of the Northeast Pacific and Northwest Atlantic," Ocean Sciences Meeting, American Geophysical Union, Portland, OR, January 2004.

Murphree, T., Ford, B., Tokmakian, R., Schwing, F., Bograd, S., and Green, P., "The Role of Wind Stress Curl in Coastal Climate Variations of the Northeast Pacific," Pacific Climate Workshop, American Geophysical Union, Pacific Grove, CA, March 2004.

DoD KEY TECHNOLOGY AREAS: Environmental Effects, Environmental Modeling, Environmental Monitoring, Environmental Processes, Modeling and Simulation

KEYWORDS: Atmospheric and Oceanic Variations, Climate Variations, Smart Climatology, California Current System, Alaska Current System, El Niño, GLOBEC, La Niña, Long Term Weather, North Pacific, Ocean Modeling, Medium and Long-Range Forecasting, Teleconnections, Weather and Climate System

DEVELOPMENT OF MARINE FORECASTER TRAINING MATERIALS
Wendell A. Nuss, Associate Professor
Department of Meteorology
Sponsor: National Weather Service

OBJECTIVE: The objective of this project was to develop training materials and conduct a workshop for marine forecasters in the National Weather Service (NWS). Web-based training materials were provided for use by the NWS.

SUMMARY: An annual Marine Forecaster Training Workshop was conducted in May 2003 for around 20 NWS forecasters. In addition, an outline of the content for a web-based training module on marine winds was developed in collaboration with Brad Colman at the NWS Seattle Forecast Office. Production of the content and images for the module has begun.

DEVELOPMENT OF MESOSCALE TRAINING MATERIALS
Wendell A. Nuss, Associate Professor
Department of Meteorology
Sponsor: Commander, Naval Meteorology and Oceanography Command

OBJECTIVE: The objective of this project was to develop web-based training modules on mesoscale meteorology for use by the U.S. Navy. This work was conducted in collaboration with the Cooperative Operational Meteorological Education and Training (COMET) program.

SUMMARY: This is an ongoing project. During 2003, content was developed for a module on Coastal Jets and Dust Forecasting. The Principal Investigator (PI) also contributed content for modules on Mountain Waves and Mesoscale Precipitation Bands. In addition to the content development, the PI reviewed modules during the production process. The materials developed for this project during past years were used to conduct a three and one-half day training workshop in January 2004 in Yokosuka, Japan, for Navy and Air Force weather forecasters.

CONFERENCE PUBLICATION:

Schreiber-Abshire, W., Bol, A.J., Wesley, D., Sigafoose, M., Nuss, W.A., and Miles, C.B., "The COMET Program and the U.S. DoD: A Model Partnership in Meteorology Education," *Preprints of the 13th Symposium on Education*, Seattle, WA, 11-15 January 2004.

KEYWORDS: Web-Based Training, Mesoscale Meteorology, COMET Coastal Jets, Dust Forecasting, Mountain Waves, Mesoscale Precipitation, Yokosuka, Japan

FIRE WEATHER FORECASTING
Wendell A. Nuss, Associate Professor
Department of Meteorology
Sponsor: U.S. Army Corps of Engineers

OBJECTIVE: The objective of this research was to examine the historical record to assess the conditions under which controlled burns could be conducted at Fort Ord to allow ordnance removal. In addition to this characterization, operational weather forecasts during the burn season were made in direct support of this effort.

SUMMARY: The Fort Ord wind profiler data from 1994 through 2003 was used to characterize the winds and mixing height in order to find the number of days that would meet suggested burn criteria. The synoptic weather patterns associated with appropriate burn days were assessed. The ability of the models to predict these conditions was also assessed. Results showed that forecast false alarm rates of as much as 90% occur with three day forecast ranges. The forecast skill improved only slightly at shorter ranges, leading to a high potential for missed forecasts. Using the results from the historical study as well as other local weather knowledge, operational forecasts of burn conditions were made from August through early November. Favorable conditions were identified on October 24 and a controlled burn was conducted on that day (which subsequently expanded beyond the controlled area).

PRESENTATIONS:

Nuss, W.A., "Boundary Layer Mixing Height Forecasting at Ft. Ord, California," Battlespace Atmospherics and Cloud Impacts on Military Operations Conference, Monterey, CA, 9-11 September 2003.

TECHNICAL REPORT:

Nuss, W.A., "Report on Historical Meteorological Conditions in Support of Prescribed Burning at Ft. Ord," Naval Postgraduate School Technical Report, February 2003.

THESIS DIRECTED:

Gahard, C.F., "An Estimation of the Ability to Forecast Boundary Layer Mixing Height and Wind Parameters through Forecast Verification Over Fort Ord," Master's Thesis, Naval Postgraduate School, September 2003.

KEYWORDS: Controlled Burn, Fort Ord, Fire Weather Prediction

HIGH RESOLUTION FIRE WEATHER MODELING
Wendell A. Nuss, Associate Professor
Douglas K. Miller, Associate Research Professor
Department of Meteorology
Sponsors: U.S. Department of Agriculture, U.S. Forest Service

OBJECTIVE: The objective of this research was to develop high-resolution numerical-model forecasting to support fire weather and smoke modeling. Local mesoscale observations were assimilated into the model and assessed to improve model accuracy.

SUMMARY: During 2003, research was focused on accuracy assessment using the local mesoscale observations. The observations were routinely collected and used to calculate differences with the 12km MM5 model forecasts. This has defined locations where large differences occur between the model and the observations. In many cases, the observations seemed to be problematic and so changes to their relative weighting in the data assimilation were made to improve analysis accuracy. Model fields were provided to several fire weather users to develop products useful to fire weather forecasting.

PUBLICATION:

Gallaher, S.G., Miller, D.K., and Ludwig, F.L., "An Efficient Prognostic/Diagnostic Hybrid Model for Improving the Resolution of Forecast Winds in Complex Coastal Topography," California and Nevada Smoke Advisory Council (CANSAC), (submitted).

PRESENTATION:

Nuss, W.A. and Miller, D.K., "2003: Mesonet Observations and Applications in the Central California Region," U.S. Weather Research Program (USWRP) Mesoscale Observing Networks Workshop, Boulder, CO, 8-10 December 2003.

OTHER:

D. Miller served on the Technical Advisory Group for the California and Nevada Smoke Advisory Council (CANSAC). One manuscript was submitted: "An Efficient Prognostic/Diagnostic Hybrid Model for Improving the Resolution of Forecast Winds in Complex Coastal Topography," (S.G Gallaher, D.K. Miller, and F.L. Ludwig).

KEYWORDS: High-Resolution Numerical-Model Forecasting, Fire Weather Prediction, Smoke Modeling

METEOROLOGY

PRACTICAL LIMITS TO MESOSCALE ATMOSPHERIC PREDICTABILITY

Wendell A. Nuss, Associate Professor
Douglas K. Miller, Associate Research Professor
Department of Meteorology
Sponsor: Office of Naval Research

OBJECTIVE: The objective of this research was to define the mesoscale predictability limits and their dependence on the synoptic scale uncertainty in a variety of weather situations. Specifically, the mesoscale prediction sensitivities were quantified for a broad spectrum of flow situations.

SUMMARY: In 2003, this ongoing project examined the predictability of summertime coastal weather patterns using the MM5 model forecasts for the California region. Time-lagged model forecasts were used to construct simple mesoscale ensembles from which predictability error growth could be assessed. This was done for the summer of 2002. Because of the 12-hour run cycle for the MM5 model, ensembles could only be constructed out through 12 hours. These showed only minimal error growth. However, an examination of the structure of mesoscale forecast spread showed that features such as the coastal jet and thermally driven sea breeze/mountain-valley circulations have a high degree of uncertainty. While these features are climatologically persistent, their intensity and position can vary considerably, which indicates a surprisingly low predictability in the mesoscale structure of these features. In addition to this examination of the California weather patterns, the sensitivity of ocean waves forecasts to mesoscale wind forcing along the Gulf Stream was also examined. The results showed that the wave model captured the correct wave field if proper wind forcing was used. However, mesoscale wind forecasts off by as little as 10 degrees in direction could lead to poor wave forecasts due to the impact on the relative fetch differences. These results suggest that very accurate wind forecasts are needed in the fetch-limited, highly interactive wave growth associated with North Wall events.

PUBLICATIONS:

Miller, D.K., Nuss, W.A., and Cross, P.S., "Model-simulated Sensitivity of the Low-level Coastal Jet Structure to Surface Properties," (in preparation).

Nuss, W.A., Miller, D.K., and Kuypers, M.A., "Effects of Boundary Conditions and Initial Synoptic-scale Error on Mesoscale Error Growth," (in preparation).

CONFERENCE PUBLICATIONS:

Cross, P.S., Miller, D.K., and Nuss, W.A., "The Effect of Flow Over Coastal Topography on the Character of Low-Level Offshore Wind Maxima Along the California Coast in Summer," *Preprints of the 5th Conference on Coastal Oceanic and Atmospheric Prediction and Processes*, Seattle, WA, 5-8 August 2003.

Miller, D.K., Nuss, W.A., and Cross, P.S., "Sensitivity of Coastal Jet Structure to Coastal Topography," *Preprints of the 5th Conference on Coastal Oceanic and Atmospheric Prediction and Processes*, Seattle, WA, 5-8 August 2003.

Okon, J.A. and Nuss, W.A., "Mesoscale Forcing of Ocean Waves During Gulf Stream North Wall Events," *Preprints of 12th Conference on Interactions of the Sea and Atmosphere*, Long Beach, CA, 9-13 February 2003.

PRESENTATION:

Nuss, W.A., "Initial and Lateral Boundary Condition Impacts on Mesoscale Predictability," Mesoscale Ensemble Forecasting Workshop, Naval Research Laboratory, Monterey, CA, 14-15 July 2003, (invited).

THESES DIRECTED:

Beattie, J.C., "A Numerical Investigation of Mesoscale Predictability," Master's Thesis, Naval Postgraduate School, March 2003.

Okon, J.A., "Mesoscale Forcing of Ocean Waves During Gulf Stream North Wall Events," Master's Thesis, Naval Postgraduate School, March 2003.

KEYWORDS: Mesoscale Predictability, Synoptic Scale Uncertainty MM5, California, Gulf Stream

CBLAST MEASUREMENTS OF MARINE ATMOSPHERIC BOUNDARY LAYERS
Qing Wang, Associate Professor
Department of Meteorology
Sponsor: Office of Naval Research

OBJECTIVE: The objective of this project was to quantify the boundary layer characteristics from an island. These data are critical in the evaluation of the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) forecast and development of the new parameterizations.

SUMMARY: Ground-based measurements were conducted at the Nantucket site from 20 July to 30 August, as part of CBLAST-Low 2003 field experiment efforts. The measurements included rawinsonde measurement 2-4 times daily; continuous SODAR (sonic detection and ranging) measurements of boundary layer height and vertical profiles of turbulence variances; *in situ* high-rate sampling for turbulence fluxes at two levels and mean wind, temperature, and relative humidity at three levels on a 20-m mast; cloud base height from a laser ceilometer; and solar and IR radiation, pressure, wind speed, temperature, and humidity from a meteorological package.

DoD KEY TECHNOLOGY AREA: Environmental Quality

KEYWORDS: Surface Flux, Boundary Layer Measurements

IMPLEMENTING AND TESTING ENTRAINMENT PARAMETERIZATION FOR STRATOCUMULUS-TOPPED BOUNDARY LAYERS IN COUPLED OCEAN/ATMOSPHERE MESOSCALE PREDICTION SYSTEM (COAMPS)
Qing Wang, Associate Professor
Department of Meteorology
Sponsor: Office of Naval Research

OBJECTIVE: The objective of this project was to improve the predictions for the stratocumulus-topped boundary layers as well as the cloud-free boundary layers from mesoscale models.

SUMMARY: Work in fiscal year 2003 focused on understanding the capability of current Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) in simulating boundary layer roll structure and stratocumulus-topped boundary layers and the coding to incorporate entrainment parameterization into COAMPS. Observations from past experiments, the Japan/East Sea experiment (JES), the Development and Evolution of Coastal Stratocumulus (DECS), and Dynamics and Chemistry of the Marine Stratocumulus (DYCOMS-II) were used for this purpose. The approach was to perform COAMPS simulations on selected cases with sufficient observations to quantify the marine boundary layer and surface characteristics. This enabled researchers to compare multiple aspects of the boundary layer and near-surface properties between the model outputs and the observations in order to clearly identify the model inadequacy. The model sensitivity to a variety of boundary layer parameters was also tested in order to better understand the model physics. Under this project, work was performed on the fine structure of the cloud top in relation to entrainment using aircraft measurements. A mechanism with which the layered structure above the cloud top can form was proposed and verified from this analysis. In addition, systematic

evaluation was made of the COAMPS simulated boundary layer height observed value. A new method to identify the boundary layer height was developed from this work.

PUBLICATIONS:

Khelif, D., Friehe, C.A., Jonsson, H., Wang, Q., and Rados, K., "Wintertime Boundary-Layer Structure and Air-Sea Interaction Over the Japan/East Sea," *Deep Sea Research*, 2003, (accepted).

Wang, Q., Rados, K., Kalogiros, J.A., Wang, S., Khelif, D., and Friehe, C., "Evaluating Surface Flux and Boundary Layer Parameterizations in a Mesoscale Model Using Aircraft Measurements," *Monthly Weather Review*, 2004, (in preparation).

DoD KEY TECHNOLOGY AREA: Environmental Quality

KEYWORDS: Stratocumulus-topped Boundary Layer, Entrainment, Aircraft Measurements

IMPROVING SURFACE FLUX PARAMETERIZATION IN THE NAVY'S COAMPS
Qing Wang, Associate Professor
Department of Meteorology
Sponsors: Office of Naval Research, Naval Research Laboratory

OBJECTIVE: The objective of this project was to improve surface flux parameterizations, particularly in low-wind conditions.

SUMMARY: Traditionally, the boundary layer turbulence processes in mesoscale models have been parameterized based on the ensemble mean averaging. In this framework, the dominating scale in the parameterization was the large-eddy size, which did not depend on the grid spacing used in the models. When the grid size is close to the boundary layer height or less, which means that the models should be able to resolve part of large eddy processes, the parameterized eddy scale should be a function of grid spacing. This issue was addressed from two aspects: observational turbulence spectra analysis and development of a new generalized grid spacing dependent turbulence parameterization. The new subgrid turbulence length scale was a weighted average of the ensemble mean closure scale and grid spacing. The Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) simulations using two length scale parameterizations resulted in significantly different findings, both in the turbulence power spectrum and in the details of the resolved boundary layer convective circulation.

CONFERENCE PUBLICATION:

Wang, Q., Whisenhant, M.K., Wang, S., and Doyle, J., "Scale-Dependent Turbulence Mixing for High-Resolution Mesoscale Models," *7th Annual GMU Conference on Transport and Dispersion Modeling*, George Mason University, Fairfax, VA, 17-19 June 2003.

THESIS DIRECTED:

Whisenhant, M.K., "Boundary Layer Parameterization in High-resolution Mesoscale Models," Ph.D. Thesis, Naval Postgraduate School, 2003.

DoD KEY TECHNOLOGY AREA: Environmental Quality

KEYWORDS: Surface Flux Parameterization, Mesoscale Modeling

UNDERSTANDING THE EVOLUTION OF STRATOCUMULUS CLOUDS IN THE COASTAL REGION

Qing Wang, Associate Professor
Department of Meteorology
Sponsor: National Science Foundation

OBJECTIVE: The objective of this project was to examine the physical processes affecting the evolution of coastal stratocumulus clouds.

SUMMARY: During the first year of this project (1999), field measurements of the coastal stratocumulus and the associated boundary layer were made off the coast of Monterey using the Center for Remotely-Piloted Aircraft Studies (CIRPAS) Twin Otter research aircraft. In 2001, additional efforts were made in calibrating the wind/turbulence measurements by considering the effects of flow distortion. This effort resulted in a new understanding of aircraft measured turbulence in general. Fully calibrated high-rate turbulence data is now available to collaborating research groups.

Efforts were made to study the interaction between the evolution of stratocumulus cloud and the coastal flow field. The effects of the coastal jet on the evolution of stratocumulus clouds were studied through analyses on the case observed on 6 July. The variation of the cloud layer along a vertical crosssection due west from Monterey Bay was analyzed. It was found that the strong low-level coastal jet promoted the cloud decoupling from the surface layer and the cloud start thinning quickly.

Under this project, researchers also worked on the fine structure of the cloud top in relation to entrainment using aircraft measurements. A mechanism with which the layered structure above the cloud top can form was proposed and verified from this analysis.

Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) simulations were performed for cases observed during this experiment and the model cloudy boundary layer was compared with that measured from the Twin Otter aircraft. The model runs assisted in understanding the observed boundary layer evolution, and in turn, the measured boundary layer characteristics helped in understanding the model weakness in simulating the cloudy boundary layers. A new method to identify the boundary layer height was developed from this work.

PUBLICATIONS:

Kalogiros, J.A. and Wang, Q., "Observations of Stratocumulus Entrainment in the Coastal Zone," *JAS,* 2004, (in preparation).

Wang, Q. and de Roode, S., "Layered Structure and Cloud Top Entrainment in Stratocumulus-Topped Boundary Layers," *JAS*, 2004, (in preparation).

Wang, Q. and Wang, S., "Turbulent and Thermodynamic Structure of the Autumnal Arctic Boundary Layer Due to Embedded Clouds," *Boundary Layer Meteorology*, 2003, (accepted).

DoD KEY TECHNOLOGY AREA: Environmental Quality

KEYWORDS: Coastal Clouds, Boundary Layer Evolution, Aircraft Turbulence Measurement

UNDERSTANDING NEAR-SURFACE AND IN-CLOUD TURBULENT FLUXES IN THE COASTAL STRATOCUMULUS-TOPPED BOUNDARY LAYERS

Qing Wang, Associate Professor
Department of Meteorology
Sponsor: Office of Naval Research

OBJECTIVE: The objectives of this project were threefold: to produce high-rate turbulence, temperature, and specific humidity data and processed surface fluxes from raw aircraft measurements; to understand the spatial and temporal variability of the surface fluxes in the coastal California region; and to use the results to understand and evaluate Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) for

simulating the STBL in conjunction with the Principal Investigator's existing Office of Naval Research project.

KEYWORDS: High-Rate Turbulence, Processed Surface Flux, Raw Aircraft Measurement, California, Coupled Ocean/Atmosphere Mesoscale Prediction System, COAMPS Project

COLLABORATIVE RESEARCH PROJECTS IN DIRECT SUPPORT OF FLEET NUMERICAL METEOROLOGY AND OCEANOGRAPHY CENTER (FNMOC) OPERATIONAL
Carlyle H. Wash, Professor
Department of Meteorology
Sponsor: Office of Naval Research

SUMMARY: The objective of this research was to execute collaborative thesis research projects with the Fleet Numerical Meteorology and Oceanography Center (FNMOC) and other CNMOC regional centers. The collaboration involved Naval Postgraduate School (NPS) Department of Meteorology faculty, NPS students conducting thesis research, and FNMOC personnel. The collaboration projects addressed FNMOC's operational needs and advanced the understanding of marine meteorology.

KEYWORDS: Fleet Numerical Meteorology and Oceanography Center, FNMOC, CNMOC Marine Meteorology

METEOROLOGY AND OCEANOGRAPHY (METOC) THESIS SUPPORT FOR OPERATIONALLY FOCUSED TOPICS
Carlyle H. Wash, Professor
Department of Meteorology
Sponsor: Space and Naval Warfare Systems Command

SUMMARY: The broad objective of this research was to conduct Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) evaluation and verification studies and to support other Naval Postgraduate School (NPS) Meteorology and Oceanography (METOC) theses on Fleet Numerical Meteorology and Oceanography Center (FNMOC) and regional METOC Center problems.

KEYWORDS: Coupled Ocean/Atmosphere Mesoscale Prediction System, COAMPS, METOC, Fleet Numerical Meteorology and Oceanography Center, FNMOC

BOUNDARY LAYER EFFECTS ON ATMOSPHERIC FRONTS
Roger T. Williams, Professor
Department of Meteorology
Sponsor: National Science Foundation

OBJECTIVE: To improve the simulation of boundary layer effects on fronts in coastal regions.

KEYWORDS: Mesoscale Simulation, Topography, Fronts, Coastal Effects

DEPARTMENT OF METEOROLOGY

2003
Faculty Publications
and Presentations

METEOROLOGY

JOURNAL PUBLICATIONS

Andreas, T.L., Fairall, C.W., Persson, P.O.G. and Guest, P.S., "Probability Distributions for the Inner Scale and the Refractive Index Structure Parameter and Their Implications for Flux Averaging," *Journal of Applied Meteorology*, 42, pp. 1316-1329, 2003.

Chang, C.-P., Liu, C.H. and Kuo, H.C., "Typhoon Vamei: An Equatorial Tropical Cyclone Formation," *Geophysical Research Letters,* 30, 50, pp. 1-4, 2003.

Chen, J.M., Chang, C.-P., and Li, T., "Annual Cycle of the South China Sea Surface Temperature Using the NCEP/NCAR Reanalysis," *Journal of the Meteorological Society of Japan*, 81, pp. 879-884, 2003.

Krahmann, G., Visbeck, M., Smethie, W., D'Asaro, E.A., Rhines, P.B., Clarke, R.A., et al., "The Labrador Sea Deep Convection Experiment Data Collection," *Geochemistry, Geophysics, and Geosystems*, 4, (10), 1091, doi:10.1029/2003GC000536, 2003.

Li, T.B., Wang, Q., Chang, C.-P., and Zhang, Y., "A Theory for the Indian Ocean Dipole Mode," *Journal of Atmospheric Science*, 60, pp. 2119–2135, 2003.

Murphree, T., Bograd, S., Schwing, F., and Ford, B., "Large Scale Atmosphere-Ocean Anomalies in the Northeast Pacific During 2002," *Geophysical Research Letters*, 30, pp. 8026-8029, 2003.

Murphree, T., Green-Jessen, P., Schwing, F., and Bograd, S., "The Seasonal Cycle of Wind Stress Curl and its Relationship to Subsurface Ocean Temperature in the Northeast Pacific," *Geophysical Research Letters*, 30, pp. 1469-1472, 2003.

Sullivan, D., Zande, J., Butcher, S., Murphree, T., and Ford, B., "Using Marine Technology to Teach Ocean Literacy and Workplace Competencies," *Current: The Journal of Marine Education*, 19, 3, pp. 20-26, 2003.

CONFERENCE PUBLICATIONS

Andreas, E.L., Fairall, C.W., Grachev, A.A., Guest, P.S., Horst, T.W., Jordan, R.E., et al., "Turbulent Transfer Coefficients and Roughness Lengths Over Sea Ice: The SHEBA Results," *Seventh Conference on Polar Meteorology and Oceanography and Joint Symposium on High-Latitude Climate Variations*, American Meteorological Society, Hyannis, MA, 12-16 May 2003.

Cantu, R., Wash, C., and Murphree, T., "The Role of Weather in Naval Aviation Mishaps," *Proceedings of Battlespace Atmospheric and Cloud Impacts on Military Operations (BACIMO) Conference*, Monterey, CA, September 2003.

Cross, P.S., Miller, D.K., and Nuss, W.A., "The Effect of Flow Over Coastal Topography on the Character of Low-Level Offshore Wind Maxima Along the California Coast in Summer," *Preprints of the 5th Conference on Coastal Oceanic and Atmospheric Prediction and Processes*, Seattle, WA, 5-8 August 2003.

Grachev, A.A., Fairall, C.W., Persson, P.O.G., Andreas, E.L., and Guest, P.S., "Turbulence Decay in the Stable Arctic Boundary Layer," *Seventh Conference on Polar Meteorology and Oceanography and Joint Symposium on High-Latitude Climate Variations,* American Meteorological Society, Hyannis, MA, 12-16 May 2003.

Guest, P.S., Andreas, E.L., Fairall, C.W., Grachev, A.A., Jordan, R.E., and Persson, P.O.G., "Modeling Surface Interactions in the Arctic Ocean: Accuracy vs. Computational Cost," *Seventh Conference on Polar Meteorology and Oceanography and Joint Symposium on High-Latitude Climate Variations,* American Meteorological Society, Hyannis, MA, 12-16 May 2003.

Jordan, R.E., Andreas, E.L., Fairall, C.W., Grachev, A.A., Guest, P.S., and Persson, P.O.G., "Modeling Surface Exchange and Heat Transfer for the Shallow Snow Cover at SHEBA," *Seventh Conference on Polar Meteorology and Oceanography of the American Meteorological Society and Joint Symposium on High-Latitude Climate Variations*, American Meteorological Society, Hyannis, MA, 12-16 May 2003.

Jordan, M.S. and Durkee, P.A., "Marine Boundary Layer Cloud-top Altitude Analysis from Satellite Measurements," *Proceedings of the Battlespace Atmospheric and Cloud Impacts on Military Operations (BACIMO) Conference*, Monterey, CA, 9-11 September 2003.

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

Miller, D.K., Nuss, W.A., and Cross, P.S., "Sensitivity of Coastal Jet Structure to Coastal Topography," *Preprints of the 5th Conference on Coastal Oceanic and Atmospheric Prediction and Processes*, Seattle, WA, 5-8 August 2003.

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

Persson, P.O.G., Andreas, E.L., Fairall, C.W., Grachev, A.A., Guest, P.S., and Perovich, D.K., "Pack Ice Surface Energy Changes at SHEBA Initiated by Late Summer Synoptic Forcing," *Seventh Conference on Polar Meteorology and Oceanography and Joint Symposium on High-Latitude Climate Variations*, American Meteorological Society, Hyannis, MA, 12-16 May 2003.

Sullivan, D., Ford, B., and Murphree, T., "Are We Adequately Preparing Students for Ocean Occupations?," *Proceedings of Marine Technology Society Oceans 2003 Marine Technology and Ocean Science Conference*, San Diego, CA, September 2003.

Wang, Q., Whisenhant, M.K., Wang, S., and Doyle, J., "2003: Scale-Dependent Turbulence Mixing for High-Resolution Mesoscale Models," *7th Annual George Mason University Conference on Transport and Dispersion Modeling*, George Mason University, Fairfax, VA, 17-19 June 2003.

CONFERENCE PRESENTATIONS

Cantu, R., Wash, C., and Murphree, T., "The Role of Weather in Naval Aviation Mishaps," Battlespace Atmospheric and Cloud Impacts on Military Operations (BACIMO) Conference, Monterey, CA, September 2003.

Chang, C.-P., "East Asia Monsoon. Distinguished Meteorological Lecture, Commemoration of 120th Anniversary of the Hong Kong Observatory," Hong Kong Science Museum, Hong Kong, China, 19 October 2003, (invited).

Chang, C.-P., "Typhoon Vamei, An Equatorial Tropical Cyclone Formation," Naval Weather Center, Tam-Shui, Taiwan, 18 March 2003, (invited).

Chang, C.-P., "Typhoon Vamei, An Equatorial Tropical Cyclone Formation," Hong Kong Observatory, Hong Kong, China, 20 October 2003, (invited).

Chang, C.-P., "Typhoon Vamei, An Equatorial Tropical Cyclone Formation," National Central University, Chung-Li, Taiwan, 28 October 2003, (invited).

Jordan, M.S. and Durkee, P.A., "Marine Boundary Layer Cloud-top Altitude Analysis from Satellite Measurements," Battlespace Atmospheric and Cloud Impacts on Military Operations (BACIMO) Conference, Monterey, CA, 9-11 September 2003.

Martin, B., Murphree, T., and Wash, C., "Meteorology, Oceanography, and Naval Afloat Operations: Risk Management, Safety, and Readiness," Battlespace Atmospheric and Cloud Impacts on Military Operations (BACIMO) Conference, Monterey, CA, September 2003.

Murphree, T., "Meteorological Metrics-Measuring Meteorological Products and their Operational Impacts," Seminar, Department of Meteorology, Naval Postgraduate School, December 2003.

Murphree, T. and Hinz, J., "METOC Metrics-Measuring and Modeling Operational Products and Impacts," Seminar, Fleet Numerical Meteorology and Oceanography Center, Monterey, CA, December 2003, (invited).

Murphree, T. and Martin, B., "METOC Aspects of Naval Afloat ORM: Application of a System for METOC Impacts Assessments," Brief to Chief of Staff, Oceanographer of the Navy, Washington, D.C., January 2003, (invited).

Murphree, T., Martin, B., Cantu, R., Wash, C., and Hinz, J., "Systems for Analyzing METOC Impacts on Military Operations," Battlespace Atmospheric and Cloud Impacts on Military Operations (BACIMO) Conference, Monterey, CA, September 2003.

Murphree, T., Wash, C., Hinz, J., Vodola, P., and Simms, D., "Developing and Applying METOC Metrics for Sea Strike Operations," Rapid Transition Program Workshop, Space and Naval Warfare Systems Command (SPAWAR), San Diego, CA, November 2003.

Nuss, W.A., "Boundary Layer Mixing Height Forecasting at Ft. Ord, California," Battlespace Atmospherics and Cloud Impacts on Military Operations (BACIMO) Conference, Monterey, CA, 9-11 September 2003.

Nuss, W.A., "Initial and Lateral Boundary Condition Impacts on Mesoscale Predictability," Mesoscale Ensemble Forecasting Workshop, Naval Research Laboratory, Monterey, CA, 14-15 July 2003, (invited).

Nuss, W.A. and Miller, D.K., "2003: Mesonet Observations and Applications in the Central California Region," U.S. Weather Research Program (USWRP) Mesoscale Observing Networks Workshop, Boulder, CO, 8-10 December 2003.

Sullivan, D., Ford, B., and Murphree, T., "Are We Adequately Preparing Students for Ocean Occupations?," Oceans 2003 Marine Technology and Ocean Science Conference, Marine Technology Society, San Diego, CA, September 2003.

Sullivan, D., Zande, J., Ford, B., and Murphree, T., "A Strategy for Improving Marine Technical Education," Offshore Technology Conference, Houston, TX, May 2003.

Wang, Z., Wang, B., and Chang, C.-P., "Great Plain Summer Rainfall Variability: U.S. CLIVAR," Pan American Workshop, Boulder, CO, 16-18 September 2003.

TECHNICAL REPORT

Andreas, E.L., Fairall, C.W., Persson, P.O.G., Guest, P. S., "Probability Distributions for the Inner Scale and the Refractive Index Structure Parameter and their Implications for Flux Averaging," Cold Regions Research and Engineering Laboratory, *ERDC/CRREL TR-03-24*, 55 pages, 2003.

DEPARTMENT OF OCEANOGRAPHY

MARY L. BATTEEN
CHAIR

OCEANOGRAPHY

OVERVIEW:

The Department of Oceanography has developed a broad research program focused on physical oceanography to meet the anticipated future needs of the Navy. Our basic research themes are the development of scientific capabilities to measure, analyze, and forecast fields of littoral ocean variables, which occur in association with synoptic/mesoscale processes over limited regional temporal domains. The areas of emphasis include coastal and nearshore ocean dynamics, air-sea interaction phenomena and boundary currents. Regions of interest include the polar seas, coastal ocean regions and strategic straits of the world.

Our applied research themes are the application of analyses and forecasts of upper ocean synoptic/mesoscale variability to Naval operations. Areas of emphasis include the impact of littoral processes, eddies and boundary currents on ocean surveillance systems, the effect of storms on acoustic propagation and ambient noise, and the impact that the wave climate exerts on nearshore processes and beach character as it pertains to mine/mine countermeasure and amphibious warfare.

These research themes require the development of numerical ocean prediction models and synoptic observation capabilities. They are achieved through employment of modern dynamical and mathematical principles, numerical and statistical methods, computational and graphical facilities, and in-site and remote sensing observations.

CURRICULA SERVED:

- Meteorology and Oceanography
- Operational Oceanography
- Oceanography
- Undersea Warfare
- Space Systems Operations
- Space Systems Engineering

DEGREES GRANTED:

- Master of Science in Meteorology and Physical Oceanography
- Master of Science in Physical Oceanography
- Doctor of Philosophy in Physical Oceanography

RESEARCH THRUSTS:

- Acoustical Oceanography:
  Ching-Sang Chiu, Robert Bourke, Arthur Parsons
- Air-Sea Interaction and Ocean Turbulence:
  Roland Garwood, Tim Stanton, Peter Chu, Le Ly
- Coastal and Nearshore Oceanography:
  Jeff Paduan, Mary Batteen, Ed Thornton, Thomas Herbers, Edith Gallagher, Pierre Poulain, Curt Collins, Steven R. Ramp, Leslie K. Rosenfeld
- Numerical Prediction and Data Assimilation:
  Mary Batteen, Bert Semtner, Julie McClean, Robin Tokmakian, Ramsey Harcourt, Wieslaw Maslowski, Pierre Poulain, Arlene Guest, Le Ly
- GI&S and Navigation:
  James Clynch, Arthur Parsons
- Polar Oceanography:
  Wieslaw Maslowski, Yuxia Zhang, Robert Bourke, Roland Garwood, Ramsey Harcourt

RESEARCH FACILITIES:

- Research Vessel Point Sur
- Rapid Environmental Assessment Laboratory
- Ocean Acoustic Observatory at Point Sur
- Computer Graphics Laboratory
- Moored Equipment Laboratory
- Calibration Laboratory
- Tactical Environmental Support Laboratory

RESEARCH CHAIR:

- Office of Naval Research Chair in Arctic Marine Science

RESEARCH PROGRAM (Research and Academic)-FY2003:

The Naval Postgraduate School's sponsored program exceeded $71 million in FY2003. Sponsored programs included both research and educational activities funded from an external source. A profile of the sponsored program for the Department of Oceanography is provided below:
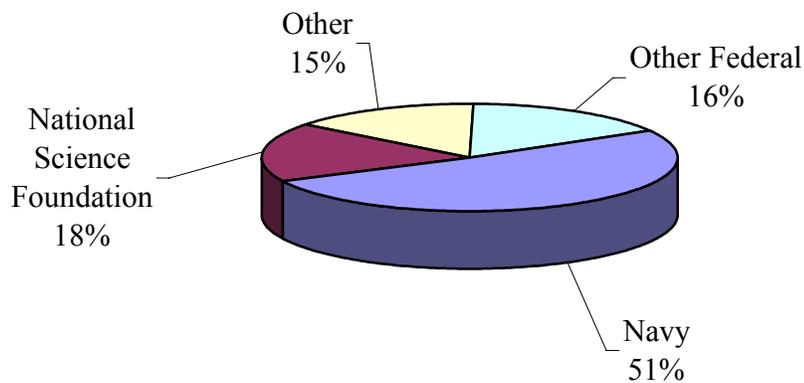
Size of Program: $3,847K

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OCEANOGRAPHY

OFFICE OF NAVAL RESEARCH CHAIR IN ARCTIC MARINE SCIENCE
Mary L. Batteen, Associate Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: The Chief of Naval Research has established a chair in Arctic Marine Science at the Naval Postgraduate School. The objectives of the chair are to foster oceanographic research in the Arctic, acquaint Naval officer students with Arctic problems, reduce results of pure research to operational usage, and publicize Navy interest in the Arctic.

SUMMARY: Professors Batteen and Bourke served as administrators of the chair, handling such details as soliciting chair candidates, writing IPAs and proposals, and setting up visits and seminars for the chair incumbent.

Professor Max Coon, a senior research scientist from Northwest Research Associates, Inc., in Seattle, Washington, served as chairman during FY03. While at NPS, he continued his groundbreaking research related to frazil ice production in the marginal sea ice zones of Arctic waters. He worked directly with the Naval Ice Center to incorporate his modeling efforts and their remotely sensed data into the Navy's operational ice forecasting model.

KEYWORDS: Arctic Ocean, Frazil Ice, Ice Forecasting Model

COUPLED OCEAN ACOUSTICS AND PHYSICAL OCEANOGRAPHY OBSERVATIONS IN THE SOUTH CHINA SEA: THE NAVAL POSTGRADUATE SCHOOL (NPS) ACOUSTIC COMPONENT
Ching-Sang Chiu, Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: This effort is part of a large, international program called the Asian Sea International Acoustic Experiment (ASIAEX). In collaboration and coordination with other U.S. and Asia investigators participating in ASIAEX, this research involved comprehensive measurements and analysis of the different oceanographic factors affecting low frequency (< 600 Hz) acoustic propagation in a shelfbreak region in the Northeastern South China Sea (SCS). Specifically, the Naval Postgraduate School (NPS) acoustic research objectives were twofold. One, to understand the physics, variability and predictability of low-frequency sound pulse propagation along and across the NE SCS shelfbreak, including the dependence on frequency, source/receiver depth and path orientation, and the relations to water-column, bathymetric and sub-bottom structures. Acoustic variables studied included intensity, travel time, and temporal and spatial coherences. Empirical and theoretical relations to the environmental changes were derived and compared to investigate predictability and establish statistical variances. A second research objective was to expand the acoustic knowledge acquired from previous shelf-slope experiments, including shelfbreak PRIMER and SWARM, with added emphasis on the horizontal properties of the sound field. Due to source and receiver limitations, both Shelfbreak PRIMER and SWARM were limited to the study of the vertical properties of sound propagation at two narrow frequency bands, 210-235 Hz and 350-450 Hz. The combined ASIAEX assets permit extended investigation into the horizontal properties as well as acoustic transmissions covering the entire low-frequency band from 50 to 600 Hz.

SUMMARY: The simultaneous, high-resolution observations of the acoustic propagation characteristics and water column properties were accomplished by a combination of moored and shipboard observations in May of 2001. The processing and analysis of the acoustic data set, in conjunction with the oceanographic data, was underway with the goal of understanding the influences of inherent ocean variability on acoustic propagation, coherence, and predictability. Work completed in 2003 included:

1. Studied the impact of a strong ocean current on the signal-processing (pulse-compression) gain, and devised a Doppler-compensation algorithm to minimize the degradation.

2. Completed pulse-compression processing of all phase-modulated acoustic signals transmitted by the moored sources and received by the WHOI/ Naval Postgraduate School (NPS) L-shaped hydrophone array for the entire three-week transmission experiment. The L-shaped hydrophone array was moored on the continental shelf that monitored a variety of signals transmitted parallel to and across the shelfbreak by both moored and towed sources.

3. Formulated an *a priori* model for the geoacoustic parameters based on the chirp-sonar images obtained by Shock (2003), and extracted the frequency-modulated (FM) signals transmitted from a towed J15 source on three separate days, May 5, 16 and 17, containing minimal internal wave activities. This work is in preparation for a geoacoustic inversion for the sediment properties. The inferred sediment properties will then be used to investigate the role of the bottom in its contribution to the observed signal intensity fluctuations in FY04.

4. Documented data-analysis and modeling results in manuscripts submitted to the IEEE Journal of Oceanic Engineering. These results are on the space-time structure of the observed sound-speed variability, which was dominated by "transbasin" and local internal tides and by "transbasin" nonlinear internal waves generated remotely in Luzon Strait via shallow ridges-tidal current interactions during spring and neap tides, and on the observed changes in the acoustic signal intensity and coherences due to this volume variability.

PUBLICATIONS:

Chiu, C.-S., Ramp, S.R., Miller, C.W., Lynch, J.F., Duda, T.F., and Tang, T.-Y., "Acoustic intensity fluctuations induced by South China Sea internal tides and Solitons," *IEEE Journal of Oceanic Engineering*, (accepted).

Duda, T.F., Lynch, J.F., Irish, J.D., Beardsley, R.C., Ramp, S.R., Chiu, C.-S., et al., "Internal tide and nonlinear internal wave behavior at the continental slope in the northern South China Sea," *IEEE Journal of Oceanic Engineering*, (accepted).

Duda, T.F., Lynch, J.F., Wu, L., and Chiu, C.-S., "Fluctuation of 400 Hz sound intensity in the 2001 ASIAEX South China Sea experiment," *IEEE Journal of Oceanic Engineering*, (accepted).

Ramp, S.R., Lynch, J.F., Dahl, P.H., Chiu, C.-S., and Simmen, J.A., "ASIAEX fosters advances in shallow-water acoustics," *EOS, Transactions, AGU*, 84(37), pp. 361 and 367, 2003.

Ramp, S.R., Tang, T.-Y., Duda, T.F., Lynch, J.F., Liu, A.K., Chiu, C.-S., et al., "Internal solitons in the northeastern South China Sea Part I: Sources and deep water propagation," *IEEE Journal of Oceanic Engineering*, (accepted with revision).

PRESENTATIONS:

Chiu, C.-S., "Acoustics plan for SCS 2005," Office of Naval Research, Research Planning Meeting on the Luzon Straits/Northeastern South China Sea Region," San Francisco, CA, 10 December 2003.

Chiu, C.-S., "ASIAEX SCS acoustics: Cross-shelf results," Commander, Naval Meteorology and Oceanography Command/Office of Naval Research/Naval Oceanographic Office/Naval Research Laboratory Meeting on ASIAEX Findings, Stennis Space Flight Center, MS, 20 May 2003.

Chiu, C.-S., "A discussion of current status and future directions in low-frequency, shallow-water acoustics," Office of Naval Research Shallow-Water Acoustics Workshop, Seattle, WA, 23-24 September 2003.

Chiu, C.-S., Ramp, S., Miller, C., Lynch, J., Duda, T., Newhall, A., et al., "Measurement and analysis of acoustic intensity fluctuations induced by South China Sea internal solitons," 2003 ASIAEX Analysis Workshop, Taipei and Hua-Lien, Taiwan, 3-7 March 2003.

Ramp, S.R., Chiu, C.-S., Miller, C., Kim, H.-R., Bahr, F., Tang, T.-Y., et al., "Tracking the generation sites and packet variability of internal solitons in the South China Sea," 2003 ASIAEX Analysis Workshop, Taipei and Hua-Lien, Taiwan, 3-7 March 2003.

TECHNICAL REPORT:

Chen, C.-F., Tang, T.-Y., Wei, R.-C., Too, G.-P., Yang, Y.-J., Ramp, et al., "Proceedings, The Asian Seas International Acoustics Experiment (ASIAEX) Analysis Workshop, Taipei, Taiwan, March 3-7, 2003," National Taiwan University Technical Report, UAL-NTU TR 0303, April 2003.

KEYWORDS: Littoral, Acoustics, Shelfbreak

DETERMINATION OF THE DETECTION AND CLASSIFICATION PROBABILITIES AND RANGE LIMITS OF INEXPENSIVE ACOUSTIC SENSORS AND DATA PROCESSING TECHNIQUES FOR MONITORING ODONTOCNETI WHALES
Ching-Sang Chiu, Professor
Curtis A. Collins, Professor
Christopher W. Miller, Research Assistant Professor
Department of Oceanography
Sponsor: Chief of Naval Operations (N45)

OBJECTIVE: To evaluate and predict the performance of inexpensive passive systems for monitoring vocalizing Odontoceti whales using conditional statistical measures. These performance measures included detection and classification probabilities and range limit against false-alarm rate. The sonar devices included freely drifting sonobuoys and fixed, bottom-lying hydrophones, as individual sensors and in array configurations.

SUMMARY: The approach was to analyze the statistics of the detector output as a function of signal-to-noise ratio (SNR), or source level and distance, and signal type in controlled, playback experiments under contrasting environmental conditions. The analyzed performance data will also be used to validate and refine a predictive model. The study was focused on signals in the 1-to-8 kHz frequency band. This is in part due to the limitation of the sound source and in part due to the consideration that seawater absorption naturally low-passes sound energy.

A representative set of Odontoceti signals was collected and a playback experiment was conducted using mid-water hydrophones at the San Clemente Island Undersea Range (SCIUR) ship self radiated noise measurement array in July 2002. The dependence of the performance statistics of an energy detector and correlation detector/classifier on signal characteristics, number of sonobuoys, geometry, SNR, range and environmental conditions was analyzed for three of the signals by a Naval Postgraduate School student for his thesis. A second experiment was planned for August 2003 using the SCORE bottom-mounted hydrophones.

Additional tasks were added in 2003. A data collection system was built for use at the SCORE range. Also under investigation was the availability of archived Navy data that would document ambient noise in the ocean over five or six decades. Finally, a California State University, Fresno, Master's degree program student completed analysis of the frequency of blue whale calls using data from the Pt. Sur SOSUS (sound-surveillance system) array.

PUBLICATION:

Chiu, C. S., Miller, C.W., Moore, T.C., and Collins, C.A., "Detection and censusing of blue whale vocalizations along the central California Coast using a decommissioned SOSUS receiver," *U.S. Navy Journal of Underwater Acoustics*, 2003.

PRESENTATION:

Kumar, A., "Estimation of abundance of blue whale calls off Central California using a seafloor-mounted hydrophone," Society for Marine Mammalogy, Greensboro, NC, 14-19 December 2003.

THESES DIRECTED:

Daziens, J., "Assessing the Performance of Omni-directional Receivers for Passive Acoustic Detection of Vocalizing Odontocetes," Master's Thesis, Naval Postgraduate School, June 2004.

Kumar, A., "Estimation of Abundance of Blue Whale Calls Off Central California Using a Seafloor-mounted Hydrophone," Master's Thesis, California State University, Fresno, December 2003.

KEYWORDS: Odontocetes, Underwater Acoustics, Sonobuoys, Hydrophones

UNCERTAINTIES AND INTERDISCIPLINARY TRANSFERS THROUGH THE END-TO-END SYSTEM (UNITES)
Ching-Sang Chiu, Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: This effort is part of a multi-institutional team effort, which started in the second half of 2001, to capture uncertainty in the common tactical picture. The team's name is UNITES, which stands for Uncertainties and Interdisciplinary Transfers through the End-to-End System. Led by Abbot, OASIS, Inc., and Robinson, Harvard University, the UNITES team, with expertise spanning the ocean environment, underwater acoustics and tactical sonar systems, consists of a total of twelve principal investigators from nine different organizations including the NPS, Woods Hole Oceanographic Institution and University of North Carolina.

The NPS component in the UNITES team's paradigm to solve the interdisciplinary, end-to-end problem has two objectives:

- To characterize acoustic prediction uncertainties, including their connections to the uncertainties in the ocean and geo-acoustic parameter estimates.
- To forecast and improve acoustic baselines and their uncertainties in a data-assimilation framework involving coupled ocean and acoustic state variables.

SUMMARY: In acoustic wavefield uncertainty characterization, NPS continued to focus on the tidal and shorter-scale uncertainties in FY03 with the following accomplishments:

1. Analyzed the dependence of TL fluctuation statistics on signal bandwidth using both Shelfbreak PRIMER and Asian Sea International Acoustic Experiment (ASIAEX) (SCS) data.
2. Performed model simulation of ASIAEX TL fluctuation statistics, compared modeled statistics to measured statistics, and began studying uncertainty in the mean TL prediction.

In acoustic field uncertainty reduction and forecast, NPS continued to focus on the small mesoscale uncertainties. Significant work completed in FY03 in this topic includes:

1. Combined Shelfbreak PRIMER SeaSoar and moored data in a data assimilation framework to upgrade daily sound speed profile and TL estimates.
2. Examined the sensitivity of the TL estimate to the resolution of the sound speed estimate.

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PUBLICATIONS:

Gawarkiewicz, G., Bahr, F., Brink, K., Caruso, M., Lynch, J., and Chiu, C.-S., "A large-amplitude meander of the shelfbreak front south of New England – Observations from the Shelfbreak PRIMER experiment," *Journal of Geophysical Research,* 2003, (submitted).

Lynch, J.F., Newhall, A.E., Sperry, B., Gawarkiewicz, G., Fredricks, A., Tyack, P., et al., "Spatial and temporal variations in acoustic propagation characteristics at the New England shelfbreak front," *IEEE Journal of Oceanic Engineering*, 28 (1), pp. 129-150, 2003.

Sperry, B.J., Lynch, J.F., Gawarkiewicz, G., Chiu, C.-S., and Newhall, A., "Characteristics of acoustic propagation to the eastern vertical line array receiver during the summer 1996 New England shelfbreak PRIMER experiment," *IEEE Journal of Oceanic Engineering*, 28(4), pp. 729- 749, 2003.

PRESENTATION:

Chiu, C.-S., "TL uncertainty characterization and reduction," Office of Naval Research (ONR) Uncertainty DRI Review and Planning Meeting, Providence, RI, 17-19 June 2003.

KEYWORDS: Environmental Uncertainties, Acoustic Uncertainties, Sonar Performance

ASSESSMENT AND RECONSTRUCT OF NAVY'S MINE IMPACT BURIAL PREDICTION MODEL

Peter C. Chu, Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVES: To assess the current Navy Impact Burial Prediction Model (IBPM), and reconstruct of IBPM using the advanced hydrodynamic theory. Both efforts were closely connected to the field experiment at Corpus Christi, Texas-Louisiana, shelf sponsored by Office of Naval Research (ONR) IBPM program. This effort provided guidance for field experiments such as site selection, determination of variables to be measured (e.g., ocean and sediment conditions as well as mine burial depth). In addition, data collected from the field experiments will be used to verify the reconstructed IBPM in a more realistic environmental scenario.

SUMMARY: During the performance period, work included analysis of data collected from Naval Postgraduate School (NPS) and Naval Research Laboratory (NRL) mine drop experiments with various sizes, improvement of the Navy's mine impact burial prediction model (IMPACT28) with realistic physics, and evaluation of the new model using the analyzed observational data.

PUBLICATIONS:

Chu, P.C. and Fan, C.W., 2003: Three-dimensional rigid body impact burial model. *Advances in Fluid Mechanics*, 6, (in press).

Chu, P.C., Fan, C.W., Evans, A.D., and Gilles, A., Triple coordinate transforms for prediction of falling cylinder through the water column. *Journal of Applied Mechanics*, 2003, (in press).

Chu, P.C., Ivanov, L.M., and Margolina, T.M., Rotation method for reconstructing process and field from imperfect data. *International Journal of Bifurcation and Chaos*, 2003, (in press).

Chu, P.C., Perry, M.D., Gottshall, E.L., and Cwalina, D.S., Satellite data assimilation for improvement of Naval undersea capability. *Marine Technology Society Journal*, (in press).

CONFERENCE PUBLICATIONS:

Chu, P.C., C.W. Fan, A. Evans, A. Gilles, and P. Fleischer, Three-dimensional hydrodynamic model for prediction of falling cylinder through water column. *The OCEANS 2003 MTS/IEEE Conference Proceedings*, San Diego, CA, 22-26 September 2003, [DVD-ROM].

Chu, P.C., M. Perry, E.L. Gottshall, and D. Cwalina, Satellite data assimilation for undersea warfare. *The OCEANS 2003 MTS/IEEE Conference Proceedings*, San Diego, CA, 22-26 September 2003, [DVD-ROM].

PRESENTATIONS:

(a) Invited

Chu, P.C., Mine impact burial modeling. Office of Naval Research Impact Burial Modeling Workshop, St. Petersburg, FL, 28-30 January 2003.

(b) Contributed

Chu, P.C., C.W. Fan, A. Evans, and A. Gilles, Three dimensional hydrodynamic model for falling cylinder through the water column. OCEANS2003, Marine Technology Society, San Diego, CA, 22-26 September 2003.

Chu, P.C., E. Gottshall, and M. Perry, Satellite remote-sensed altimetry data for improvement of Naval undersea capability. OCEANS2003, Marine Technology Society, San Diego, CA, 22-26 September 2003.

THESIS DIRECTED:

Perry, M.D., "Value Aided Satellite Altimetry Data for Weapon Presets," Master's Thesis, Naval Postgraduate School, June 2003.

KEYWORDS: Mine Drop, Mine Impact, IMPACT28

LITTORAL ZONE OCEANOGRAPHY FOR MINE WARFARE
Peter C. Chu, Professor
Department of Oceanography
Institute for Joint Warfare Analysis
Sponsor: Naval Oceanographic Office

OBJECTIVES: To improve the current Navy Impact Burial Prediction Model (IBPM) and Mine Acoustic Detection Model (CASS-GRAB) using the advanced hydrodynamic theory and littoral zone oceanography. The efforts are closely connected to the field experiment at Corpus Christi, Texas-Louisiana, shelf sponsored by Office of Naval Research (ONR) IBPM program. This effort provides guidance for field experiments such as site selection, determination of variables to be measured (e.g., ocean and sediment conditions as well as mine burial depth). On the other hand, data collected from the field experiments will be used to verify the reconstructed IBPM in a more realistic environmental scenario.

SUMMARY: During the performance period, Peter Chu improved the U.S. Navy's mine acoustic detection model and mine burial prediction models using realistic marginal sea ocean models and data. He published 17 refereed journal papers, 5 conference proceeding papers, presented 23 papers (5 invited papers) at national and international conferences. He also directed three thesis students.

PUBLICATIONS:

(a) Journal Articles

Chu, P.C. 2003: Multifractal thermal characteristics of the Southwestern GIN Sea upper layer. *Chaos, Solitons and Fractals*, 19 (2), 275-284.

Chu, P.C. and C.W. Fan, 2003: A finite volume ocean model with a temporally varying crystal grid. *Journal of Oceanography*, in press.

Chu, P.C. and C.W. Fan, 2003: Hydrostatic correction for reducing horizontal pressure gradient errors in sigma coordinate models. *Journal of Geophysical Research*, Vol. 108, No. C6, 3206, 10.1029/2002JC001668.

Chu, P.C. and C.W. Fan, 2003: Three-dimensional rigid body impact burial model. *Advances in Fluid Mechanics*, 6, in press.

Chu, P.C., C.W. Fan, A.D. Evans, and A. Gilles, 2003: Triple coordinate transforms for prediction of falling cylinder through the water column. *Journal of Applied Mechanics*, in press.

Chu, P.C. and C.L. Fang, 2003: Observed Rossby waves in the South China Sea from satellite altimetry data. *SPIE – The International Society for Optical Engineering*, Vol. 5233, 142-149.

Chu, P.C. and J. Lan, 2003: Extremely strong thermohaline source/sinks generated by diagnostic initilization. *Geophysical Research Letters*, Vol. 30, No. 6, 10.1029/2002GL016525, 29 March 2003.

Chu, P.C., L.M. Ivanov, L.H. Kantha, T.M. Margolina, O.M. Melnichenko, and Y.A, Poberenzhny, 2003: Lagrangian predictability of high-resolution regional ocean models. *Nonlinear Processes in Geophysics*, in press.

Chu, P.C., L.M. Ivanov, T.P. Korzhova, T.M. Margolina, and O.M. Melnichenko, 2003: Analysis of sparse and noisy ocean current data using flow decomposition. Part 1: Theory. *Journal of Atmospheric and Oceanic Technology*, 20 (4), 478-491.

Chu, P.C., L.M. Ivanov, T.P. Korzhova, T.M. Margolina, and O.M. Melnichenko, 2003: Analysis of sparse and noisy ocean current data using flow decomposition. Part 2: Application to Eulerian and Lagrangian data. *Journal of Atmospheric and Oceanic Technology*, 20 (4), 492-512.

Chu, P.C., L.M. Ivanov, and T.M. Margolina, 2003: Rotation method for reconstructing process and field from imperfect data. *International Journal of Bifurcation and Chaos*, in press.

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

Chu, P.C., M.D. Perry, E.L. Gottshall, and D.S. Cwalina, 2003: Satellite data assimilation for improvement of Naval undersea capability. *Marine Technology Society Journal*, in press.

Chu, P.C., Y.Q. Qi, Y.C. Chen, P. Shi, and Q.W. Mao, 2003: Validation of Wavewatch-III using the TOPEX/POSEIDON data. *SPIE – The International Society for Optical Engineering*, Vol. 5233, 98-107.

Chu, P.C. and G.H. Wang, 2003: Seasonal variability of thermohaline front in the central South China Sea. *Journal of Oceanology*, 59, 65-78.

Chu, P.C., J. Wang, Y.Q. Qi, Y.C. Chen, P. Shi, and Q. Mao, 2003: Determination of the South China Sea surface height variability using TOPEX/POSEIDON data. *SPIE – The International Society for Optical Engineering*, Vol. 5233, 169-178.

Wang, G.H., J.-L. Su, and P.C. Chu, 2003: Mesoscale eddies in the South China Sea observed with altimeter data. *Geophysical Research Letters*, 30 (21), doi: 10.1029/2003GL018532.

(b) Proceedings

Chu, P.C., C.W. Fan, A. Evans, A. Gilles, and P. Fleischer, Three-dimensional hydrodynamic model for prediction of falling cylinder through water column. *OCEANS 2003 MTS/IEEE Conference Proceedings*, San Diego, CA, 22-26 September 2003, [DVD-ROM].

Chu, P.C. and C.L. Fang, Observed Rossby waves in the South China Sea from satellite altimetry data. *Proceedings of SPIE Conference on Remote Sensing of the Ocean and Sea Ice*, Barcelona, Spain, 8-12 September 2003, [DVD ROM].

Chu, P.C., M. Perry, E.L. Gottshall, and D. Cwalina, Satellite data assimilation for undersea warfare. *The OCEANS 2003 MTS/IEEE Conference Proceedings*, San Diego, CA, 22-26 September 2003, [DVD-ROM].

Chu, P.C., Y.Q. Qi, Y.C. Chen, P. Shi, and Q.W. Mao, Validation of Wavewatch-III using the TOPEX/POSEIDON data. *Proceedings of SPIE Conference on Remote Sensing of the Ocean and Sea Ice*, Barcelona, Spain, 8-12 September 2003, [DVD-ROM].

Chu, P.C., J. Wang, Y.Q. Qi, Y.C. Chen, P. Shi, and Q. Mao, Determination of the South China Sea surface height variability using TOPEX/POSEIDON data. *Proceedings of SPIE Conference on Remote Sensing of the Ocean and Sea Ice*, Barcelona, Spain, 8-12 September 2003, [DVD ROM].

PRESENTATIONS:

(a) Invited

Chu, P.C., Mine impact burial modeling. Office of Naval Research Impact Burial Modeling Workshop, St. Petersburg, FL, 28-30 January 2003.

Chu, P.C., Second baroclinic equatorial Kelvin waves and two types of El Nino onset. International Workshop on Upper Ocean Circulation and Air-Sea Interaction, Tallahassee, FL, 27-29 April 2003.

Chu, P.C., South China Sea circulation and thermohaline structure. 23rd General Assembly of the International Union of Geodesy and Geophysics, Sapporo, Japan, 30 June-11 July 2003.

Chu, P.C. and S.H. Lu, Second kind predictability in climate models. International Symposium on Clean Environment, Cheonan, Korea, 21-22 November 2003.

Chu, P.C., J.L. Sun, and Q.Y. Liu, High baroclinic equatorial Kelvin waves, central Pacific warming, and El Nino onset. 23rd General Assembly of the International Union of Geodesy and Geophysics, Sapporo, Japan, 30 June-11 July 2003.

(b) Contributed

Chu, P.C., Multifractal thermal characteristics and nonlinear dynamics of the Southwestern GIN Sea upper layer. American Geophysical Union Fall Meeting, San Francisco, CA, 8-12 December 2003.

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

Chu, P.C. and C.W. Fan, Conservative schemes for terrain-following ocean models. Fifth Conference on Coastal Meteorology and Oceanography, American Meteorological Society, Seattle WA, 7-9 August 2003.

Chu, P.C. and C.W. Fan, Hydrostatic correction for terrain-following ocean models. International Terrain-Following Ocean Models Workshop, PMEL/NOAA, Seattle WA, 4-6 August 2003.

Chu, P.C. and C.W. Fan, A terrain-following finite volume ocean model. Eighth International Conference on Estuarine and Coastal Modeling (ECM8), Monterey, CA, 3-5 November 2003.

Chu, P.C., C.W. Fan, A. Evans, and A. Gilles, Three dimensional hydrodynamic model for falling cylinder through the water column. OCEANS2003, Marine Technology Society, San Diego, CA, 22-26 September 2003.

Chu, P.C. and C.L. Fang, Observed Rossby waves in the South China Sea from satellite altimetry data. SPIE 10th International Symposium on Remote Sensing, Barcelona, Spain, 8-12 September 2003.

Chu, P.C., E. Gottshall, and M. Perry, Satellite Remote-sensed altimetry data for improvement of Naval undersea capability. OCEANS2003, Marine Technology Society, San Diego, CA, 22-26 September 2003.

Chu, P.C. and L.M. Ivanov, Prediction-skill variability in regional ocean models. International Terrain-Following Ocean Models Workshop, PMEL/NOAA, Seattle, WA, 4-6 August 2003.

Chu, P.C. and L.M. Ivanov, Prediction-skill variability in atmospheric and oceanic models. International Conference on Earth System Modeling, Hamburg, Germany, 15-19 September 2003.

Chu, P.C. and L.M. Ivanov, Regional sea model predictability. Joint European Geophysical Society and American Geophysical Union Meeting, Nice, France, 7-11 April 2003.

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

Chu, P.C., L.M. Ivanov, T.M. Margolina, and O.V. Melnichenko, Flow decomposition for velocity data assimilation. 23rd General Assembly of the International Union of Geodesy and Geophysics, Sapporo, Japan, 30 June-11 July 2003.

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

Chu, P.C., J.L. Sun, and Q.Y. Liu, Effects of high baroclinic equatorial Kelvin waves on ENSO onset. International Conference on Earth System Modeling, Hamburg, Germany, 15-19 September 2003.

Chu, P.C., J.L. Sun, and Q.Y. Liu, Effects of high baroclinic equatorial Kelvin waves on ENSO onset. Joint European Geophysical Society and American Geophysical Union Meeting, Nice, France, 7-11 April 2003.

Chu, P.C., J.L. Sun, and Q.Y. Liu, High baroclinic equatorial Kelvin waves, central Pacific warming, and El Nino onset. 23rd General Assembly of the International Union of Geodesy and Geophysics, Sapporo, Japan, 30 June-11 July 2003.

Chu, P.C., J. Wang, and Y.Q. Qi, South China Sea surface elevation variability determined using TOPEX/POSEIDON data. SPIE 10th International Symposium on Remote Sensing, Barcelona, Spain, 8-12 September 2003.

THESES DIRECTED:

Fang, C.-L., "Predictability of Japan/East Sea (JES) System to Uncertain Initial/Lateral Boundary Conditions and Surface Winds," Master's Thesis, Naval Postgraduate School, September 2003.

Ong, A., "Diagnostic Initialization of Coastal Ocean Models," Master's Thesis, Naval Postgraduate School, March 2003.

Perry, M., "Value-added of Satellite Altimetry Data for Undersea Acoustic Preset," Master's Thesis, Naval Postgraduate School, June 2003.

KEYWORDS: Sea Ocean Models, IBPM, CASS-GRAB

UPGRADE OF THE HYDRODYNAMIC COMPONENT OF THE NAVY'S MINE IMPACT BURIAL PREDICTION MODEL (IMPACT28)
Peter C. Chu, Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: To improve performance of the U.S. Navy's mine impact burial prediction capabilities in littoral regions through updating the Navy's existing mine impact burial models (2D with imperfect physics) such as IMPACT28 to 3D mine impact burial prediction model with full physics (IMPACT35). Development of the Navy's new model (IMPACT35) includes Naval Postgraduate School (NPS) students (U.S. Naval officers) participating as part of their thesis studies, which enhances the Navy's R&D program and well prepares the students with their combat effectiveness.
   The specific objectives of the effort included:
 * Collection and analysis of the data from mine drop experiments for model development and evaluation
 * Development of a new noise filtering method (i.e., the rotation method) to process the data collected from the mine drop experiments
 * Development of the triple coordinate transform scheme for predicting the mine movement in the water column
 * Update of the hydrodynamic part of IMPACT28 (two dimensional with simplified physics) to IMPACT35, a three dimensional full physics model
 * Providing analyzed data from mine drop experiments to the mine impact burial prediction modeling (IBPM) community
 * Delivery of the hydrodynamic part of IMPACT35 to the IBPM community
 * Integration of the NPS mine impact burial prediction model into the Naval Oceanographic Office mine warfare program for operational use

SUMMARY: The approach included data analysis and modeling effort and interrelated objectives identified in the section above to develop a comprehensive three dimensional mine impact burial prediction model, IMPACT35. IMPACT35 was developed from 2D IMPACT28 with new physics and schemes. IMPACT35 keeps all the mine types and their physical parameters as used in IMPACT28, and contains new components of hydrodynamics, new treatments of air-water and water-sediment interfaces. The model contains five types of input: (1) mine types, (2) release medium (air or water), (3) bottom type (profile of shear stress), (4) release kinematics (release angle and rotation rate), and (5) release medium parameters (release altitude, water depth, and water temperature). The output included: temporally varying position and orientation (3D) in the air, water, and sediment phases, the bottom impact angle, and penetration depth. The computer codes were written using Matlab with full 3D visualization capability.
   Since the new model (IMPACT35) contains new physics and treatments, the model evaluation included theoretical and experimental procedures. The theoretical evaluation procedure was conducted through the peer-review process of journal articles. The experimental evaluation procedure was conducted through model-data inter-comparison.
   The structure of the new 3D IBPM model with full physics was constructed from the existing 2D IBPM model with reduced physics (IMPACT28). IMPACT35 has three phases (air, water, and sediment) and two interfaces (air-water, and water-sediment.

The hydrodynamic model was developed and evaluated for the cylindrical mines moving in the water phase using the data collected from the Mine Drop Experiment (MIDEX) conducted at NPS in July 2001 (Chu, et al., 2002).

Triple coordinate transform method was developed and evaluated. This method is the core of the hydrodynamic part of IMPACT35. The theoretical part of the method will be published in the Journal of Applied Mechanics.

The rotation method for noise reduction was developed and tested. The results will be published in the International Journal of Biurfication and Chaos.

> (1) The triple coordinate transform method developed in FY03 has wide application to predict the position and orientation of an object falling through the fluid.
> (2) The rotation method for noise reduction developed in FY03 can be widely used for reconstructing process and field from imperfect data for many disciplines.

TRANSITIONS:

• The results obtained from this project were transferred to the Naval Oceanographic Office, Commander, Mine Warfare Command (COMINEWARCOM), and the Office of Naval Research (ONR) Mine Impact Burial Prediction group such as the mine expert system and mine scour and liquifaction groups.

• The hydrodynamic component of IMPACT35 was transferred to the IBPM community such as to Drs. Alan Brandt and Sarah Rennie at the Applied Physics Laboratory (APL) at the John Hopkins University.

• Hydrodynamic component of IMPACT35 was used for development of the Expert System for Mine Impact Burial at the Applied Physics Laboratory of the John Hopkins University and the Environmental Sciences Department of the University of Virginia.

• The datasets collected from MIDEX (1/15th size), Naval Surface Warfare Center (NSWC) - Carderock Experiment (1/3rd size), and Corps Christi Experiment (full size) will greatly impact on the development of an accurate Mine Impact Burial Prediction Model.

• The data were also used for development of the Mine Scouring and Liquifaction modeling effort at the Scripps Oceanographic Institution (headed by Dr. Scot Jenkins).

PUBLICATIONS:

Chu, P.C., Fan, C.W., Evans, A.D., and Gilles, A., "Triple coordinate transforms for prediction of falling cylinder through the water column," *Journal of Applied Mechanics*, 2003, (in press).

Chu, P.C., Gilles, A.F., Fan, C., and Fleischer, P., "Hydrodynamical characteristics of a falling cylinder in the water column," *Advances in Fluid Mechanics,* Vol. 4, pp. 163-181, M. Rahman, R. Verhoeven, and C.A. Brebbia (Eds.), Southampton, UK: WIT Press, 2002.

Chu, P.C., Ivanov, L.M., and Margolina, T.M., "Rotation method for reconstructing process and field from imperfect data," *International Journal of Bifurcation and Chaos*, 2003, (in press).

CONFERENCE PUBLICATIONS:

Chu, P.C., Fan, C.W., Evans, A.D., Gilles, A., and Fleischer, P., "Three dimensional hydrodynamic model for prediction of falling cylinder through the water column," *Proceedings on IEEE/MTS OCEANS2003 Conference*, 2003, [CD-ROM].

Chu, P.C., Gottshall, E., and Perry, M., "Satellite remote-sensed altimetry data for improvement of Naval undersea capability," *Proceedings on IEEE/MTS OCEANS2003 Conference*, 2003, [CD-ROM].

PRESENTATIONS:

Chu, P.C., Fan, C.W., Evans, A., Gilles, A., and Fleischer, P., "Three dimensional hydrodynamic model for falling cylinder through the water column," IEEE/MTS OCEANS2003, San Diego, CA, 22-26 September 2003.

Chu, P.C., Gottshall, E., and Perry, M., "Satellite remote-sensed altimetry data for improvement of Naval undersea capability," IEEE/MTS OCEANS2003, San Diego, CA, 22-26 September 2003.

THESIS DIRECTED:

Perry, M., "Value Aided Satellite Altimetry Data for Weapon Presets," Master's Thesis, Naval Postgraduate School, June 2003.

KEYWORDS: IMPACT28, IMPACT35, MIDEX

VALUE-ADDED OF ALTIMETRY DATA TO UNDERSEA WARFARE
Peter C. Chu, Professor
Department of Oceanography
Institute for Joint Warfare Analysis
Sponsor: Space and Naval Warfare Command (PMW 155)

OBJECTIVE: The Navy's Modular Ocean Data Assimilation System (MODAS) provides critical input to real-time environmental conditions such as the sound velocity profiles (SVP) with high time and spatial fidelity. An important building block of MODAS is the real-time satellite altimetry. The superiority of MODAS products versus climatological data (i.e., the Navy's Generalized Digital Environmental Model (GDEM)) should be first verified before investment on the improvement of satellite altimetry.

SVPs from Mark-48 table group are generally used in undersea warfare operations. Difference of SVPs between MODAS (or GDEM) and Mark-48 table reflects the SVP errors in undersea warfare. If SVP errors are less using MODAS than using GDEM, MODAS is thought to be superior to GDEM, and therefore update of the satellite altimetry becomes necessary for undersea warfare.

SUMMARY: This research was conducted in conjunction with a Naval Postgraduate School student and scientists at the Naval Undersea Warfare Center (NUWC) Keyport, Washington, and involved weapons acoustic preset, development of a statistical package of quantitative measures on MODAS (or GDEM) SVP errors (i.e., deviation from Mark-80 table group SVPs), and skill score and investigation of the statistical characteristics of the MODAS errors in various scenarios.

PUBLICATIONS:

Chu, P.C. and Fang, C.L., "Observed Rossby waves in the South China Sea from satellite altimetry data," *SPIE – The International Society for Optical Engineering*, Vol. 5233, pp.142-149, 2003.

Chu, P.C., Perry, M.D., Gottshall, E.L., and Cwalina, D.S., "Satellite data assimilation for improvement of Naval undersea capability," *Marine Technology Society Journal*, 2003, (in press).

Chu, P.C., Wang, J., Qi, Y.Q., Chen, Y.C., Shi, P., and Mao, Q., "Determination of the South China Sea surface height variability using TOPEX/POSEIDON data," *SPIE – The International Society for Optical Engineering*, Vol. 5233, pp.169-178, 2003.

CONFERENCE PUBLICATION:

Chu, P.C., Perry, M., Gottshall, E.L., and Cwalina, D., "Satellite data assimilation for undersea warfare," *The OCEANS 2003 MTS/IEEE Conference Proceedings*, San Diego, CA, 22-26 September 2003, [DVD-ROM].

PRESENTATIONS:

Chu, P.C. and Fang, C.L., "Observed Rossby waves in the South China Sea from satellite altimetry data," SPIE 10th International Symposium on Remote Sensing, Barcelona, Spain, 8-12 September 2003.

Chu, P.C., Gottshall, E., and Perry, M., "Satellite remote-sensed altimetry data for improvement of Naval undersea capability," OCEANS2003, Marine Technology Society, San Diego, CA, 22-26 September 2003.

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

Chu, P.C., Wang, J., and Qi, Y.Q., "South China Sea surface elevation variability determined using TOPEX/POSEIDON data," SPIE 10th International Symposium on Remote Sensing, Barcelona, Spain, 8-12 September 2003.

THESES DIRECTED:

Mancini, S., "Sensitivity of Satellite Altimetry Data Assimilation on a Naval Anti-Submarine Warfare Weapon System," Master's Thesis, Naval Postgraduate School, September 2004.

Perry, M., "Value Added Satellite Altimetry Data for Weapon Presets," Master's Thesis, Naval Postgraduate School, June 2003.

KEYWORDS: Undersea Warfare, MODAS, Altimetry

GPS ANTARCTIC NAVIGATION APPLICATIONS FISCAL YEAR 2002
James R. Clynch, Research Professor
Department of Oceanography
Sponsor: Space and Naval Warfare Systems Command

SUMMARY: Assisted in the planning and implementation of GPS (Global Positioning System) within U.S. Antarctica program supported by Space and Naval Warfare Systems Command (SPAWAR). Subjects included aircraft landing systems, air-traffic control, navigation-calibration systems, and communications requirement for such systems.

KEYWORDS: GPS, Antarctica, SPAWAR

1999 CENTRAL CALIFORNIA HYDROGRAPHIC SURVEYS
Curtis A. Collins, Professor
Department of Oceanography
Sponsor: San Jose State University Foundation

SUMMARY: Two surveys of central California waters were conducted in 1999. This project provided support for carrying out these surveys, for calibrating CTD (conductivity, temperature, and depth) salinity observations, and for data processing. Results were archived at the U.S. Naval Oceanographic Office.

KEYWORDS: Hydrographic, CTD, Central California, Naval Oceanographic

2001 CENTRAL CALIFORNIA HYDROGRAPHIC SURVEYS
Curtis A. Collins, Professor
Department of Oceanography
Sponsor: Moss Landing Marine Lab

SUMMARY: A survey of central California waters was conducted in November 2002. This project provided support for carrying out these surveys, for calibrating CTD salinity observations, and for data processing. Results were archived at the U.S. Naval Oceanographic Office.

KEYWORDS: Hydrographic, CTD, Central California, Naval Oceanographic

CENTRAL CALIFORNIA HYDROGRAPHIC SURVEYS
Curtis A. Collins, Professor
Department of Oceanography
Sponsors: National Marine Fisheries Service and Scripps Institution of Oceanography,
Naval Oceanographic Office and San Jose State University Foundation

OBJECTIVE: The objective of this project was to collect synoptic oceanographic surveys in Central California waters. The project, sponsored by San Jose State University Foundation, aided the planning, calibration, collection and processing of hydrographic data collected on the *R/V Point Sur* for the Naval Oceanographic Office. The objective of the effort sponsored by Scripps Institution of Oceanography is to continue quarterly cruises along a hydrographic section which lies to the west of Moss Landing.

SUMMARY: The data collection program for the Naval Oceanographic Office ended with a 15-day survey in October 2002. Data from the last survey were analyzed by a Naval Postgraduate School student for her Master's Thesis. Data from the December 1999 survey were used by a second Naval Postgraduate School student as part of his Ph.D. dissertation.

Cruises for National Marine Fisheries Service (NMFS) were carried out on the *Western Flyer* in July 2003 and on *Point Sur* in October 2003.   The NMFS cruises are a collaborative activity with Monterey Bay Aquarium Research Institute and University of California Santa Cruz.

PUBLICATIONS:

Collins, C., Castro, C.G., Pennington, J.T., Rago, T.A., and Chavez, F.P., "The California Current System off Monterey, California: Physical and biological coupling," *Deep-sea Research II*, Vol. 50, pp. 2389-2404.

Collins, C., Ivanov, L.M., Melnichenko, O.V., and Garfield, N., "California undercurrent variability and eddy transport estimated from RAFOS float observations," *Journal of Geophysical Research*, (in press).

PRESENTATION:

Jones, H., Batteen, M.L., Collins, C.A., Nuss, W.A., and Miller, D.K., "Sensitivity of a Navy regional ocean model to high-resolution atmospheric model and scatterometer wind forcing," Fifth Conference on Coastal Atmospheric and Oceanic Prediction and Processes, Seattle, WA, 5-8 August 2003.

THESES DIRECTED:

Jones, H., "Sensitivity of a Navy Regional Ocean Model to High-Resolution Atmospheric Model and Scatterometer Wind Forcing," Ph.D. Dissertation, Naval Postgraduate School, September 2003.

O'Malley, C., "The Fall Transition Off Central California in 2002," Master's Thesis, Naval Postgraduate School, June 2003.

Pickett, M., "Improving Wind-based Upwelling Estimates Off the West Coasts of North and South America," Ph.D. Dissertation, Naval Postgraduate School, December 2003.

KEYWORDS: California Current System, Hydrographic Data, El Niño

OCEANOGRAPHY

COMPARISON OF SWATH AND MONOHULL VESSEL MOTION FOR REGIONAL CLASS RESEARCH VESSELS
Curtis A. Collins, Professor
Department of Oceanography
Sponsor: Office of Naval Research

SUMMARY: To compare the motion of the *R/V Western Flyer*, a swath vessel, to the monohull *R/V Point Sur*. Observations included a variety of sea states, vessel orientations and speeds. Standard observations of winds, sea, and swell that are made by the ship's officers were used to characterize the forcing field. The response of the vessel was measured by means of a tiltmeter and an accelerometer.

KEYWORDS: *Western Flyer*, Swath Vessel, *Point Sur,* R/V, Research Vessel*,* Forcing Field, Response

DETERMINATION OF THE DETECTION/CLASSIFICATION PROBABILITIES/RANGE LIMITS OF INEXPENSIVE ACOUSTIC SENSORS/DATA PROCESSING TECHNIQUES FOR MONITORING ODONTOCETI
Curtis A. Collins, Professor
Department of Oceanography
Sponsor: Chief of Naval Operations, N45

SUMMARY: To quantify the detection and classification probabilities and range limits of inexpensive sensors and data processing techniques on known signals produced by toothed whales or odontoceti in central California's coastal waters in the frequency range of 1.5 to 5 khz. The sensors investigated included sonobuoys, short-aperture suspended vertical and horizontal line arrays, and bottom-mounted arrays.

KEYWORDS: Odontoceti, Whales, Acoustic Sensors

MOORED CURRENT MEASUREMENTS AT THE ENTRANCE TO THE GULF OF CALIFORNIA
Curtis A. Collins, Professor
Department of Oceanography
Sponsor: National Science Foundation

SUMMARY: To resolve the character of the exchanges of mass and heat between the Pacific Ocean and the Gulf of California. Specific scientific objectives included determining the kinematics of the forcing of the Gulf by the Pacific Ocean at both coasts, determining the characteristics of the water masses exchanged between the Pacific and the Gulf of California, and determining if the circulation yields fluxes of heat and salt consistent with current model physics.

KEYWORDS: Gulf of California, Pacific, Kinematics

OCEAN CURRENT AND SEDIMENT TRAP MEASUREMENTS
Curtis A. Collins, Professor
Department of Oceanography
Sponsor: Monterey Bay Aquarium Research Institute

OBJECTIVE: To make long-term measurements of ocean currents and sedimentation rates on the upper slope off Monterey Bay, California.

SUMMARY: This observational program supplemented ongoing measurements of near-surface conditions at a surface mooring at 36-40N, 122-25W. An intermediate mooring, which provides a stable platform for measurements of currents and sedimentation rates, has been moored just outside the watch circle of the surface mooring since February 1998. The mooring was instrumented with current meters at 305 m depth

and 615 meters above the bottom, with an upward looking acoustic Doppler current profiler at 300 m depth, and with sediment traps at 320 m and 600 meters above the bottom. Bottom depth is about 1800 m. The mooring is replaced at twice a year. A Naval Postgraduate School student analyzed the first five years of data for his thesis.

PUBLICATION:

Collins, C., Castro, C.G., Asanuma, H., Rago, T., Han, S.-K., Durazo, R., et al., "Changes in the hydrography of Central California waters associated with the 1997-8 El Niño," *Progress in Oceanography,* 54(1-4), pp. 129-148, 2002.

CONFERENCE PUBLICATION:

Chavez, F.P., Pennington, J.T., Collins, C.A., Paduan, J.D., and Marinovich, B., "Ocean observatory efforts in and around Monterey Bay, California, 1930 to the present," *EOS, Transactions AGU*, 83(47), Fall Meeting Supplement, Abstract OS71F-03, (proceedings not published).

THESIS DIRECTED:

Morales, J.A., "Subtidal Circulation over the Upper Slope to the West of Monterey Bay, California," Master's Thesis, Naval Postgraduate School, September 2003.

KEYWORDS: Ocean Currents, Monterey Bay, Ocean Sediments

UNRESOLVED THERMODYNAMICS OF HIGH-LATITUDE MIXED LAYER SYSTEM
Roland W. Garwood, Jr., Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: To develop and verify algorithms for subgrid thermodynamic processes neglected or treated unrealistically in hydrostatic ocean model codes for air-sea-ice interactions. These processes are related to nonlinearities in the equation of state for seawater, which are greatly augmented in polar seas. A major result expected is a thermodynamically more realistic and numerically more efficient prediction of ice-open water boundaries, polynyas, and coastal and deep-water formation in the polar seas.

SUMMARY: Discoveries (Garwood, 1991) concerning cold-water thermodynamics related to nonlinearities in the equation of state for seawater are greatly augmented wherever the mixed layer temperature approaches freezing. Particularly important is "thermobaricity," the joint dependence of seawater thermal expansion on temperature and pressure. Although thermobaric processes are mostly unresolved in hydrostatic models, these subgrid-scale processes may profoundly influence the global thermohaline conveyor belt and basin circulation initiated by vertical mixing of energy, mass and momentum in the polar seas. Because thermobarically-enhanced entrainment heat flux reduces freezing and increases melting, the overall thermodynamic state of the coupled ice-mixed layer system will be modeled as a vertically-integrated system. New model algorithms for mixing and entrainment were proposed and verified by field observations.

Third-order turbulence closure and LES have guided the development of a realistic coupled mixed layer-ice model. Vertically integrating the enthalpy budget of the coupled ice-mixed layer system leads to a generalized prediction of the dependence of mixed layer stability and ice melting/freezing upon thermobaricity, internal ocean heat, and wind forcing. This generalized enthalpy solution for the vertically-integrated mixed layer-ice system that was hypothesized by Garwood (2002) was first demonstrated by Roth (2003) and is being tested by Swick (2003).

In addition to predicting ice reduction in spite of strong surface cooling, particularly important is the change in system feedback in transitioning from an ice-covered ocean to an ice-free case. As soon as the surface is ice-free, the deepening rate of the mixed layer increases significantly, causing the mixed layer

temperature to rise rapidly. This positive feedback will help ensure the maintenance of an ice-free surface, and it may explain the onset of significant deep water formation.

These first model results demonstrate the realism and potential numerical model efficiency gained by considering the ice and surface mixed layer as a single thermodynamic system. First, the polar ocean mixed layer prediction includes thermobaricity and realistic entrainment. Second, there is no need for a "flux coupler" that passes boundary condition fluxes between ice, ocean and atmosphere models, which are solved on separate spatial and temporal grids.

REFERENCES:

Garwood, R.W., Jr., "Critical mixed layer depth for maintaining convective polynyas," International Polynya Symposium, Quebec City, Canada, September 2001.

Garwood, R.W., Jr., "Enhancements to deep turbulent entrainment," *Deep Convection and Deep Water Formation in the Ocean*, P.C. Chu and J.C. Gascard (Eds.), Elsevier, pp. 189-205, 1991.

Garwood, R.W., Jr., "Thermodynamics critical to arctic mixed layer systems," Small-Scale Sea Ice Ocean Modeling (SIOM) Workshop, Fairbanks, AK, August 2002.

Garwood, R.W., Jr., Isakari, S.M., and Gallacher, P.C., "Thermobaric convection," *The Role of the Polar Oceans in Shaping the Global Environment*, O. Johannessen, R. Muench, and J. Overland (Eds.), Geophysical Monograph 85, pp.199-209, 1994.

THESES DIRECTED:

Roth, M. K., "Effects of Thermobaricity on Coupled Ice-Mixed Layer Thermodynamics," Master's Thesis, Naval Postgraduate School, June 2003.

Swick, W., "Feedback Between Mixed Layer and Ice in the Arctic," Master's Thesis, Naval Postgraduate School, December 2003, (in preparation).

KEYWORDS: Environmental Effects, Ocean Turbulence, Modeling and Simulation

COLLABORATIVE RESEARCH: NEARSHORE CANYON EXPERIMENT
Thomas H. C. Herbers, Professor
Department of Oceanography
Sponsor: National Science Foundation

OBJECTIVE: To understand the effect of complex continental-shelf bathymetry on surface gravity waves and on the breaking-wave-driven circulation onshore of the irregular bathymetry.

SUMMARY: Abrupt shelf bathymetry can cause dramatic alongshore variations in waves, resulting in beaches with large waves located only a few hundred meters away from beaches with small waves. These along-coast changes in wave height and direction can force complicated circulation patterns, including alongshore flows that reverse direction across the surf zone and along the shoreline, and strong offshore-directed rip currents that may be an important mechanism for transport of water, sediment, and pollution between the surf zone and inner shelf.

During September 2003 this project deployed, in collaboration with Scripps Institute of Oceanography and Woods Hole Oceanographic Institute, a large array of wave- and current measuring instruments near two steep submarine canyons offshore of La Jolla, California. This deployment was part of the Nearshore Canyon Experiment (NCEX), funded jointly by the National Science Foundation and the Office of Naval Research. The project's array included 7 surface-following wave buoys, 17 bottom pressure recorders, 12 pressure-velocity sensors, and 7 current profilers in depths ranging from 10-50 m. High quality measurements were collected over a 3-month period including numerous swell arrivals from storms in the Southern and Northern Hemispheres. Preliminary analysis of pilot data collected during the fall of 2002

confirmed the pronounced refraction of swell over the complex two-dimensional bathymetry and associated extreme nearshore wave height variations that were first reported in a classic study by Munk and Traylor (1947).

PUBLICATIONS:

Ardhuin, F. and Herbers, T.H.C., "Numerical and physical diffusion: Can wave prediction models resolve directional spread?" *Journal of Atmospheric and Oceanic Technology*, (in press).

Ardhuin, F., Herbers, T.H.C., Jessen, P.F., and O'Reilly, W.C., "Swell transformation across the continental shelf. Part II. Validation of a spectral energy balance equation," *Journal of Physical Oceanography*, 33(9), pp. 1940-1953, 2003.

Ardhuin, F., O'Reilly, W.C., Herbers, T.H.C., and Jessen P.F., "Swell transformation across the continental shelf. Part I. Attenuation and directional broadening," *Journal of Physical Oceanography*, 33(9), pp. 1921-1939, 2003.

Elgar, S., Raubenheimer, B., and Herbers, T.H.C., "Bragg reflection of ocean waves from sandbars," *Geophysical Research Letters*, 30(1), 1016, doi:10.1029/2002GL016351, 2003.

Herbers, T.H.C., Orzech, M., Elgar, S., and Guza, R.T., "Shoaling transformation of wave frequency-directional spectra," *Journal of Geophysical Research*, 108(C1), 3013, doi:10.1029/2001JC001304, 2003.

Noyes, T.J., Guza, R.T., Elgar, S., and Herbers, T.H.C., "Field observations of shear waves in the surf zone," *Journal of Geophysical Research*, (in press).

THESIS DIRECTED:

Ray, T.A., "Wave Propagation Over Complex Bathymetry," Master's Thesis, Naval Postgraduate School, June 2003.

KEYWORDS: Ocean Surface Waves, Surf Zone, Continental Shelf

NEARSHORE CANYON EXPERIMENT
Thomas H. C. Herbers, Professor
Department of Oceanography
Sponsors: Office of Naval Research, Naval Postgraduate School

OBJECTIVE: To understand the effect of complex continental-shelf bathymetry on surface gravity waves and on the breaking-wave-driven circulation onshore of the irregular bathymetry.

SUMMARY: Recent studies have shown that waves propagating across a continental shelf are strongly affected by both dissipation in the bottom boundary layer and scattering by small-scale seabed irregularities. The ability to accurately forecast wave conditions on the shelf and beach is hampered by a lack of understanding of the small-scale bottom variability (sand ripples and ridges) that evolves under the influence of large storm waves and strong currents. This research effort, conducted in collaboration with a former Naval Postgraduate School (NPS) Ph.D. student, analyzed data from an array of surface following buoys and pressure transducers which were deployed on the North Carolina continental shelf during the fall of 1999 as part of the SHOWEX Experiment. This dataset contains unique observations of large swells from Hurricanes Floyd, Gert, and Irene. Supporting measurements of seabed characteristics, including sediment samples and side-scan sonar surveys of wave-induced sand ripples were also collected. Results of this research (Ardhuin, et al., 2003a,b) confirmed the critical importance of rough bed-forms in swell transformation across a wide continental shelf. Analysis of swell decay shows that as much as 80% of the incident wave energy flux is dissipated on the shelf and the variable dissipation rates appear consistent with

existing bed roughness models. This dramatic sheltering of a coastline with a wide, sandy shelf has important implications for nearshore hydrodynamics and sediment transport.

A Boussinesq model for the nonlinear transformation of ocean surface waves in shallow water was developed and tested with extensive field and laboratory observations (Herbers, et al., 2003). Effects of surf zone wave breaking were incorporated with a heuristic dissipation term in the spectral energy balance equation. The associated coefficients were calibrated with observations that span a wide range of surf zone conditions. The model accurately predicts the observed evolution of the wave frequency spectrum from an initially narrow swell spectrum to the development of pronounced harmonic peaks in the outer surf zone, to an almost uniform spectrum in the inner surf zone. Predictions of sea surface skewness and asymmetry, parameters often used to characterize the steepness of wave fronts, also agree fairly well with observations. The observed directional spectra inside the surf zone are broader than the predicted spectra, suggesting that neglected scattering effects associated with the random onset of wave breaking or with higher-order nonlinearity may be important.

PUBLICATIONS:

Ardhuin, F. and Herbers, T.H.C., "Numerical and physical diffusion: Can wave prediction models resolve directional spread?" *Journal of Atmospheric and Oceanic Technology*, (in press).

Ardhuin, F., Herbers, T.H.C., Jessen, P.F., and O'Reilly, W.C., "Swell transformation across the continental shelf. Part II. Validation of a spectral energy balance equation," *Journal of Physical Oceanography*, 33(9), pp. 1940-1953, 2003.

Ardhuin, F., O'Reilly, W.C., Herbers, T.H.C., and Jessen P.F., "Swell transformation across the continental shelf. Part I. Attenuation and directional broadening," *Journal of Physical Oceanography*, 33(9), pp. 1921-1939, 2003.

Elgar, S., Raubenheimer, B., and Herbers, T.H.C., "Bragg reflection of ocean waves from sandbars," *Geophysical Research Letters*, 30(1), 1016, doi:10.1029/2002GL016351, 2003.

Herbers, T.H.C., Orzech, M., Elgar, S., and Guza, R.T., "Shoaling transformation of wave frequency-directional spectra," *Journal of Geophysical Research*, 108(C1), 3013, doi:10.1029/2001JC001304, 2003.

Noyes, T.J., Guza, R.T., Elgar, S., and Herbers, T.H.C., "Field observations of shear waves in the surf zone," *Journal of Geophysical Research*, (in press).

THESIS DIRECTED:

Watts, K.P., "Fetch-Limited Wind Wave Generation on the Continental Shelf," Master's Thesis, Naval Postgraduate School, December 2003.

KEYWORDS: Ocean Surface Waves, Surf Zone, Nearshore Processes

ARCTIC OCEAN MODEL INTERCOMPARISON PROJECT (AOMIP)
Wieslaw Maslowski, Research Associate Professor
Department of Oceanography
Sponsor: Woods Hole Oceanographic Institute

OBJECTIVE: To compare qualitative/quantitative behavior of different regional Arctic Ocean and sea ice models forced with realistic atmospheric conditions, and understand differences/similarities in their ability to simulate variability of the Arctic Ocean climate and major processes maintaining observed variability.

SUMMARY: A coordinated 50-year simulation using available forcing data sets from various reanalysis products is now underway. A web site for the Arctic Ocean Model Intercomparison Project (AOMIP) (http://fish.cims.nyu.edu/project_aomip/overview.html) continues to serve as the focal point for electronic

exchange of all modeling related intercomparison activities. A description of various contributing models, the forcing data sets, the seasonal climatology, and the interannual variability runs are served and archived at the site. To date, AOMIP intercomparison efforts have focused on the seasonal variability of main properties of the Arctic Ocean. Results of these investigations were discussed during the 7th AOMIP Workshop held at the National Oceanic and Atmospheric Administration (NOAA) Geophysical Fluid Dynamics Laboratory (GFDL) from 14-15 June 2004.

PUBLICATION:

Steiner, N., Holloway, G., Gerdes, R., Hakkinen, S., Holland, D., Karcher, M., et al., "Comparing modeled streamfunction, heat and freshwater content in the Arctic Ocean," *Ocean Modeling*, V6(3-4), pp. 265-284, 2004.

CONFERENCE PUBLICATIONS:

Maslowski, W., Clement, J.C., Marble, D.C., Lipscomb, W.H., and Walczowski, W., "The role of resolution in modeling the Arctic Ocean circulation and dynamics," *Proceedings of the AMS 7th Conference on Polar Meteorology and Oceanography Joint Symposium on High-Latitude Climate Variations,* (Extended Abstract), Hyannis, MA, 12-16 May 2003.

Maslowski, W., Romanou, A., Holland, D.M., Clement, J.L., and Walczowski, W., "A comparison of high-resolution ice-ocean model results with SHEBA data," *Proceedings of the AMS 7th Conference on Polar Meteorology and Oceanography Joint Symposium on High-Latitude Climate Variations*, (Extended Abstract), Hyannis, MA, 12-16 May 2003.

PRESENTATION:

Maslowski, W., Stark, D., Clement, J.L., Marble, D.C., and Walczowski, W., "Modeled Arctic - Subarctic Ocean fluxes 1979-2002: A case for intercomparison study," AOMIP Workshop, Woods Hole, MA, 8-9 May 2003.

KEYWORDS: Numerical Modeling, Arctic Ocean, Sea Ice, Model Intercomparison

CARBON CYCLING IN THE CHUKCHI AND BEAUFORT SEAS – FIELD AND MODELING STUDIES
Wieslaw Maslowski, Research Associate Professor
Department of Oceanography
Sponsor: National Science Foundation

OBJECTIVE: The main goal of this collaborative project was to determine the impacts of the impacts of decadal-scale environmental regime shifts in the northern high latitudes ocean and sea ice conditions on carbon cycling in the Western Arctic Ocean.

SUMMARY: Volume transport and property fluxes between shelves and basins were investigated using a coupled ice-ocean model of the Pan-Arctic region configured at $1/12^o$ and 45-level grid in this ongoing 5-year project. Western Arctic Ocean circulation, mean transport, and fluxes were quantified to identify the main pathways and directions of shelf-basin exchange in the region. Long-term variability was evaluated through comparisons of decade-apart model results. Mean velocity fields during 1979-2002 have been found to describe a generally cyclonic climatological circulation pattern that intensified during the late 1980s and early 1990s. The northern Chukchi Plateau was modeled as a region of major volume, heat and freshwater transport from the boundary currents into the Canada Basin interior. The shelves and slopes of the northeastern Chukchi Sea and the southwestern Beaufort Sea, the main focus area of the Western Arctic Ocean Shelf Basin Interaction field program, were simulated as another main region of mass and property export from the shelf to basin. Further analyses are underway, including investigations of interannual and

decadal variability. Biophysical coupling in the western Arctic Ocean ecosystem has been investigated through joint effort with the SBI program.

PUBLICATIONS:

Maslowski, W. and Lipscomb, W.H., "High-resolution simulations of Arctic Sea ice during 1979-1993," *Polar Research*, 22, pp. 67-74, 2003.

Maslowski, W., Marble, D.C., Walczowski, W., Schauer, U., and Semtner, A.J., "Simulated annual mass, heat and salt transport through the Barents Sea from an eddy-permitting pan-Arctic coupled ice-ocean model," *Journal of Geophysical Research*, 2004, (in print).

Walsh, J.J., Dieterle, D.A., Maslowski, W., and Whitledge, T.E., "Decadal shifts in biophysical forcing of Arctic marine food webs: the numerical consequences," *Journal of Geophysical Research*, 2004, (in print).

PRESENTATIONS:

Maslowski, W., "Modeling the Pan-Arctic environment and its variability," Oceanography Chair's Seminar Series, Department of Oceanography, Naval Postgraduate School, 17 October 2003.

Maslowski, W., Clement, J.L., Dixon, J.S., Jakacki, J., Marble, D.C., Lipscomb, W.H., et al., "Naval Postgraduate School Arctic Modeling Effort (NAME) - A Review," Invited Seminar #1, Université Catholique de Louvain, Lovain-la-Neuve, Belgium, 28 May 2003.

Maslowski, W., Clement, J.C., Dixon, J., and Walczowski, W., "Ocean-ice modeling contributions to SBI 2004 Planning," Shelf –Basin Interactions (SBI) PI Planning Meeting, Seattle, WA, 12 December 2003.

Maslowski, W., Clement, J.L., Dixon, J.S., and Walczowski, W., "On arctic environmental change – 1979-2001 Coupled Ice-Ocean Model results," Fall AGU Meeting, San Francisco, CA, 12 December 2003, (invited).

Maslowski, W., Clement, J.C., Dixon, J., Marble, D., Walczowski, W., Osinski, R., et al., "High resolution modeling of the Arctic Ocean – A decade of progress," ACSYS Final Science Conference, St. Petersburg, Russia, 13 November 2003, (invited).

Maslowski, W., Clement, J.C., Dixon, J., Marble, D., Walczowski, W., Osinski, R., et al., "Modeled arctic - subarctic ocean fluxes during 1979-2001," 3rd ASOF ISSG Meeting, Seattle, WA, 26 October 2003, (invited).

Maslowski, W., Clement, J.C., Dixon, J., Marble, D., Walczowski, W., Osinski, R., et al., "Towards a regional arctic climate model for SEARCH," SEARCH Open Science Meeting Seattle, WA, 28 October 2003, (invited).

Maslowski, W., Clement, J.C., Dixon, J., Walczowski, W., Lipscomb, W.H., and Hunke, E., "From local to Pan-Arctic ecosystem modeling – An approach and requirements," 3rd Shelf – Basin Interactions (SBI) Pan-Arctic Meeting, Cadiz, Spain, 3 November 2003, (invited).

Maslowski, W. and Lipscomb, W.H., "Advancements and challenges in modeling the Arctic Sea ice," AOSB Sea Ice Panel, Kiruna, Sweden, 30 March 2003, (invited).

Maslowski, W., Lipscomb, W.H., Hunke, E., Marble, D., Walczowski, W., and Clement, J.L., "Improving arctic climate modeling for weather and climate prediction," High Latitude NWP Workshop, Fairbanks, AK, 9 October 2003, (invited).

Maslowski, W., Lipscomb, W.H., Walczowski, W., Clement, J.C., and Dixon, J., "Advancements in high-resolution modeling of Arctic sea ice," EGS-AGU-EUG Joint Assembly, Nice, France, 10 April 2003, (invited).

Maslowski, W., Lipscomb, W.H., Walczowski, W., Clement, J.C., and Dixon, J.S., "Advancements in modeling environmental arctic change during 1979-2001," UGC 2003, Bellevue, WA, 12 June 2003.

Maslowski, W., Lipscomb, W.H., Walczowski, W., Clement, J.C., and Dixon, J., "Modeled Arctic - Subarctic ocean fluxes during 1979-2001," EGS-AGU-EUG Joint Assembly, Nice, France, 11 April 2003.

Maslowski, W., Marble, D.C., Walczowski, W., Clement, J.L., and Dixon, J.S., "The circulation and variability in the Nordic Seas," UCL Invited Seminar #3, Louvain-la-Neuve, Belgium, 6 June 2003.

Maslowski, W., Walczowski, W., Clement, J.L., and Dixon, J.S., "Modeled mass and property exchange between the Arctic and Subarctic Oceans 1979-2001 – work in progress," Invited Seminar #2, Louvain-la-Neuve, Belgium, 3 June 2003.

Maslowski, W., Walczowski, W., Clement, J.C., Dixon, J., and Lipscomb, W.H., "Towards understanding of marine environments in the Western Arctic – Physical modeling for the SBI Program," SBI 2 Principal Investigators Meeting, RSMAS, Miami, FL, 6 March 2003.

THESES DIRECTED:

Dixon, J.S., "The Circulation and Variability in the Western Arctic Ocean - Model Results," Master's Thesis, Naval Postgraduate School, September 2003.

Williams, C., "The Circulation and Fluxes from the Arctic into the North Atlantic Ocean, 1979-2002 Model Results," Master's Thesis, Naval Postgraduate School, September 2004.

KEYWORDS: Oceanography, Sea Ice, Numerical Modeling, Arctic Ocean

INTERANNUAL VARIABILITY OF BIOPHYSICAL LINKAGES BETWEEN THE BASIN AND SHELF IN THE BERING SEA AND GULF OF ALASKA
Wieslaw Maslowski, Research Associate Professor
Department of Oceanography
Sponsor: University of Alaska Fairbanks

OBJECTIVE: To investigate interannual and decadal variations in shelf-basin exchanges of properties and nutrients in and between the Gulf of Alaska and the Bering Sea, using a regional coupled ocean and sea ice model at high resolution validated against available observations in those regions.

SUMMARY: A 70-year integration of the coupled ice-ocean model configured at 9-km and 45-level Pan-Arctic grid was completed, forced with realistic 1979-2002 atmospheric data from the European Centre for Medium-range Weather Forecasts (ECMWF). This modeling approach yielded realistic simulation of ocean circulation, and mass and property fluxes in and between the northern North Pacific, the Bering Sea, and the Arctic Ocean. The long-term mean depth-integrated mass, heat, and freshwater fluxes in the western Alaska Gyre were quantified. Analyses of results determined the mean circulation, volume, and property transports in the Alaskan Stream and through the eastern and central Aleutian passes. The mean total westward transport of the Alaskan Stream was estimated between 45 Sv and 56 Sv. A significant westward increase in the Alaskan Stream transport was due to northward entrainment of part of the eastward flowing Subarctic Current, which appeared to be topographically steered by the Aleutian Rise. Researchers hypothesized that this influx of water to the west from around 168°W determines the environmental shift from the coastal regime along the eastern Aleutian Islands to the more marine environment at Amukta Pass and further west. In addition, large anticyclonic eddies (200-300 km in diameter) were simulated propagating to the west along the southern slopes of the Alaska Peninsula and the Aleutian Islands. Those

eddies were shown to significantly influence water mass and property exchanges between the Gulf of Alaska and the Bering Sea as they slowly propagate from the northeastern Gulf of Alaska westward towards the central North Pacific.

PUBLICATIONS:

Maslowski, W., Clement, J.L., Okkonen, S.R., Stabeno, P., and Walczowski, W., "On the mean ocean circulation and property transport from the Alaskan Stream through eastern and central Aleutian Island passes – model results," *Fisheries Oceanography*, 2002, (submitted).

Okkonen, S.R. and Maslowski, W., "Numerical investigations of seasonal and interannual variability of shelf break hydrography in the western Gulf of Alaska," *Journal of Geophysical Research*, 2002, (in preparation).

PRESENTATIONS:

Maslowski, W., Clement, J.C., Dixon, J., Okkonen, S., Whitledge, T., and Walczowski, W., "Advancements and challenges in modeling ocean circulation in the Northern high latitudes," Arctic Region Supercomputing Center Technology Panel, Fairbanks, AK, 26 March 2003, (invited).

Maslowski, W. and Okkonen, S., "Large-scale, high-resolution, interdecadal ocean-ice modeling for SSL," Steller Sea Lion Synthesis Workshop, Newport Beach, CA, 3 December 2003.

Maslowski, W., Okkonen, S., and Whitledge, T., "Environmental conditions and their variability in the Gulf of Alaska and Bering Sea," Bering Sea Ecosystem Study (BEST) Workshop - Seattle, WA, 17-19 March 2003.

Maslowski, W., Okkonen, S., and Whitledge, T., "Towards understanding environmental conditions and their variability in the Gulf of Alaska and Bering Sea – Model results Part I," Marine Science in the Northeast Pacific – Joint Science Symposium, Anchorage, AK, 13-17 January 2003.

KEYWORDS: Oceanography, Sea ice, Numerical Modeling, Sub-polar Pacific

MESOSCALE VARIABILITY AND PROCESSES IN AN EDDY-RESOLVING GLOBAL PARALLEL OCEAN PROGRAM (POP) SIMULATION
Julie L. McClean, Research Associate Professor
Department of Oceanography
Sponsor: National Science Foundation

OBJECTIVE: To quantify and understand the dynamics, particularly of the eddy variability and mesoscale processes, in a high-resolution global configuration of the Parallel Ocean Program (POP) model. This project is continuing.

SUMMARY: To address the nature of the mesocale in a global high-resolution (0.1°, 40-level) POP simulation, daily averages of all quantities needed to calculate fluxes, eddy statistics, and intrinsic scales were saved in regional boxes of roughly 10-degrees by 10-degrees for 1998-2000. It was impossible to archive all the needed terms on a daily basis for the entire grid, so the regions selected were the low-latitude western boundary currents in all basins, the Kuroshio Extension, the Antarctic Circumpolar Current, and the Agulhas Current. Particle trajectories were released globally on roughly the ARGO grid (3°x3° across the entire global ocean). Analyses of this output are part of this on-going project.

To understand the dynamics of exchanges between the western Pacific and Indian Ocean via the Indonesian Throughflow output from an eddy-permitting (1/3°, 32-levels) global POP run forced with synoptic surface fluxes was used. Higher resolution output of sufficient duration was not available at the time of this study, so the lower resolution output was used in the interim. The impact of interannual off-equatorial and equatorial Pacific long waves on the eastern tropical Indian Ocean was examined. The latter

process was documented in the literature; however, this was the first numerical study to examine the importance of the Pacific off-equatorial interannual signal on the eastern Indian Ocean.

PUBLICATIONS:

Maltrud, M.E. and McClean, J.L., "An eddy resolving global 1/10-degree ocean simulation," *Ocean Modeling*, 2004, (in press).

Prasad, T.G. and McClean, J.L., "Mechanisms for anomalous warming in the western Indian Ocean during the Dipole Mode events," *Journal of Geophysical Research*, 109, C02019, doi: 10.1029/2003JC001872, 2004.

CONFERENCE PUBLICATION:

McClean, J.L., Ivanova, D.P., and Sprintall, J., "Interannual variability of the Indonesian Throughflow from WOCE IX1 data and a global eddy-permitting global ocean model," *EOS, Transactions, AGU*, 84(52), Ocean Science Meeting Supplement, Abstract OS42L-07, January 2004.

PRESENTATIONS:

McClean, J.L., "How have WOCE observations challenged ocean models?" Seminar, Lawrence Livermore National Laboratory, Livermore, CA, 19 May 2003.

McClean, J.L., "Modeling the global ocean at high resolution," Seminar, Moss Landing Marine Laboratory, Moss Landing, CA, 17 October 2003.

McClean, J.L., "Use of high-resolution global POP in short-term ocean climate studies," Climate Change Prediction Program Meeting, Charleston, SC, March 2003.

McClean, J.L. and Maltrud, M., "Analyses of 0.1°, 40-level POP," Eighth Annual Coupled Climate System Model Workshop, Breckenridge, CO, June 2003.

KEYWORDS: Ocean Circulation, Model Validation, Model/Data Synthesis

TOWARDS THE USE OF PARALLEL OCEAN PROGRAM (POP) AND SEA ICE (CICE) IN A GLOBAL COUPLED NAVY PREDICTION SYSTEM
Julie L. McClean, Research Associate Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: To perform high-resolution global ocean and coupled ocean/ice simulations using the Los Alamos National Laboratory (LANL) Parallel Ocean Program (POP) and CICE (sea ice) models. These high-resolution ocean and ice states can be used as initial conditions in a future global coupled atmosphere/ocean/ice Navy forecasting system. This project is continuing.

SUMMARY: A two-decade (1979-2001) 0.1°, 40-level global ocean simulation using the Parallel Ocean Program (POP), forced with daily National Centers for Environmental Prediction (NCEP) atmospheric model fluxes, was completed. Key quantities such as transports through important passages, mean and variability of surface currents, and mesoscale variability compared favorably to observations. Surface fluxes from the Navy Operational Global Atmospheric Prediction System (NOGAPS) were prepared for a comparative simulation to take place in FY04. A global eddy-permitting (0.4°, 40 levels) coupled sea/ice simulation using POP and CICE was conducted. Quantities such as ice edge and concentration were compared with those from satellite data and a stand-alone CICE simulation. The analyses were used to resolve coupling issues and understand the performance of ice parameterizations, particularly that responsible for ridging. Ocean mixed layer properties from data were compared to fields from eddy-

permitting and eddy-resolving configurations of global POP. Heat budget analyses of POP output were used to understand the physical process governing the upper water column.

PUBLICATIONS:

Maltrud, M.E. and McClean, J.L., "An eddy resolving global 1/10°ocean simulation," *Ocean Modeling*, (in press).

McClean, J.L., Maltrud, M.E., Ivanova, D.P., Thoppil, P.G., and Hunke, E., "High-resolution global ocean and ocean/ice models for synoptic and climate prediction," *EOS, Transactions, AGU*, 84(46), Fall Meeting Supplement, Abstract A52D-01, 2003, (invited).

McClean, J.L., Maltrud, M., Ivanova, D., Thoppil, P., and Hunke, E., "Towards a high-resolution global coupled Navy prediction system: Ocean and ocean/ice components," *Application Briefs 2003*, Maui High Performance Computing Center, Kihei-Maui, HI, pp. 34-35, 2003.

Prasad, T.G. and McClean, J.L., "Mechanisms for anomalous warming in the western Indian Ocean during the Dipole Mode events," *Journal of Geophysical Research*, 109, C02019, doi: 10.1029/2003JC001872, 2004.

Tokmakian, R. and McClean, J.L., "How realistic is the high frequency signal of a 0.1° resolution ocean model?" *Journal of Geophysical Research*, 108(C4), 3115, doi:10.1029/2002JC001446, 2003.

PRESENTATIONS:

McClean, J.L., "Modeling the global ocean at high resolution," Seminar, Naval Postgraduate School, 15 October 2003.

McClean, J.L., Maltrud, M.E., Bryan, F., Ivanova, D., Thoppil, P., Nakashiki, N., et al., "Towards global high resolution coupled synoptic and climate prediction systems," National Science Foundation – Office of Naval Research Sponsored Workshop: Progress and Prospects of Data Assimilation, Williamsburg, VA, September 2003.

Prasad, T.G. and McClean, J.L., "A comparison of mixed layer depth from eddy permitting and eddy-resolving POP models," International Union of Geodesy and Geophysics (IUGG), Sapporo, Japan, 30 June-11 July 2003.

Prasad, T.G., McClean, J.L., and Ikeda, M., "Evidence for a thermal dome in the Arabian Sea during winter monsoon," International Union of Geodesy and Geophysics (IUGG), Sapporo, Japan, 30 June - 11 July 2003.

KEYWORDS: Ocean Circulation, Model Validation, Model/Data Synthesis

ANALYSIS OF HIGH FREQUENCY (HF) RADAR DATA FROM THE NORTHERN ADRIATIC SEA
Jeffrey D. Paduan, Associate Professor
Department of Oceanography
Sponsor: Consiglio Nazionale delle Ricerche Istituto di Scienze Marine

OBJECTIVE: To work with Italian and NATO-sponsored research groups in the northern Adriatic Sea region to deploy and utilize high frequency surface current mapping systems.

SUMMARY: This project utilized funding from the Consiglio Nazionale delle Ricerche (CNR) Istituto di Scienze Marine (ISMAR), Venice, Italy, to support analyses of ocean surface current maps offshore of the Venice Lagoon produced from a three-site high frequency (HF) radar network. Instrument siting and

calibration were included along with the analysis of a year-long record of hourly surface current maps. The maps showed patterns of tidal currents, low-frequency currents, and recurring sub-mesoscale (~5 km) eddies features offshore of Malamocco Inlet. The project also supported integration of these efforts with a second array of HF radar systems along the western Adriatic Sea.

PRESENTATIONS:

Fernandez, D., Vesecky, J., Drake, J., Laws, K., Teague, C., Ludwig, F., et al., "Surface maps and vector wind fields constructed from multi-frequency HF radar," Third International Radiowave Oceanography Workshop (ROW-3), CNR Istituto di Scienze Marine (ISMAR), Venice, Italy, 13-16 April 2003.

Flament, P., Poulain, P.-M., Paduan, J., Chavanne, C., and Gurgel, G.-W., "Results from the WERA HF radar array in the Adriatic Sea," Third International Radiowave Oceanography Workshop (ROW-3), CNR Istituto di Scienze Marine (ISMAR), Venice, Italy, 13-16 April 2003.

Kovacevic, V., Paduan, J., Mazzoldi, A., Mosquera, I.M., Gacic, M., and Marinetti, S., "Year-long CODAR/SeaSonde observations near Venice," Third International Radiowave Oceanography Workshop (ROW-3), CNR Istituto di Scienze Marine (ISMAR), Venice, Italy, 13-16 April 2003.

Paduan, J.D., Gacic, M., Kovacevic, V., Mosquera, I.M., and Mazzoldi, A., "Vorticity patterns offshore of the Venetian Lagoon from HF radar observations," Abstract from the 2nd Annual CORILA Conference, Venice, Italy, 31 March–2 April 2003.

KEYWORDS: HF Radar, Ocean Currents, Ecosystem Modeling, Cross Shore Exchange

DATA ACQUISITION, ASSIMILATION, DISTRIBUTION, AND VISUALIZATION IN SUPPORT OF THE CENTER FOR INTEGRATED MARINE TECHNOLOGIES
Jeffrey D. Paduan, Associate Professor
Leslie K. Rosenfeld, Research Associate Professor
Department of Oceanography
Sponsors: National Oceanic and Atmospheric Administration, University of California Santa Cruz

OBJECTIVE: To pull together ocean observing system components in the region around Monterey Bay to form a pilot observing system to serve stakeholder needs.

SUMMARY: This work was supported by the University of California-Santa Cruz for activities within the National Oceanic and Atmospheric Administration (NOAA) sponsored Center for Integrated Marine Technologies (CIMT). Naval Postgraduate School (NPS) personnel contributed to CIMT through research and development related to coastal ocean observing, modeling and data assimilation technologies, and implementation of data visualization and distribution schemes. Real-time data flow from high frequency (HF) radar installations within and around Monterey Bay was maintained and data quality was monitored. In addition, data quality for near-surface meteorological variables and ocean velocity, temperature, and salinity from Monterey Bay Aquarium Research Institute's (MBARI) M1 and M2 moorings was monitored. Data products for the above suite of variables, plus CIMT-specified biological and chemical variables, were developed. Modeling results from the NOPP/ICON (National Ocean Partnership Program/Innovative Coastal-Ocean Observing Network), NOPP/SCOPE (National Ocean Partnership Program/Simulations of Coastal Ocean Physics and Ecosystems), and Office of Naval Research (ONR) / Autonomous Ocean Sampling Network (AOSN)-II projects were extended and linked to CIMT observational activities.

CONFERENCE PUBLICATIONS:

Cook, M.S. and Paduan, J.D., "Processing HF radar data using the HFRadarmap software system," *Proceedings of the Radiowave Oceanography the First International Workshop*, University of Miami, Rosenstiel School of Marine and Atmospheric Science, pp. 11-16, 2003.

Lipphardt, Jr., B.L., Kirwan, Jr., A.D., Grosch, C.E., and Paduan, J.D., "Normal mode analysis of velocity gradient fields in Monterey Bay," *Proceedings of the Radiowave Oceanography the First International Workshop*, University of Miami, Rosenstiel School of Marine and Atmospheric Science, pp. 115-119, 2003.

Paduan, J.D. and Graber, H.C., "Radiowave oceanography - An overview of the First International Workshop (ROW-1)," *Proceedings of the Radiowave Oceanography the First International Workshop*, University of Miami, Rosenstiel School of Marine and Atmospheric Science, 5-11, 2003.

Paduan, J.D., Benson, S., Bruland, K., Chavez, F., Costa, D., Croll, D., et al., "Ocean observing and modeling system developments around Monterey Bay," *Proceedings, California and the World Oceans,* Santa Barbara, CA, 2 October 2003.

PRESENTATIONS:

Cook, M.S., Lipphardt, B.L., Paduan, J.D., Atwater, D.P., and Grosch, C.E., "Web-based, near-real-time surface current analysis in Monterey Bay from HF radar," 50th Eastern Pacific Ocean Conference (EPOC), Wrigley Marine Science Center, Catalina Island, CA, 24-27 September 2003.

McLaughlin, B., Griggs, G., McManus, M., Croll, D., Kudela, R., Chavez, F., et al., "The Center for Integrated Marine Technologies," 50th Eastern Pacific Ocean Conference (EPOC), Wrigley Marine Science Center, Catalina Island, CA, 24-27 September 2003.

Paduan, J.D., "Ocean. U.S. Surface Current Initiative: An update," 9th GOOS Steering Committee Meeting, St. Petersburg, FL, 12-14 November 2003, (invited).

Paduan, J.D., Benson, S., Bruland, K., Chavez, F., Costa, D., Croll, D., et al., "Ocean observing and modeling system developments around Monterey Bay," California and the World Oceans*,* Santa Barbara, CA, 2 October 2003.

Paduan, J.D., Chao, Y., Choi, J.-K., and Doyle, J., "Near shore wind stress curl over Monterey Bay from a high-resolution model and repeated aircraft surveys," 50th Eastern Pacific Ocean Conference (EPOC), Wrigley Marine Science Center, Catalina Island, CA, 24-27 September 2003.

KEYWORDS: HF Radar, Ocean Currents, Instrumentation, Observing Systems

GLOBAL OCEAN ECOSYSTEMS DYNAMICS (GLOBEC) MAPPING THE EVOLUTION OF MESOSCALE JETS AND EDDIES IN THE UPWELLING ECOSYSTEM OFF CAPE BLANCO, OR USING LONG-RANGE HIGH FREQUENCY RADAR
Jeffrey D. Paduan, Associate Professor
Department of Oceanography
Sponsor: National Science Foundation

SUMMARY: This research deployed a new application of high frequency (HF) radar instruments for extended range coverage of filaments and eddies in the California Current System with specific applications to the mesoscale jets and eddies in the upwelling system of Cape Blanco, or in support of Global Ocean Ecosystems Dynamics (GLOBEC) processes studies sited in that area.

KEYWORDS: GLOBEC, Mesoscale Jets, Upwelling, Capo Blanco, HF Radar

MODELING THE CENTRAL CALIFORNIA COASTAL UPWELLING SYSTEM: PHYSICS, ECOSYSTEMS, AND RESOURCES
Jeffrey D. Paduan, Associate Professor
Department of Oceanography
Sponsors: National Aeronautics and Space Administration, Monterey Bay Aquarium Research Institute

OBJECTIVE: To incorporate a multi-component ecosystem model within a circulation model of the central California coastal region.

SUMMARY: This project modeled the oceanographic processes within the Monterey Bay National Marine Sanctuary (MBNMS) at high resolution (kms). A large body of observations was available from the region for model validation. The high-resolution coastal model was nested within basin-scale and regional models. The model included physical, chemical, and biological properties and was capable of assimilating data from satellites and in situ sensors. The model focused on simulating the observed strong seasonal and interannual variations in oceanographic processes. Naval Postgraduate School scientists participated through quality control and interpretation of physical oceanographic data sets from the Monterey Bay region.

PUBLICATIONS:

Chao, Y., Li, Z., Kindle, J., Paduan, J., and Chavez, F., "A high-resolution surface vector wind product for coastal oceans: blending satellite scatterometer measurements with regional mesoscale atmospheric model simulations," *Geophysical Research Letters,* 30, 13-1 to 13-4, 2003.

Paduan, J.D. and Shulman, I., "CODAR data assimilation in the Monterey Bay area," *Journal of Geophysical Research*, 2003, (in press).

Pickett, M. and Paduan, J.D., "Wind stress curl and related upwelling in the California Current System from high resolution COAMPS reanalysis fields," *Journal of Geophysical Research*, 108, 25-1 to 25-10, 2003.

CONFERENCE PUBLICATIONS:

Kirwan, Jr., A.D., Lipphardt, B., Paduan, J., Small, D., Grosch, C., and Wiggin, S., "Upwelling and downwelling in Monterey Bay inferred from HF radar," *Third International Radiowave Oceanography Workshop (ROW-3)*, CNR Istituto di Scienze Marine (ISMAR), Venice, Italy, 13-16 April 2003.

Laws, K.E., Paduan, J.D., and Fernandez, D.M., "Effect of Stokes drift on HF radar measurements," *Proceedings of the Radiowave Oceanography the First International Workshop*, University of Miami, Rosenstiel School of Marine and Atmospheric Science, pp. 49-55, 2003.

Lipphardt, B.L., Small, D., Kirwan, Jr., A.D., Wiggins, S., Ide, K., Grosch, C.E., and Paduan, J.D., "Synoptic maps of particle transport in Monterey Bay from HF radar," *50th Eastern Pacific Ocean Conference (EPOC)*, Wrigley Marine Science Center, Catalina Island, CA, 24-27 September 2003.

Paduan, J.D., Cook, M.S., Fernandez, D.M., Whelan, C., Shulman, I., and Wu, C.-R., "Statistics and data assimilation results from long-term HF radar-derived surface currents around Monterey Bay, California," *Proceedings of the Radiowave Oceanography the First International Workshop*, University of Miami, Rosenstiel School of Marine and Atmospheric Science, pp. 20-127, 2003.

KEYWORDS: HF Radar, Ocean Currents, Ecosystem Modeling

MODELING THE CENTRAL CALIFORNIA COASTAL UPWELLING SYSTEM: PHYSICS, ECOSYSTEMS, AND RESOURCES-2
Jeffrey D. Paduan, Associate Professor
Leslie K. Rosenfeld, Research Associate Professor
Department of Oceanography
Sponsor: Monterey Bay Aquarium Research Institute

OBJECTIVE: To incorporate a multi-component ecosystem model within a circulation model of the central California coastal region.

SUMMARY: The specific activities of this sub-project involved data processing and quality assurance for physical oceanographic and meteorological sensors on real-time mooring platforms deployed in Monterey Bay. The moorings are maintained by the Monterey Bay Aquarium Research Institute (MBARI). Naval Postgraduate School personnel retrieved both real-time and post-recovery data from the sensors, conducted quality control and reformatted the data, and returned the processed data sets to MBARI.

KEYWORDS: HF Radar, Ocean Currents, Observing Systems

ADVANCED ANALYSIS AND SYNTHESIS OF THE ASIAN SEA INTERNATIONAL ACOUSTIC EXPERIMENT (ASIAEX) DATA
Steven R. Ramp, Research Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: To analyze and publish results from a multi-national oceanographic field program in the East and South China Seas to investigate how the complex littoral environment (i.e., its water column, boundary, sediment and sub-bottom structure and inhomogenities) affects the ray paths, mode structure, propagation loss, and temporal and spatial (both vertical and horizontal) coherence for low-to-intermediate frequency (50-4000 Hz) acoustic transmissions in shallow water. The work is part of a continuing project.

SUMMARY: Several years of advance planning and work came to fruition with the successful execution of the Asian Sea International Acoustic Experiment (ASIAEX) main field program during April-June 2001. The South China Sea (SCS) portion took place during April – May 2001 on the Chinese continental shelf and slope between Dongsha Island and Taiwan. The East China Sea (ECS) portion took place during May and June in the region bounded by 28-30°N and 126° 30' to 128°E. Professor Ramp was a Principal Investigator in both the SCS and ECS programs. Greater effort was extended during 2001 on the SCS program, which was executed during eight cruises from three Taiwanese research vessels. Eight oceanographic moorings, eight acoustic source/receiver moorings, and numerous smaller, experimental moorings were deployed and recovered. The area was also surveyed using the SeaSoar towed undulating vehicle and a chirp sonar sub-bottom profiling system. This was the largest simultaneous, high-resolution physical oceanography and acoustic propagation data set ever collected. The result from the program was the discovery of the world's largest nonlinear internal waves, which were generated in the Luzon Strait and propagated WNW towards the Chinese continental shelf. The dynamics of these features and their impact on acoustic propagation were analyzed.

The Principal Investigator and another Naval Postgraduate School faculty member also served as the International Scientific Coordinator and Assistant Coordinator respectively for both the SCS and ECS ASIAEX programs. They helped organize and also attended the ASIAEX Analysis Workshop in Taipei, Taiwan, during March 2003.

PUBLICATIONS:

Beardsley, R.C., Duda, T.F., Lynch, J.F., Irish, J.D., Ramp, S.R., Chiu, C.-S., et al., "The barotropic tide in the northeast South China Sea," *IEEE Journal of Oceanic Engineering*, 2004, (in press).

Chiu, C.-S., Ramp, S.R., Miller, C.W., Lynch, J.F., Duda, T.F., and Tang, T.-Y., "Acoustic intensity fluctuations induced by South China Sea internal tides and solitons," *IEEE Journal of Oceanic Engineering*, 2004, (in press).

Duda, T.F., Lynch, J.F., Irish, J.D., Beardsley, R.C., Ramp, S.R., Chiu, C.-S., et al., "Internal tide and nonlinear internal wave behavior at the continental slope in the northern South China Sea," *IEEE Journal of Oceanic Engineering*, 2004, (in press).

Gawarkiewicz, G., Wang, J., Caruso, M., Ramp, S.R., Brink, K., and Bahr, F., "Shelfbreak circulation and thermohaline structure in the northern South China Sea: Contrasting spring conditions in 2000 and 2001," *IEEE Journal of Oceanic Engineering*, 2004, (submitted).

Kim, H.-R., Ramp, S.R., Duda, T., and Liu, A.K., "Solitons in the Northeastern South China Sea Part II: Transformation in shallow water," *IEEE Journal of Oceanic Engineering*, April 2004 Special Issue, (in preparation).

Liu, A.K., Ramp, S.R., Zhao, Y., and Tang, T.-Y., "A case study of internal wave propagation during ASIAEX-2001," *IEEE Journal of Oceanic Engineering*, 2004, (in press).

Ramp, S.R., Chiu, C.S., Bahr, F.L., and Qi, Y., "The shelf-edge environment in the central East China Sea and its impact on low frequency acoustic propagation," *IEEE Journal of Oceanic Engineering*, April 2004 Special Issue, (revised and resubmitted).

Ramp, S.R., Chiu, C.S., Kim, H.-R., Bahr, F.L., Tang, T.-Y., Yang, et al., "Solitons in the northeastern South China Sea Part I: Sources and propagation through deep water," *IEEE Journal of Oceanic Engineering*, April 2004 Special Issue, (revised and resubmitted).

Ramp, S.R., Lynch, J., Dahl, P., Chiu, C.S., and Simmen, J., "ASIAEX fosters advances in shallow-water acoustics in Southeastern Asia," *EOS, Transactions, American Geophysical Union*, Vol. 84, No. 37, pp. 361-367, 2004.

Yang, Y.J., Tang, T.Y., Chuang, M.H., Liu, A.K., Hsu, M.-K., and Ramp, S.R., "2004: Solitons northeast of Tung-Sha Island, observed during the ASIAEX 2000 pilot study," *IEEE Journal of Oceanic Engineering*, 2004, (in press).

CONFERNECE PUBLICATION:

Chen, C.-F., Tang, T.-Y., Wei, R.-C., Too, G.-P., Yang, Y.-J., Ramp, et al., *Proceedings: The Asian Seas International Acoustic Experiment (ASIAEX) Analysis Workshop*, Taipei, Taiwan, 3-7 March 2003.

PRESENTATIONS:

Ramp, S.R., et al., "Moored observations of internal solitons in the northeastern South China Sea," ASIAEX Analysis Workshop, Taipei, Taiwan, March 2003.

Ramp, S.R., et al., "Operational impacts of internal solitons in the northeastern South China Sea," Office of Naval Research Workshop on Nonlinear Internal Waves, Williamsburg, VA, July 2003.

OTHER:

In the process of transitioning new operational knowledge of the Asian marginal seas to Commander, Pacific Submarine Fleet (COMPACSUBFLT) in Pearl Harbor, Honolulu, Hawaii.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Modeling and Simulation

AERIAL SURVEYS OF THE OCEAN AND ATMOSPHERE OFF CENTRAL CALIFORNIA

Steven R. Ramp, Research Professor
Jeffrey D. Paduan, Associate Professor
Curtis A. Collins, Professor
Department of Oceanography
Wendell A. Nuss, Associate Professor
Department of Meteorology
Sponsor: Office of Naval Research

OBJECTIVE: The project consisted of biweekly overflights of the Monterey Bay for a year, with many flights nested in the month of August, as part of the Office of Naval Research (ONR) Autonomous Ocean Sensing Network (AOSN) program. The objective of the biweekly flights was to observe the half-dozen or so "characteristic states" of the Monterey Bay air/sea system and the associated adjacent coastal ocean and atmosphere. These states included onset and retreat of summer upwelling, the advance and retreat of the Monterey Bay Eddy, the passage of winter fronts and storms, the diurnal monsoon, poleward propagating events in the atmosphere and ocean, and the occasional anomalous passing atmospheric systems. The objective of the every-other-day flights during August was to observe the development and destruction of three-dimensional upwelling centers near Point Sur and Cape Ano Nuevo near the mouth of the Monterey Bay in support of the AOSN program. The surface distribution maps were essential to force the numerical models running in real-time in the Bay for the AOSN program. The observations will be used to enhance and improve existing and future coupled models of the coastal air/sea system.

SUMMARY: A time series of forty (40) aircraft flights were conducted over the Monterey Bay and adjacent waters between March 2003 and March 2004 to make high-resolution maps of critical parameters in the ocean and atmosphere. The mapping portion of the flight path was flown at a constant altitude of 33 m off the sea surface, beneath the usual regional stratus deck. Additionally, two sawtooth transects, elevating offshore, were flown to map the height of the atmospheric inversion layer at the northern and middle sections of the region. The flights were conducted nominally every two weeks, with a concentration of flights during August 2003 in support of the ONR Autonomous Ocean Sensing Network – II (AOSN-II) experiment in the Monterey Bay. Flight times were adjusted slightly to coordinate with cruises in the bay, primarily on the research vessel *POINT SUR*, in support of operational education for U.S. Navy officer students at the Naval Postgraduate School. The aircraft was provided by the NPS Center for Remotely-Piloted Aircraft Studies (CIRPAS), housed locally at the Marina Municipal Airport. The Twin Otter aircraft was used for all but three flights and the smaller payload "Pelican" aircraft (a modified Cessna Skymaster) was used when the Twin Otter was deployed out of town. The basic suite of sensors deployed on all flights included air temperature, dew point temperature, atmospheric pressure, and sea surface temperature. The Twin Otter additionally carried a LIDAR altimeter, atmospheric turbulence sensors, aerosol sensors, two six-megapixel digital cameras, and a new hyperspectral radiometer. The flights produced an unprecedented time series of high-resolution air/sea observations for use in verifying Navy models such as Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS). Researchers cooperated with Naval Research Laboratory (NRL) Monterey and Naval Research Laboratory, Stennis Space Center (NRL-SSC) on model initialization and verification issues. As the August 2003 field campaign was just completed, the publications to date have been mostly oral. Written publications are in preparation.

PUBLICATION:

Ramp, S.R., Paduan, J.D., Shulman, I., Kindle, J., and Bahr, F.L., "Observations and modeling of upwelling and relaxation events in the northern Monterey Bay during August 2000," 2003, (in advanced preparation).

CONFERENCE PUBLICATION:

Shulman, I., Kindle, J.C., Paduan, J.D., Ramp, S.R., Rosenfeld, L.K., Haddock, S., et al., "Modeled circulation patterns and bioluminescence distribution predictions during upwelling and relaxation events in the Monterey Bay area," *Abstract Book of ASLO/TOS Ocean Research 2004 Conference*, Honolulu, HI, 15-20 February 2004.

PRESENTATIONS:

Paduan, J.D., Ramp, S.R., Anderson, T.E., Chao, Y., Choi, J.K., and Doyle, J., "Near shore wind stress curl over Monterey Bay from a high resolution model and repeated aircraft surveys within the autonomous ocean sensing network (AOSN)," Eastern Pacific Ocean Conference (EPOC), Santa Catalina Island, CA, September 2003.

Ramp, S.R., et al., "The utilization of light aircraft in operational coastal ocean observing systems," Office of Naval Research Northeast Regional Review, Narragansett, RI, November 2003.

Ramp, S.R., Paduan, J.D., Anderson, T.E., and Bahr, F.L., "Distributions of sea surface temperature and plant pigments in and around the Monterey Bay during August 2003," Autonomous Ocean Sensing Network (AOSN)-II Hotwash Conference, Asilomar Beach, CA, October 2003.

Ramp, S.R., Paduan, J.D., Anderson, T.E., and Bahr, F.L., "Distributions of sea surface temperature and plant pigments in and around the Monterey Bay during August 2003," Eastern Pacific Ocean Conference (EPOC), Santa Catalina Island, CA, September 2003.

Shulman, I., Paduan, J.D., Rosenfeld, L.K., Ramp, S.R., and Kindle, J.C., "Modeling study of the coastal upwelling system of the Monterey Bay area during 1999 and 2000," Terrain-Following Ocean Models Users Workshop, Seattle, WA, 4-6 August 2003.

Shulman, I., Paduan, J.D., Rosenfeld, L.K., Ramp, S.R., and Kindle, J.C., "Modeling study of the coastal upwelling system of the Monterey Bay area during 1999 and 2000," 31st Conference on Radar Meteorology and the Fifth Conference on Coastal Atmospheric and Oceanic Prediction and Processes (Joint Session, Coastal Weather and Ocean Processes), Seattle, WA, 6-7 August 2003.

KEYWORDS: Real-time Observations, Ocean Currents, Air-Sea Interaction, Bioluminescence

ASIAN SEA INTERNATIONAL ACOUSTIC EXPERIMENT (ASIAEX) PROJECT MANAGEMENT
Steven R. Ramp, Research Professor
Department of Oceanography
Sponsor: Office of Naval Research

SUMMARY: To shepherd the Asian Sea International Acoustic Experiment (ASIAEX) program to a successful conclusion by fostering international collaborations, planning symposia, and facilitating publication of the ASIAEX results in the scientific literature.

KEYWORDS: Asian Sea International Acoustic Experiment, ASIAEX

GLOBAL OCEAN ECOSYSTEMS DYNAMICS (GLOBEC): MOORED CURRENT OBSERVATIONS ALONG THE EUREKA LONG-TERM OBSERVATION PROGRAM (LTOP) TRANSECT

Steven R. Ramp, Research Professor
Department of Oceanography
Sponsor: National Oceanic and Atmospheric Administration

OBJECTIVE: The over-arching goal of the Global Ocean Ecosystems Dynamics (GLOBEC) Northeast Pacific Program (NEP) is to understand the effects of climate variability and climate change on the distribution, abundance, and production of marine animals in the eastern North Pacific Ocean. The objective of the five-year Long-Term Observation Program (LTOP) moorings is to monitor the temporal and spatial variability of the currents and bottom temperature over the continental shelf off Oregon, from tidal to interannual scales, and to relate this physical variability to long-term changes in the ecosystem.

SUMMARY: Oceanographic moorings to measure temperature, salinity, and velocity at the 73 m isobath 6.5 nm off the mouth of the Rouge River near Gold Beach, Oregon, have been maintained by the Naval Postgraduate School (NPS) since May 2000.   Instrument recovery has been 100% so far, with most instruments working well. The moorings are still in the ocean and will be recovered for the final time during October 2004. The data was analyzed in conjunction with other moorings off Coos Bay and Newport, Oregon, maintained by other GLOBEC investigators.   Early results indicated significant differences in the environment north (Coos Bay) and south (Rogue River) of Cape Blanco, Oregon, where the coastal jet separates from the coast. The physical changes apparently propagate through the ecosystem as larger numbers of salmon, birds, and marine mammals were also observed south of Cape Blanco than north. Occasional onshore advection events of Columbia River Plume water were also noted. Researchers worked with the GLOBEC biologists to understand these results. To date, most of the effort was expended collecting these long-term data sets. The first paper was presented orally at several meetings. The GLOBEC synthesis phase begins in FY05.

PUBLICATION:

Ramp, S.R., Bahr, F.L., and Venegas, R., "Seasonal variability of the upwelling process south of Cape Blanco, OR," 2003, (in advanced preparation).

PRESENTATIONS:

Ramp, S.R., Bahr F.L., and Venegas, R., "Seasonal variability of the upwelling process south of Cape Blanco, OR," GLOBEC Annual PI Meeting, Portland, OR, January 2004.

Ramp, S.R., Bahr F.L., and Venegas, R., "Seasonal variability of the upwelling process south of Cape Blanco, OR," AGU Ocean Sciences Meeting, Portland, OR, January 2004.

KEYWORDS: Coastal Oceanography, Upwelling Fronts, Ecosystem Dynamics, GLOBEC

HYPERSPECTRAL RADIOMETER FOR AIRBORNE DEPLOYMENT

Steven R. Ramp, Research Professor
Department of Oceanography
Sponsor: Office of Naval Research

SUMMARY: The goal of this research was to augment forty flights over Monterey Bay (funded separately) with a simple hyperspectral radiometer to observe surface leaving light field quantities from 350 to 850 nm in 2.6 nm bands. The data was used in support of the Autonomous Ocean Sampling Network (AOSN)-II program during August 2003, when several closely related in-situ data sets were collected, and in support of Naval officer education at the Naval Postgraduate School.

OCEANOGRAPHY

PROCESSES IN MARGINAL SEAS: SOUTH CHINA SEA
Steven R. Ramp, Research Professor
Department of Oceanography
Sponsor: Office of Naval Research

SUMMARY: A combined acoustics and physical oceanography field experiment was conducted to investigate the impact of oceanographic variability and bottom structure on the propagation of low-to-intermediate frequency (50-4000 Hz) sound on and onto the continental shelf in the South China Sea (ASIAEX). Field-work was planned from the *R/V ROGER REVELLE* during both 2000 and 2001 in the shelfbreak region between Taiwan and Dong-Sha Island. This research focused on the collection and analysis of the shipboard CTD (conductivity, temperature, and depth), ADCP (acoustic Doppler profile), and IMET (improved meteorology) observations from both cruises, and on continued cooperation with the acousticians, moored observations team, SeaSoar observations group, and the international community. Analysis and synthesis of these measurements should provide new insights into the detailed physics of acoustic transmission in this complex littoral environment.

DoD KEY TECHNOLOGY AREAS: Battlespace Dominance, Environmental Prediction

KEYWORDS: Coastal Oceanography, Environmental Acoustics, South China Sea

INVESTIGATION OF SOURCE OF HUNTINGTON BEACH SEWAGE CONTAMINATION
Leslie K. Rosenfeld, Research Associate Professor
Department of Oceanography
Sponsor: Orange County Sanitation District

OBJECTIVE: To determine whether Orange County Sanitation District's (OCSD) ocean outfall could be the source of sewage contamination to the surf zone off Huntington Beach, California.

SUMMARY: During 2001, a multi-agency field project was undertaken to determine whether OCSD's ocean outfall could be the source of bacterial contamination causing closures of Huntington Beach in the summertime. This project was essentially completed in 2003. A number of coastal ocean transport processes, including internal tides, seabreeze-driven flow, upwelling, and topographic steering, were examined. Additionally, the spatial and temporal patterns of the beach contamination were determined and compared with the coastal ocean processes. It was concluded that it was very unlikely that OCSD's ocean outfall was the source of the beach contamination. This has been confirmed by the fact that OCSD now chlorinates their waste, thus killing the bacteria, and the bacterial contamination at the beach is undiminished.

PRESENTATION:

Rosenfeld, L.K., "Fecal indicator bacteria patterns in the Huntington Beach Surf Zone," 50th Eastern Pacific Ocean Meeting, Wrigley Marine Science Center, Catalina Island, CA, 24-27 September 2003.

THESIS DIRECTED:

Taylor, K., "An Investigation of Diurnal Variability in Winds and Ocean Currents off Huntington Beach, CA," Master's Thesis, Naval Postgraduate School, February 2003.

KEYWORDS: Coastal Circulation, Sewage Outfalls, Huntington Beach

OCEANOGRAPHY

SEDIMENT TRANSPORT IN MONTEREY CANYON
Leslie K. Rosenfeld, Research Associate Professor
Department of Oceanography
Sponsor: U.S. Geological Survey

OBJECTIVE: To investigate the deep current structure and sediment transport in the region of a significant bend in Monterey Submarine Canyon.

SUMMARY: In the fall of 2002, the mooring array was designed, parts were ordered, and instruments were prepared. In December of 2002, three moorings supporting instrumentation to measure temperature, salinity, velocity, light transmission, and particle settling were deployed in Monterey Submarine Canyon. The moorings were recovered in November 2003. While the near-bed instrumentation from two moorings was lost, the mooring design worked as planned, allowing recovery of the upper portions of all three moorings. Dramatic evidence of multiple turbidity flows was gathered, and a manuscript describing these was in preparation.

KEYWORDS: Submarine Canyon, Monterey Bay, Sediment Transport

USE OF A CIRCULATION MODEL TO ENHANCE PREDICTABILITY OF
BIOLUMINESCENCE IN THE COASTAL OCEAN
Leslie K. Rosenfeld, Research Associate Professor
Jeffrey D. Paduan, Associate Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: To apply output from a data assimilating, high-resolution model to the short-term prediction of bioluminescence in the coastal ocean. Prediction of the bioluminescence potential is critical for numerous Naval operations, including preventing detection of covert operations involving submarines, Swimmer Delivery Vehicles and AUVs, and – conversely - in aiding detection of enemy incursions. The long-term objective is to contribute to the development of the components of limited area, open boundary, coastal nowcast/forecast systems that will resolve the time and length scales of the relevant physical-biological dynamics in shallow coastal environments.

SUMMARY: Results from particle-tracking and tracer simulation experiments run with a primitive equation hydrodynamic numerical model were compared with three field experiments: the MUSE experiment of 2000, the Monterey Bay Aquarium Research Institute (MBARI) Spoke cruise of August 2002, and the more extensive Autonomous Ocean Sampling Network (AOSN) experiment in August 2003. Additionally, a significant enhancement to the hydrodynamic model was made by including tidal forcing. Comparisons with sea level observations have led to some initial corrections. There was good agreement between model-predicted and observed sea levels at coastal tidal stations, but further analysis and testing is ongoing. Also, tuning of model tidal currents is needed as well as analysis of model internal tides predictions in the Monterey Bay.

PUBLICATION:

Shulman, I., Haddock, S.H.D., McGillicuddy, D.J., Paduan, J.D., and Bissett, W.P., "Numerical modeling of bioluminescence distributions in the coastal ocean," *Journal of Atmospheric and Oceanic Technology*, 20: 1060-1068, 2003.

PRESENTATIONS:

Shulman, I., Paduan, J.D., Rosenfeld, L.K., Ramp, S.R., and Kindle, J.C., "Modeling study of the coastal upwelling system of the Monterey Bay area during 1999 and 2000," Terrain-Following Ocean Models Users Workshop, Seattle, WA, 4-6 August 2003.

Shulman, I., Paduan, J.D., Rosenfeld, L.K., Ramp, S.R., and Kindle, J.C., "Modeling study of the coastal upwelling system of the Monterey Bay area during 1999 and 2000," 31st Conference on Radar Meteorology and the Fifth Conference on Coastal Atmospheric and Oceanic Prediction and Processes (Joint Session, Coastal Weather and Ocean Processes), Seattle, WA, 6-7 August 2003.

KEYWORDS: HF Radar, Ocean Currents, Tides, Bioluminescence

APPLICATION OF PARALLEL OCEAN AND CLIMATE MODELS TO DECADE/CENTURY PREDICTION
Albert J. Semtner, Professor
Wieslaw Maslowski, Research Associate Professor
Julie L. McClean, Research Associate Professor
Robin Tokmakian, Research Associate Professor
Department of Oceanography
Sponsors: U.S. Department of Energy, Naval Postgraduate School

OBJECTIVE: To use ocean, atmosphere, and ice models developed during earlier research under the Department of Energy (DOE) Computer Hardware, Advanced Mathematics, and Model Physics (CHAMMP) Program in order to simulate realistic climate states using advanced parallel computers. To understand physical processes that affect oceanic predictability and climatic fluctuations or change.

SUMMARY: This project was in its sixth of seven years. Extensive simulations were carried out the previous year. The current year research used various advanced models to analyze the variability of ocean and ocean-ice circulation at relatively high resolution. The Naval Postgraduate School group collaborated with large climate modeling efforts at Los Alamos and at the National Center for Atmospheric Research.

PRESENTATIONS:

Semtner, A.J., "Computing needs of very large heterogeneous applications," Meeting of the National Academy of Sciences Committee on the Future of Supercomputing, Santa Fe, NM, 24-26 September 2003.

Semtner, A.J., "High resolution ocean and ice modeling on U.S. and Japanese supercomputers," National Academy of Sciences Committee Meeting on the Future of Supercomputing, Washington, D.C., 13-14 March 2003.

KEYWORDS: Numerical Modeling, Ocean Prediction, Parallel Computing

DEVELOPMENT OF A GEODESIC CLIMATE MODEL WITH QUASI-LAGRANGIAN VERTICAL COORDINATES
Albert J. Semtner, Professor
Department of Oceanography
Sponsor: Colorado State University

OBJECTIVE: To participate in a Cooperative Agreement between Colorado State University and the U.S. Department of Energy and build a new climate model in which the vertical coordinate will be better suited to represent physical processes and minimize spurious computational diffusion. The horizontal gridding of all model components will be based on approximately equal area subdivisions of the faces of an icosohedral decomposition of the earth's surface.

SUMMARY: The five-year project was in its second year. The Naval Postgraduate School (NPS) Oceanography Department took the lead in designing numerically consistent operators of the gradient and divergence operators in hexagonal coordinates for use with the stress tensor of the sea-ice model's dynamics. The NPS Principal Investigator interacted with other investigators in the cooperative activity to

produce a geodesic sea-ice model, which was coupled to Los Alamos' geodesic ocean model for tests in an Arctic context by NPS investigators.

PRESENTATION:

Stark, D., "Sea-ice model development in geodesic coordinates," Santa Fe, NM, 13-14 August 2003.

KEYWORDS: Numerical Modeling, Ocean Prediction, Parallel Computing

UNDERSTANDING ANTARCTIC SEA ICE AND OCEAN INTERACTIONS USING HIGH RESOLUTION GLOBAL ICE-OCEAN MODELS
Albert J. Semtner, Professor
Department of Oceanography
Sponsor: National Science Foundation

OBJECTIVE: To simulate the Southern Ocean and its sea ice in order to analyze and understand the dynamics of the coupled system, including aspects of polynya formation and maintenance, water mass transformation, and bottom water formation.

SUMMARY: A no-cost one-year automatic extension was granted to accomplish the goals of the project. The restarted research was proceeding with coupled simulations in progress using the Los Alamos ocean and ice models (POP and CICE, respectively).

KEYWORDS: Sea Ice, Southern Ocean, Numerical Modeling, Supercomputing

AUTONOMOUS OCEAN FLUX BUOYS FOR ARCTIC STUDIES
Timothy P. Stanton, Research Associate Professor
Department of Oceanography
Sponsor: National Science Foundation

OBJECTIVES: To measure vertical heat and salt fluxes in the central Arctic Ocean over year-long intervals to observe inter-annual changes in upper ocean vertical fluxes, and to improve large-scale numerical models of polar regions. A series of autonomous ocean flux buoys were deployed at the North Pole Environmental Observatory (NPEO) ice camp as a component of the SEARCH program each April for the last three years. The buoys support instruments, processing routines, and Iridium data transfer techniques developed in the Principal Investigator's research group, to provide detailed measurements of turbulent momentum, heat and salinity fluxes without requiring manned ice-camps in the central Arctic.

SUMMARY: Analysis of the 2003 NPEO flux buoy deployment was completed with the collaborative publication of a year-long measurement of ocean heat flux in the central Arctic (McPhee, et al., 2003). This paper included a comparison of year-long vertical heat flux measurements made from the manned AIDJEX (1976) and SHEBA (1997) ice camps, and demonstrated remarkable similarity between seasonal time-scale time series from these different years measured in different regions of the Arctic. The second autonomous flux buoy was successfully deployed in April 2003, and has provided mean and spectral flux estimates and current / shear profiles every two hours throughout the year. The Iridium modem data transfers reliably transferred these large data sets directly into a workstation at the Naval Postgraduate School. A technological paper describing the flux buoy development was prepared.

PUBLICATION:

McPhee, M.G., Kikuchi, T., Morison, J.H., and Stanton, T.P., "Ocean-to-ice heat flux at the North Pole Environmental Observatory," *Geophysical Research Letters*, 30(24), 2274, 2003.

KEYWORDS: Ocean Mixed Layer, Polar Oceans, Mixed Layer Dynamics

OCEANOGRAPHY

MODELING THERMOBARIC EFFECTS IN ANTARCTIC DEEP OCEAN CONVECTION
Timothy P. Stanton, Research Associate Professor
Department of Oceanography
Sponsor: National Science Foundation

OBJECTIVES: To assess the role of thermobaric compressibility of seawater in providing an internal source of turbulent kinetic energy that can result in deep convection. Many of the T/S profile observations near Maud Rise in the Weddell Sea during ANZFLUX show that the water column is only marginally stable to thermobaric convection. The objective of this research was to perform numerical modeling of this upper ocean system based on ANZFLUX observations to further understand the process, and to guide the development of a future observational program.

SUMMARY: If water parcels from the deep mixed layer are moved by strong surface forcing below a weak, preconditioned pycnocline, typical of the Maud Rise area in the Weddell Sea, the parcel can become negatively buoyant due to nonlinearity in the equation of state for seawater. If this happens, the water parcel could continue to descend through the water column, generating further turbulence as it falls, potentially causing full overturning of the whole water column. A massive overturning event is known to have occurred during the late 1970s when the Weddell Polyna remained ice-free for two winters, causing a massive ventilation of the ocean interior.

During the second year of this program, a high resolution Large Eddy Simulation (LES) model was used to simulate the evolution of the water column using ANZFLUX profiles for an initial condition, with wind forcing timeseries measured during the ANZFLUX experiment forcing the model's ice-covered surface. The modeling work has demonstrated that thermobaric terms do indeed contribute to the negative buoyancy flux in the water column. A manuscript reporting these LES model results has been submitted to *Progress in Oceanography*. These results have also been used to design an observational program in the Weddell Sea and to compete for National Science Foundation funds for the new observational program. In March 2003, a post doctoral researcher joined the research team and has continued analysis of ANZLFUX turbulence data and turbulent parameterizations in the LES model runs.

KEYWORDS: Ocean Mixed Layer, Polar Oceans, Mixed Layer Dynamics

OBSERVATION OF VELOCITY FIELDS AND STRATIFICATION UNDER WIND-FORCED WAVES DURING CBLAST
Timothy P. Stanton, Research Associate Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVES: To measure and model the transfer of wind stress through surface turbulence and waves at the air-sea interface. This momentum transfer via surface gravity waves remains poorly understood due primarily to the difficulties of measuring turbulence immediately below the wave surface.

SUMMARY: A one-year delay in the Martha's Vineyard field experiment occurred in 2002 due to construction problems for the MV research tower. However, the large collaborative field program for CBLAST was successfully executed during the summer near Woods Hole. A six-day observation of wave and turbulent structure directly up into the crest-trough region of breaking waves was made from a tide-following instrumented frame in limited fetch wave conditions with winds between 2 and 12 m/s. These unique observations of the velocity field below wind waves were made with a five beam Bistatic Coherent Doppler Velocity Profiler (BCDVP) built explicitly to measure near-surface stress and shear and wind waves. Surface-following stress and shear production algorithms were developed to analyze these detailed velocity profile timeseries, and preliminary results were presented at the Ocean Sciences meeting in February 2004. A student analyzed a two month record into winter conditions of water column velocity structure at the ASIT tower offshore from Martha's Vineyard to study the contribution of Langmuir circulation to water column stress in a coastal setting, where there is also a strong influence of a tidally driven bottom boundary layer on the water column structure.

OCEANOGRAPHY

OBSERVATIONS OF WATER COLUMN STRATIFICATION AND TURBULENCE DURING THE CBLAST LOW-WIND EXPERIMENT

Timothy P. Stanton, Research Associate Professor
DEPARTMENT OF OCEANOGRAPHY
Sponsor: Office of Naval Research

SUMMARY: High-resolution measurements of the velocity field directly below moderately forced wind waves were made under existing Office of Naval Research (ONR) funding as a component of the CBLAST air-sea interaction defense-research initiative. The objective of this supplemental research was to make continuous profile measurements of stratification and optical properties at the same site, offshore from Martha's Vineyard, to determine the water column response to surface fluxes, and to assess the impact of near-surface stratification cycles on the near-surface distribution of turbulence.

KEYWORDS: Water Column, Stratificaton, Surface Flux, Martha's Vineyard

THE ROLE OF ICE-OCEAN EXCHANGE IN ICE-ALBEDO FEEDBACK IN THE CENTRAL ARCTIC

Timothy P. Stanton, Research Associate Professor
Department of Oceanography
Sponsor: National Science Foundation, Office of Polar Programs

OBJECTIVES: To measure the mixed layer and upper ocean heat content and heat fluxes in the central Arctic Ocean, and to use these observations to improve large-scale numerical models of polar regions. This work is a component of the multidisciplinary SHEBA program that has the objectives of improving parameterizations of the coupled atmosphere-ice-ocean system in the Arctic to improve the predictive capabilities of global climate models. A shorter process study focused on the role of ice keels in the surface heat balance

SUMMARY: Analysis of the detailed, year-long CTD and microstructure profile time series measured during the SHEBA field program as the ice camp drifted in the central Arctic ocean was completed. This analysis, in collaboration with postdoctoral researcher Bill Shaw, has successfully combined the dual, redundant, C / T sensors on the CTD to provide a "glitch-free," well calibrated profile time series of temperature, salinity, density, and optical transmission, which will be submitted to the final form SHEBA archive in 2004. A method of distinguishing inactive thermal fine structure from turbulent microstructure using the dual-sensor microstructure package developed at the Naval Postgraduate School (NPS) was used to produce profile time series of turbulent thermal heat flux and pycnocline diffusivity for the full time series. A manuscript describing this analysis is underway. On-going comparisons are being made between the SHEBA time series and Wieslaw Maslowski's high resolution Arctic Basin model now integrated through the SHEBA years to understand recent changes in pycnocline heat content and parameterizations of vertical diffusivity in the model. A dataset comparing mixed layer ocean fluxes downstream from deep ice keels and under un-rafted multi year ice contributed to a LES modeling study of ice keels (Skyllingstad, et al., 2003).

OCEANOGRAPHY

DEVELOPMENT AND VERIFICATION OF A COMPREHENSIVE COMMUNITY MODEL FOR PHYSICAL PROCESSES IN THE NEARSHORE OCEAN

Edward B. Thornton, Professor
Department of Oceanography
Sponsor: Office of Naval Research

SUMMARY: This research was part of a collaborative project with scientists at other U.S. institutions. The main objective was to develop and validate a comprehensive community model for predicting waves, currents, and evolving bathymetry in the nearshore region.

KEYWORDS: Nearshore Ocean, Community Model

EVOLUTION OF RIP CURRENTS AND MORPHOLOGY: FIELD EXPERIMENTS AND NUMERICAL MODELING

Edward B. Thornton, Professor
Timothy P. Stanton, Research Associate Professor
Department of Oceanography
Sponsor: National Science Foundation

OBJECTIVE: To predict the evolution of rip current systems and underlying morphology given the offshore wave conditions.

SUMMARY: Rip current system dynamics as observed during the RIPEX experiment were analyzed and modeled. RIPEX was conducted at Sand City, California, in the southern Monterey Bay, in April-May 2001, during a time of well-developed rip currents. This represents the first comprehensive field measurement of rip currents. Arrays of current and pressure sensors in the cross-shore and alongshore measured the mean, very-low frequency (0.0001-0.004 Hz), infragravity (0.004-0.04 Hz), and sea-swell (0.04-1 Hz) motions and sea-surface elevations. At the infragravity frequencies, the alongshore array indicated that there is significant energy in the cross-shore velocities and that there is little alongshore spatial variation, even in the presence of rip channels. The infragravity velocities are smaller within the rip channel than on the shore connected shallowing to differences in water depth. Rip current pulsations at the infragravity band frequencies are linked to the standing infragravity motions, as opposed to the ponding and subsequent release of water by wave group pumping (MacMahan, et al., 2003a).

The morphodynamic response of an embayed beach induced by wave groups generated by a directionally broad wave spectrum with mean angle normally incident is examined with a numerical model (Reniers, et al., 2003a). The model utilizes the nonlinear shallow water equations to phase resolve the mean and infragravity motion in combination with an advection-diffusion equation for sediment transport. Starting with an initially alongshore uniform barred beach, the bathymetry evolves to the shoals cut by quasi-periodic rip channels. Without directional spreading, the smallest alongshore separation is obtained and the beach response is self-organizing in nature. Introducing directional spreading results in a limited range of preferred spacing between rip channels, qualitatively similar to observations. The hypothesized correlation between the observed rip spacing and wave group forced edge waves over the initially alongshore uniform bathymetry is not found. However, there is a correlation between the alongshore lengths of the wave-group induced quasi-steady flow circulations (very-low frequency oscillations) and the rip current spacing. This suggest that the scouring associated with the flow circulations of the initial wave groups triggers the development of rip channels via a positive feedback mechanism in which the small scour holes start attracting more and more discharge.

Energetic very low frequency motions (frequencies <0.004Hz) (VLF) were observed during RIPEX. The VLF's are found outside the gravity region in alongshore wave number, k_y, space within the very low frequency band and do not appear to exist in higher frequency bands. The VLF's are significant ($U_{rms,vlf} \sim$ 0.25m/s) and are sconstant in intensity alongshore within the surf zone (shore-connected shoals and rip channels) and rapidly decrease offshore. The alongshore and cross-shore VLF velocity variances are similar in magnitude. VLF velocities are not surface driven and not correlated with rip current flow ($r^2 = 0.2$). F- k_y spectral estimates show a strong relationship with rip channel spacing ($k_y = \pm 0.00m^{-1}$) and VLF cross-shore velocities, and minimal VLF alongshore velocity variation ($k_y = 0m^{-1}$). The data analysis suggests that the VLF's are not simply instabilities of an unstable rip current jet as observed in the laboratory. A simple conceptual model suggest the f- k_y VLF spectra can be explained by the entire rip current vorticity cells oscillating in the cross-shore and alongshore (MacMahan, et al., 2003b).

PUBLICATIONS:

Gallagher, E.L., Thornton, E.B., and Stanton, T.P., "Sand bed roughness in the nearshore," *Journal of Geophysical Research*, 108 (C2), 21-1-8, 2003.

MacMahan, J., Reniers, A.J.H.M., Stanton, T.P., and Thornton, E.B., "Rip currents on a shore-connected shoal beach," *Marine Geology*, (submitted).

MacMahan, J., Reniers, A.J.H.M., Thornton, E.B., and Stanton, T.P., "Infragravity rip-current pulsations," *Journal of Geophysical Research,* 109, C01033, doi:10.1029/2003JC002068, 2004.

MacMahan, J., Reniers, A.J.H.M., Thornton, E.B., and Stanton, T.P., "Very low frequency motions on a complex beach," *Journal of Geophysical Research*, (submitted).

Reniers, A.J.H.M., Thornton, E.B., and Roelvink, J.A., "Morphodynamic modeling of an embayed beach under wave-group forcing," *Journal of Geophysical Research,* 109, C01030, doi:10.1029/2002JC001586, 2004.

Saulter, A.N., Russell, P.E., Miles, J.R., and Gallagher, E.L., "Observations of bed level change in a saturated surf zone," *Journal of Geophysical Research*, 108 (C4), 9-1-15, 2003.

CONFERENCE PUBLICATION:

MacMahan, J., Reniers, A.J.H.M, Thornton, E.B., Stanton, T.P., "RIPEX - rip pulsation measurements," *Proceedings of the 27th International Conference on Coastal Engineering*, *ASCE*, Sydney, Australia, 2002.

PRESENTATIONS:

MacMahan, J., Reniers, A.J.H.M., Thornton, E.B., and Stanton, T.P., "RIPEX: Characteristics of very low frequency motions," Fall Meeting American Geophysical Union, San Francisco, CA, 10-14 December 2002.

MacMahan, J., Thornton, E.B., Stanton, T.P., Reniers, A., and Dean, R., "RIPEX: Rip-current pulsation measurements," 28th International Coastal Engineering Conference, Cardiff, Wales, UK, July 2002.

Stanton, T.P., Weltmer, M.A., and Thornton, E.B., "Sediment transport by sand ripples within the surf zone," Fall Meeting, American Geophysical Union, San Francisco, CA, 10-14 December 2002.

THESIS DIRECTED:

Holt, R., "Rip Current Spacing in Relation to Wave Energetics and Directional Spreading," Master's Thesis, Naval Postgraduate School, June 2003.

KEYWORDS: Rip Currents, Waves, Morphology

OCEANOGRAPHY

MEGARIPPLES IN THE SURF ZONE
Edward B. Thornton, Professor
Department of Oceanography
Sponsor: National Science Foundation

SUMMARY: To measure, analyze, and model small-scale morphology, focusing on megaripples (bedforms with heights up to 50cm and lengths of 1-10m). Megaripple data and bottom stress measurements acquired during the Sandyduck experiment were analyzed. It was proposed to participate in two Coast 3D comprehensive nearshore experiments in Holland (1998) and England (1999) using their WESP vehicles to mount the array of acoustic altimeters and side-scan sonar to measure megaripples in the nearshore. In addition, researchers measured bottom shear stress using SonTek acoustic Doppler velocimeters. The data was analyzed to test predictive models and test hypotheses concerning the generation, orientation, and effect on the hydrodynamics of megaripples.

NEAR SHORE WAVE PROCESSES
Edward B. Thornton, Professor
Timothy P. Stanton, Research Associate Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: To predict the wave-induced, three-dimensional velocity field and induced sediment transport over arbitrary bathymetry in the near shore given the offshore wave conditions.

SUMMARY: Numerical model computations of infragravity motions were compared with measurements obtained during the RIP-current EXperiment (RIPEX) in concert with the Steep Beach Experiment (SBE). The experiments were performed at Sand City, Monterey Bay, California, during the spring of 2001. The nearshore bathymetry was made up of shore-connected shoals incised by relatively narrow rip channels spaced approximately 125 m apart. The comparison considered a 24-day period during which significant changes in both the offshore wave climate and nearshore bathymetry occurred. Analysis from the alongshore array (MacMahan, et al., 2003c) indicated that there was significant energy in the cross-shore infragravity velocities, and that there was little alongshore spatial variation, even in the presence of rip channels. Rip current pulsations at the infragravity band frequencies were found linked to the infragravity motions of the bound and free long waves, as opposed to forcing by dynamic hydraulic head (wave set-up) associated with incoming short-wave groups with preferred drainage through the rip channels.

Observations of vertical distribution of cross-shore and alongshore flows during the Sandy Duck experiment were compared with model predictions to assess the parameters governing the flow behavior (Reniers, et al., 2003c). Observations during breaking wave conditions showed that the maximum return flow velocities occurred in the lower part of the water column, and under non-breaking conditions, the maximum return flow velocities were closer to the water surface. The measured longshore current velocity profiles were logarithmic under non-breaking conditions and became more depth-uniform under breaking conditions, in line with previous observations.

PUBLICATIONS:

Chen, Q., Kirby, J.T., Dalrymple, R.A., Shi, F., and Thornton, E.B., "Boussinesq modeling of longshore currents," *Journal of Geophysical Research*, 108 (C11), 3362, doi:10.1029/2002JC001308, 2003.

Elgar, S., Gallagher, E., Guza, R.T., and Thornton, E.B., "Estimating nearshore seafloor roughness with altimeters," *Marine Geology*, (submitted).

Feddersen, F., Gallagher, E.L., Guza, R.T., and Elgar, S., "The drag coefficient in the nearshore," *Journal of Geophysical Research*, (submitted).

Morris, B., Thornton, E.B., and Reniers, A., "Calibration of a random wave model extended to long period swell," *Journal of Waterway, Port, Coastal, and Ocean Engineering*, (submitted).

Reniers, A.J.H.M., Thornton, E.B., Stanton, T., and Roelvink, J.A., "Vertical flow structure during SandyDuck: observations and modeling," *Journal of Waterway, Port, Coastal, and Ocean Engineering*, 2003, (in press).

Reniers, A.J.H.M., van Dongeren, A., Battjes, J., and Thornton, E.B., "Linear modeling of infragravity waves during Delilah," *Journal of Geophysical Research*, 107 (C10), 1-1-18, 2002.

PRESENTATIONS:

Chopakatla, S.C., Lippmann, T.C., Richardson, J.E., Thornton, E.B., and Holman, R.A., "A CFD model for wave transformation and breaking in the surf zone," Fall Meeting, American Geophysical Union, San Francisco, CA, 10-14 December 2002.

Foster, D., Natoo, P., Stanton, T., Fredsoe, J., and Thornton, E., "Evaluation of three bed load transport models," 28th International Coastal Engineering Conference, Cardiff, Wales, UK, July 2002.

Natoo, P., Foster, D.L., and Stanton, T., "Spatial variation of near bed concentrations," Fall Meeting, American Geophysical Union, San Francisco, CA, 10-14 December 2002.

Reniers, A., MacMahan, J., Thornton, E., and Stanton, T., "The origin of VLF-motions during RIPEX," Fall Meeting, American Geophysical Union, San Francisco, CA, 10-14 December 2002.

Thornton, E.B., Stanton, T.P., and Reniers, A.J.H.M., "Wave reflection on a steep beach," Fall Meeting, American Geophysical Union, San Francisco, CA, 10-14 December 2002.

Thornton, E., Stanton, T., and Reniers, A.J.H.M., "Wave reflection on a steep beach," 28th International Coastal Engineering Conference, Cardiff, Wales, UK, July 2002.

THESES DIRECTED:

Morichon, D., "Numerical Model of Nonlinear, Random Breaking Waves," Ph.D. Dissertation, University of Quebec, June 2003, (dissertation co-advisor).

Welsch, C.A., "Assessment of Delft3D Morphologic Model During Duck94," Master's Thesis, Naval Postgraduate School, September 2002.

Weltmer, M.A., "Bedform Evolution and Sediment Transport Under Breaking Waves," Master's Thesis, Naval Postgraduate School, March 2003.

KEYWORDS: Nearshore, Waves, Surf

INTERANNUAL TO DECADAL OCEAN VARIABILITY AND PREDICTABILITY
Robin Tokmakian, Research Associate Professor
Department of Oceanography
Sponsor: National Aeronautics and Space Administration

OBJECTIVE: This project extended research funded under Topex/Poseidon Extended Mission NASA Research Announcement. This research was continued by combining eddy resolving ocean model simulations and altimeter data to understand how predictable the variability in the ocean is and how much of it is related to the sea surface height signal. These high-resolution ocean models resulted in better representations of strong ocean currents and their heat and salt transports, as well as forced and spontaneous modes of variability that limit predictability. Through the use of the long time series of reanalyzed surface forcing fields provided by the world's meteorological agencies, the evolution of the global ocean could be simulated for extended periods.

The goal of the research was accomplished by further analyses to determine the accuracy of ocean variability in simulations of 20 years with high resolution models, in part with T/P and JASON-1 data; conducted ensemble simulations with variations of forcing prediction runs of a coupled ocean-ice atmosphere model with T/P and OPR JASON-1 altimetry data contributing to the initialization of model fields. The simulations were conducted on non-National Aeronautics and Space Administration (NASA) computers, which were available through complimentary research grants.

SUMMARY: The first paper listed continued the analysis of a one quarter degree POCM 20 year simulation, evaluated in terms of the heat content of the upper ocean and how it might relate to changes in the fisheries of the North East Pacific (Ref. Tokmakian, R., "Monitoring North Pacific Heat Content Variability; An Indicator of Fish Quantity?" *Earth Interactions*, 2004). Analysis showed that using altimeter data sampled across the basin might be useful as a tool to understand and predict changes to the fisheries on a broad scale because it reflects the change in temperature of the upper waters.

Second, this project evaluated an ocean simulation at 0.1 degrees resolution of the North Atlantic forced with winds from observed scatterometer winds. Two simulations of the North Atlantic were run using the parallel ocean processing (POP) ocean model for approximately two and one half years each. One simulation used the 1.25 degrees wind product from ECMWF and the other used the JPL Quikscat 0.25 degrees gridded product. The resulting sea level anomaly fields from the simulations were quantified by using tide gauge and altimetric sea level anomaly data. In addition, upper ocean quantities, such as the mix layer depths, were compared to understand the difference in the ocean's response when using the different wind products. The analysis found that significant improvements were made in the representation at the surface and in particular areas where comparison data exists, such as the Labrador Sea. There was also improvement in the scatterometer forced run with more realistic depths of the mixed layer. A paper was submitted to *Ocean Modeling* (Tokmakian, R., "An Ocean Model's Response to Scatterometer Winds," 2003).

Last, a 40 year ocean simulation was completed which will aid understanding of the characteristic changes on decadal scales, and help understand and characterize the variability of the Topex/Poseidon/Jason period in the context of 40 years of SSH variability of the model.

PUBLICATIONS:

Gille, S.T., Metzger, E.J., and Tokmakian, R., "Sea floor topography and ocean circulation," *Oceanography,* 17, 2004, (in press).

Tokmakian, R., "An ocean model's response to scatterometer winds," *Ocean Modeling*, 2003, (in review).

Tokmakian, R., "Monitoring North Pacific heat content variability; An indicator of fish quantity?" *Earth Interactions (AGU publication)*, 2003.

Tokmakian, R. and McClean, J., "How realistic is the high frequency signal of a 0.1 degree resolution ocean model," *Journal of Geophysical Research*, 108, 3115, doi:10.1029/2002JC0014462003, 2003.

PRESENTATIONS:

Tokmakian, R., "An ocean model's response to scatterometer winds," TPSWT, Arles, France, 2003.

Tokmakian, R., "Progress in a 40-year ocean simulation," CCPP Workshop, Charleston, SC, 17-19 March 2003.

KEYWORDS: Environment, Prediction, Supercomputing, Satellite Altimetry

DEPARTMENT OF OCEANOGRAPHY

2003
Faculty Publications
and Presentations

OCEANOGRAPHY

JOURNAL PAPERS

Ardhuin, F., Herbers, T.H.C., Jessen, P.F., and O'Reilly, W.C., "Swell transformation across the continental shelf. Part II. Validation of a spectral energy balance equation," *Journal of Physical Oceanography*, 33(9), 1940-1953, 2003.

Ardhuin, F., O'Reilly, W.C., Herbers, T.H.C., and Jessen, P.F., "Swell transformation across the continental shelf. Part I. Attenuation and directional broadening," *Journal of Physical Oceanography*, 33(9), 1921-1939, 2003.

Chao, Y., Li, Z., Kindle, J., Paduan, J., and Chavez, F., "A high-resolution surface vector wind product for coastal oceans: Blending satellite scatterometer measurements with regional mesoscale atmospheric model simulations," *Geophysical Research Letters,* 30, 13-1 to 13-4, 2003.

Collins, C., Castro, C.G., Pennington, J.T., Rago, T.A., and Chavez, F.P., "The California Current System off Monterey, California: Physical and biological coupling," *Deep-Sea Research II*, 50, pp. 2389-2404, 2003.

Collins, C.A., Ivanov, L.M., and Melnichenko, O.V., "Seasonal variability of the California Current System observed from RAFOS floats, 1992 -2002," *Marine Hydrophysics Journal,* 3, pp. 9-22, 2003.

Elgar, S., Raubenheimer, B., and Herbers, T.H.C., "Bragg reflection of ocean waves from sandbars," *Geophysical Research Letters*, 30(1), 1016, doi:10.1029/2002GL016351, 2003.

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Tokmakian, R., "Progress in a 40-Year Ocean Simulation," *CCPP Workshop*, Charleston, SC, 17-19 March 2003.

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Chiu, C.-S., "ASIAEX SCS acoustics: Cross-shelf results," Commander, Naval Meteorology and Oceanography Command /Office of Naval Research/Naval Oceanographic Office/Naval Research Laboratory Meeting on ASIAEX Findings, Stennis Space Flight Center, MS, 20 May 2003.

Chiu, C.-S., "A discussion of current status and future directions in low-frequency, shallow-water acoustics," Office of Naval Research Shallow-Water Acoustics Workshop, Seattle, WA, 23-24 September 2003.

Chiu, C.-S., "TL uncertainty characterization and reduction," Office of Naval Research Uncertainty DRI Review and Planning Meeting, Providence, RI, 17-19 June 2003.

MEETING ABSTRACTS

Chiu, C.-S., Ramp, S., Miller, C., Lynch, J., Duda, T., Newhall, A., et al., "Measurement and analysis of acoustic intensity fluctuations induced by South China Sea internal solitons," 2003 ASIAEX Analysis Workshop, Taipei and Hua-Lien, Taiwan, 3-7 March 2003.

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CONTRIBUTION TO BOOK

Semtner, A., "National Academy of Sciences Committee on the Future of Supercomputing (including A. Semtner)," *The Future of Supercomputing: An Interim Report,* The National Academies Press, 58 pp., 2003.

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DEPARTMENT OF PHYSICS

WILLIAM MAIER
CHAIR

PHYSICS

OVERVIEW:

The Department of Physics has unique resources and faculty expertise dedicated to Weapon Systems Technologies.

CURRICULA SERVED:

- Combat Systems Science and Technology
- Applied Physics
- Engineering Acoustics

DEGREES GRANTED:

- Master of Science in Physics
- Master of Science in Applied Physics
- Master of Science in Engineering Acoustics
- Doctor of Philosophy

RESEARCH THRUSTS:

- Optical and Electromagnetic Signal Propagation, Detection and Sensor Systems
- Conventional and Nuclear Weapons and their Effects
- Underwater Acoustics
- Free Electron Laser Physics
- Physical Acoustics
- Solid State Physics

RESEARCH CHAIR:

- Lawrence Livermore National Laboratory Chair Professor
- Engineering Acoustics Chair Professor

RESEARCH FACILITIES:

- The Physics Laboratories are equipped to carry on instruction and research work in acoustics, atomic, and molecular physics, electro-optics, spectroscopy, laser physics, computational physics, optical propagation, sensor physics and transient electrical discharges.
- The Optical Physics and Sensors Laboratory uses imaging, spectroscopic and sensing systems from far infrared to ultraviolet wavelengths, including instrumentation for seagoing, airborne and ground-based measurements.
- The Acoustics Laboratory equipment includes a large anechoic chamber, a small reverberation chamber and a multiple-unit acoustics laboratory for student experimentation in acoustics in air. Sonar equipment, test and wave tanks and instrumentation for investigation in underwater sound comprise the Underwater Acoustics Laboratory, a scale-model of a shallow water waveguide for the study of environmentally adaptive sonar and high-speed digital acoustic communication. The Physical Acoustics Laboratories are equipped with a variety of modern data collection and processing equipment.
- Directed Energy Lab.

RESEARCH PROGRAM (Research and Academic)-FY2003:

The Naval Postgraduate School's sponsored program exceeded $71 million in FY2003. Sponsored programs included both research and educational activities funded from an external source. A profile of the sponsored program for the Department of Physics is provided below:
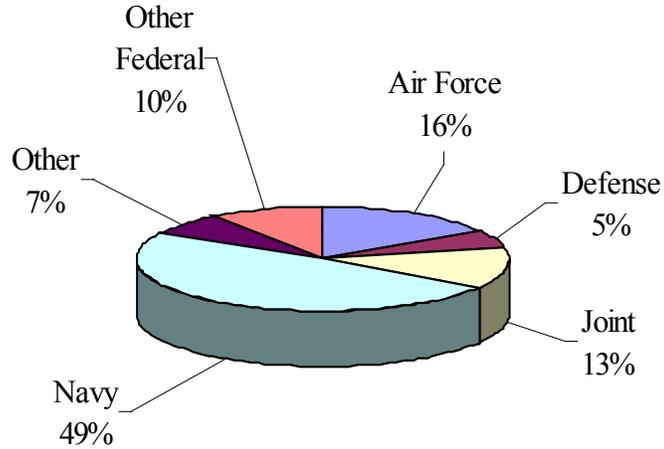
Size of Program: $3,185K

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DEVELOPMENT OF A FOUR-ELEMENT, END-FIRE ARRAY, SEISMO-ACOUSTIC SONAR SOURCE
Steven R. Baker, Associate Professor
Department of Physics
Sponsor: Naval Postgraduate School

OBJECTIVE: To develop and investigate the performance of a four-element, end-fire array, seismo-acoustic sonar-source concept.

SUMMARY: A four-element end-fire array, consisting of four vertical-motion inertial mass shakers spaced 25 cm apart (approximately one-quarter wavelength), was deployed on the sand in the near-surf zone of Del Monte Beach. The beam of the array was directed to end-fire by using a delay/pulse generator to individually trigger four function generators. Measurements of the directional pattern of the radiation were taken at a range of 3.5 m. Approximately 15 dB of suppression to the rear of the array relative to the forward direction was consistently achieved.

PUBLICATION:

Baker, S.R., Muir, T.G., Gaghan, F.E., Fitzpatrick, S.M., Sheetz, K.E., and Guy, J., "Seismic Sonar Sources for Buried Mine Detection," *Journal of the Acoustical Society of America,* 114, 2456, 2003.

CONFERENCE PUBLICATION:

Baker, S.R., Muir, T.G., Gaghan, F.E., Fitzpatrick, S.M., Sheetz, K.E., and Guy, J., "Seismic Sonar Sources for Buried Mine Detection," *146th Meeting of the Acoustical Society of America*, Austin, TX, 10-14 November 2003.

THESIS DIRECTED:

Rumph, S.E., "Development of a Four-Element End-Fire Array Seismo-Acoustic Sonar Source," Master's Thesis, Naval Postgraduate School, September 2003.

KEYWORDS: Seismo-Acoustic Sonar

RADAR IMAGE ESTIMATION AND MODEL ASSESSMENT BY SUBSPACE FITTING
Brett Borden, Associate Professor
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: To examine the nature of radar image artifacts and their relationship to scattering model mismatch with radar measurements. To develop a fitting scheme that will map these artifacts to corresponding components of correlation receiver data. To implement the scheme in appropriate (i.e., practicable) computational assets.

SUMMARY: This research is part of a continuing 6.1 effort to build a unified theory of radar imaging. The Principal Investigator's (PI) 2003 goals focused on designing a computer-efficient version of a method previously developed by the PI. The resulting code can be instantiated in existing Department of Defense (DoD) radar analysis platforms with only modest effort. The algorithm was tested and verified by applying it to a variety of real and synthetic radar data.

PUBLICATIONS:

Borden, B., "Radar Scattering Center Localization by the Variable Projection Method," *IEEE Transactions on Image Processing*, (in review).

Natterer, F., Cheney, M., and Borden, B., "Resolution for Radar and X-ray Tomography," *Inverse Problems*, 19, S55–S63, 2003, (special issue on *Inverse Problems in Imaging*).

CONFERENCE PUBLICATION:

Borden, B., "Problems in Image Construction from Radar Data," *Institute for Pure and Applied Mathematics (IPAM) Conference on Applied Inverse Problems: Theoretical and Computational Aspects (AIP2003)*, University of California Los Angeles, Los Angeles, CA, 18–23 May 2003, (invited Plenary Talk).

KEYWORDS: ISAR, Superresolution, Variable Projection Method

RADAR IMAGING OF TARGETS UNDER FOLIAGE CLUTTER
Brett Borden, Associate Professor
Department of Physics
Sponsor: Naval Postgraduate School

OBJECTIVE: Novel methods for applying low-resolution Foliage Penetrating Radar data (FOPEN) to the problem of target discovery and classification/recognition.

SUMMARY: The effort represents the first year of the Research Initiation Program that was awarded to the Principal Investigator (PI) by the Naval Postgraduate School (NPS). During this time the possibility of extending a "microlocal approach" to the problem was more completely examined (this was a continuation of work performed by the PI and his collaborator during FY02). In addition, a novel new scheme based on narrow frequency-domain signals was conceived and is in development.

PUBLICATION:

Borden, B. and Cheney, M., "Microlocal ISAR for Low Signal-to-Noise Environments," *IEEE Transactions on Image Processing*, (in review).

CONFERENCE PUBLICATIONS:

Borden, B., "ISAR for Low Signal-to-Chaff Environments," *Industrial Inverse Problems Workshop, IPAM Inverse Problems Semester*, University of California Los Angeles, Los Angeles, CA, 15–19 September 2003.

Cheney, M. and Borden, B., "Microlocal High Range Resolution ISAR for Low Signal-to-Noise Environments," *SPIE AeroSense*, Orlando, FL, 21–25 April 2003.

KEYWORDS: SAR, Doppler imaging, FOPEN

INVESTIGATION OF THE EFFECTS OF DETONATION MERGING ON UNDERWATER BLAST
Ronald E. Brown, Research Professor
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: The Office of Naval Research (ONR) and the Naval Surface Warfare Center (NSWC)-Indian Head have an on-going effort directed towards improving the energy coupling efficiencies of explosive warhead and underwater structures. The objective of this program is directed towards exploring and quantifying means for applying the detonation merging mechanism to focus and enhance the effectiveness of gaseous detonation products against underwater targets.

SUMMARY: This multi-year research project supports the SEA Power 21/Sea Shield/Under Sea Warfare goal of developing mechanisms for neutralizing submarine threats in the littoral and open ocean. It is a collaborative effort involving faculty (Ronald Brown, Ashok Gopinath, and Donald Wadsworth) in the Naval Postgraduate School (NPS) Departments of Physics, Mechanical Engineering, and Electrical and Computer Engineering. Dr. Brown is the Principal Investigator. Accomplishments during CY2003 included the validation of the Century Dynamics AUTODYN eulerian finite difference hydrodynamic code for simulating run-up from low-order to high order Chapman-Jouguet conditions, supra-pressure detonation, underwater bubble formation and collapse, and terminal effects to underwater structures, based on correlations with experimental results reported in the open literature and by NSWC and their contractors. Results of this study also correlated well with predictions from other codes, such as the Sandia CTH. As a result of this on-going work, new explosive configurations were conceived that have promise of amplifying explosive power. Experiments have been recommended for government test evaluation.

PRESENTATION:

Brown, R.E., Office of Naval Research UWT FY03 Workshop, April 2003.

TECHNICAL REPORT:

Brown, R.E. "Effect of Detonation Merging on Directed Blast," Naval Postgraduate School Annual Report, Contract N00014-WR-2-0285, 9 July 2003.

THESIS DIRECTED:

Moore, T.C., candidate for Master's Degree, Naval Postgraduate School, March 2004, (in preparation).

KEYWORDS: Detonation, Explosives, Underwater Warfare, Terminal Effects, Ordnance, Underwater Blast

UNDERWATER WARHEAD TECHNOLOGIES
Ronald E. Brown, Research Professor
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: To explore and quantify the potential for using combined effects of detonation merging and reactive shaped charge jetting mechanism for purposes of developing conceptual enhanced multi-purpose underwater warhead solutions that can be incorporated into future torpedo systems.

SUMMARY: This multi-year research project supports the SEA Power 21/Sea Shield/Under Sea Warfare goal of developing mechanisms for neutralizing submarine threats in the littoral and open ocean. It is a collaborative effort involving faculty (Ronald Brown, Ashok Gopinath, and Donald Wadsworth) in the NPS departments of physics, mechanical engineering, and electrical and computer engineering. Dr. Brown is the Principal Investigator. Accomplishments during CY03 included the validation of the Century Dynamics AUTODYN eulerian finite difference hydrodynamic code for simulating shaped charge jet formation, the formulation of approaches for increasing shaped charge terminal performance against complex underwater targets, and an estimation of the hypervelocity impact of hydro-reactive penetrators against complex targets. Also, collaborative relationships with the University of Illinois (Urbana-Champaign) and the University of Texas, Institute of Advanced Technology (Austin, Texas) were established for purposes of conducting joint chemical kinetics and gas-gun experiments, and for developing a multi-year government-industry-university program of milestones to assist the Office of Naval Research (ONR) project management.

CONFERENCE PUBLICATION:

Phua, T.C., Moore, T.C., and Brown, R.E, "Quantitative Code Evaluation for Predicting Shaped Charge Jet Stability and Characteristics," *Proceedings of the 21st International Symposium on Ballistics,* Adelaide, Australia, April 2004, (in publication).

PRESENTATION:

Brown, R.E., Office of Naval Research UWT FY03 Workshop, April 2003.

THESIS DIRECTED:

Phua, T.C., "Quantitative Code Evaluation for Predicting Shaped Charge Characteristics," Master's Thesis, Naval Postgraduate School, December 2003.

KEYWORDS: Shaped Charge, Detonation, Explosives, Underwater Warfare, Terminal Effects, Chemical Kinetics, Combustion

UNDERWATER WARHEAD TECHNOLOGY BASIC INVESTIGATION OF REACTIVE MATERIAL JETTING
Ronald E. Brown, Research Professor
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: To quantify mechanistic and kinetic details of the exothermic reaction between a hyper-velocity jet stream penetrating through water, and the development of a simulation code. This basic research program was sponsored during FY03 under the Office of Naval Research (ONR) University Laboratory Initiative (ULI). Proposed costs assume that the Naval Postgraduate School (NPS) will be able to secure funding to partially support an NRC Post Doctoral Fellow for the second and third year contract year.

SUMMARY: Assistance for initiating a parallel chemical kinetics research investigation at the University of Illinois (UC) was completed, a NRC/NAS Resident Research Associateship program was established and staffed (Dr. Linhbao Tran), and a model was developed for assessing the nearly explosive behavior of nano-aluminum thermitic compositions. It is speculated from this model and results of simulated explosive impact problems that enhanced effects from the impact of chemically reactive jets are possible. Techniques have also been developed to predict the pressures and temperatures that might be expected during the explosively accelerated collapse of reactive material shaped charge liners for the purpose of developing parameters for mitigating potential hazards and optimizing performance.

Partial NPS funding for the FY04 program was secured, in conjunction with the continuing ONR ULI grant.

PRESENTATION:

Brown, R.E., Office of Naval Research UWT FY03 Workshop, April 2003.

TECHNICAL REPORT:

Brown, R.E. "Fundamental Processes of the Combustion of Hydro-Reactive Metal Shaped Charge Jets," Naval Postgraduate School Annual Report, Contract N00014-03-WR-2-0303, July 2003.

KEYWORDS: Combustion, Chemical Kinetics, Nano-Technology, Shaped Charge

COMPUTATIONAL FREE ELECTRON LASER RESEARCH
W. B. Colson, Distinguished Professor
Department of Physics
Sponsor: Naval Sea Systems Command

OBJECTIVE: To develop computer simulation techniques and methods for the study of MW-class Free Electron Lasers (FEL).

SUMMARY: Computational methods have been identified that allow simulation of a rapidly expanding optical mode with a short Rayleigh length at high power levels. Researchers also improved the computation FFTs used and increased computer speed by a factor of nine. Analysis was carried out establishing the connection between optical rays and waves in the optical resonators.

PUBLICATIONS:

Colson, W.B., Blau, J., and Armstead, R.L., "The Free Electron Laser Interaction with a Short-Rayleigh-Length Optical Mode," *Nuclear Instruments and Methods in Physics Research*, A507, 48, 2003.

Crooker, P.P., Campbell, T., Ossenfort, W., Miller, S., Blau, J., Colson, W., "A Study of the Stability of a High-Power Free Electron Laser Utilizing a Short Rayleigh Length," *Nuclear Instruments and Methods in Physics Research*, A507, 52, 2003.

PRESENTATION:

Todd, A.M.M., Bluem, H.P., Hughes, M.H., Colson, W.B., Douglas, D.R., Neil, G.R., et al., "Compact High-Power Free Electron Systems," Sixth Annual Directed Energy Professional Society Symposium, Albuquerque, NM, October 2003.

THESIS DIRECTED:

Allgaier, G., "The Shipboard Employment of a Free Electron Laser Weapon System," Master's Thesis, Naval Postgraduate School, September 2003.

KEYWORDS: Free Electron Laser, High Energy Laser

HIGH ENERGY LASER WEAPONS: MODELING AND SIMULATION
W. B. Colson, Distinguished Professor
Department of Physics
Sponsor: Joint Technology Office

OBJECTIVE: To develop modeling and simulation of the operational maritime use of high-energy laser directed energy weapons.

SUMMARY: A Naval Postgraduate School (NPS) laboratory for the study of directed energy weapons was developed. The lab concentrated on the systems physics of directed energy weapons. An FEL course was prepared describing the systems engineering associated with the development of a directed energy FEL for naval applications. Combat scenarios were developed that describe examples of how directed weapons could be used in the military.

PUBLICATIONS:

Blau, J., Bouras, V., Kalfoutzos, A., Allgaier, G., Fontana, T., Crooker, P.P., et al., "Simulations of High-Power Free Electron Lasers with Strongly-Focused Electron and Optical Beams," *Nuclear Instruments and Methods in Physics Research*, A507, 44-47, 2003.

Colson, W.B., "Short Wavelength Free Electron Lasers in 2002," *Nuclear Instruments and Methods in Physics Research*, A507, II-61, 2003.

Colson, W.B., Blau, J., Armstead, R.L., and Crooker, P.P., "Single-Mode Simulations of a Short-Rayleigh Length FEL," *Nuclear Instruments and Methods in Physics Research*, 2004, (accepted).

PRESENTATION:

Fontana, T., Crooker, P.P., Colson, W.B., Blau, J., Armstead, R.L., Allgaier, G., et al., "The Short-Rayleigh Length Free Electron: Cavity and Undulator Design," Sixth Annual Directed Energy Professional Society Symposium, Albuquerque, NM, October 2003.

THESIS DIRECTED:

Miller, S., "Integration of the Free Electron Laser, Rail Gun, and Electromagnetic Aircraft Launch System on a Naval Surface Platform," Master's Thesis, Naval Postgraduate School, June 2003.

KEYWORDS: Free Electron Laser, High Energy Laser

UNIVERSITY OF MARYLAND (UMD)/NAVAL POSTGRADUATE SCHOOL (NPS) FREE ELECTRON LASER RESEARCH
W. B. Colson, Distinguished Professor
Department of Physics
Sponsor: University of Maryland

OBJECTIVE: Simulations and theoretical analysis were used to study the development of high-average-power free electron laser systems for directed energy weapons. Many system tolerances were developed, such as mirror vibration and electron beam misalignment.

SUMMARY: Many system tolerances for free electron lasers operating in a ship environment were determined.

PUBLICATION:

Blau, J., Allgaier, G., Miller, S., Fontana, T., Mitchell, E., Williams, B., et al., "Multi-Mode Simulations of a Short-Rayleigh Length FEL," *Nuclear Instruments and Methods in Physics Research*, 2004, (accepted).

PRESENTATIONS:

Allgaier, G., Armstead, R.L., Colson, W.B., Blau, J., Crooker, P.P., Fontana, T., et al., "The Short-Rayleigh Length Free Electron: Electron Beam Properties," Sixth Annual Directed Energy Professional Society Symposium, Albuquerque, NM, October 2003.

Colson, W.B., "FEL Oscillator Technology Status: The Short Rayleigh Length FEL," Third Navy MW Free Electron Laser Workshop, Johns Hopkins University Applied Physics Laboratory, Laurel, MD, 29-31 July 2003, (invited).

Colson, W.B., "Free Electron Laser Research at the Naval Postgraduate School," U.S. Naval Academy, Department of Physics, Annapolis, MD, January 2003, (invited).

THESIS DIRECTED:

Fontana, T., "High Power Optical Cavity Design and Concepts of Operations for a Shipboard Free Electron Laser Weapon System," Master's Thesis, Naval Postgraduate School, September 2003.

KEYWORDS: Free Electron Laser, High Energy Laser

ANALYSIS AND TESTING OF A 3-5 MM THERMAL IMAGER FOR DIFFERENTIAL COLOR AND POLARIZATION FILTER EFFECTS

Alfred W. Cooper, Professor
Department of Physics
Ron J. Pieper, Visiting Associate Professor
Department of Electrical and Computer Engineering
Sponsor: National University of Singapore

OBJECTIVE: To develop instrumentation to evaluate the potential for target discrimination in the infrared by fusion of image data between spectral sub-bands and between images with different polarizations. In the initial phase of a three year program, to acquire and construct the experimental capability to produce registered simultaneous images in sub-bands using internal spectral and polarization filters in a thermal imaging (TIS) system, and to establish reproducible measurements of standard performance metrics such as Modulation Transfer Function (MTF) and Minimum Resolvable Temperature Difference (MRT). In the long term, to evaluate the potential for improvement of target detection range by fusion of data between filter bands.

SUMMARY: In the preparatory phase, a contract has been let for a thermal imaging system including a cryogenically cooled filter wheel, which can contain spectral or polarization filters. Concurrently, measurements to establish techniques have been made using existing equipment, with the Naval Postgraduate School (NPS) Split Field Polarimeter (constructed for the LWIR 8 – 12 μm band) and with external (uncooled) polarizing filters. For this purpose, the NPS Split-Field system was modified to operate in the 3 – 5 μm band. Polarized and unpolarized images of a multifaceted laboratory target were compared qualitatively and for feature extraction. Measurements were made of system Minimum Resolvable Temperature Difference with no filter, with the Split-Field Polarimeter (separated images with vertical and horizontal polarization), and with an external plane polarizing filter. The modified polarimeter was shown to separate the polarizations, but with significantly degraded MRT, whereas the external polarizer caused relatively little degradation in MRT. Increase in contrast due to polarization was demonstrated, and the decrease in detection range for an unpolarized scene was estimated using the SEARAD Code for atmospheric attenuation. This analysis is to be extended to polarized scenes. The continuation of the project will involve the evaluation and testing of the thermal imager, to include MRT with filters in the cooled filter wheel.

CONFERENCE PUBLICATION:

Pieper, R.J., Cooper, A.W., Celik, M., and Kenter, Y., "Objective MRTD Experimental Measurements Compared with Predictions Based on the Visibility Model," *Proceedings of SPIE, Infrared Imaging Systems: Design, Analysis, Modeling and Testing XIV,* Gerald C. Holst (Ed.), Bellingham, WA: SPIE, Vol. 5076, 196-207, 2003.

THESIS DIRECTED:

Tung, Y.F., "Testing and Performance Characterization of the Split-Field Polarimeter in the 3-5 μm Waveband," Master's Thesis, Naval Postgraduate School, December 2003.

KEYWORDS: Infrared Sensors, Polarization, TIS

MULTI-IR BAND DATA FUSION FOR TARGET RECOGNITION
Alfred W. Cooper, Professor
Department of Physics
Ron J. Pieper, Visiting Associate Professor
Monique P. Fargues, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: National University of Singapore

OBJECTIVE: To develop algorithms and techniques for fusion of infrared images between Thermal Imaging (TIS) and Night Vision (NVD) devices, to enhance the night detection of targets. Include evaluation by application to comparison image pairs and estimation of image enhancement.

SUMMARY: In the preparatory phase of this multi-year project, an existing set of 20 paired images in the Near IR (Night Vision Band) and the MidWave (3-5 μm) was evaluated pending establishment of comparison band measurement facilities. Application of proportional addition techniques failed to show enhancement of image content, due to deficient contrast found in the NVD intensifier images. Accordingly, algorithms for digital enhancement were evaluated. Best results for perceived image quality were found with the "Contrast Limited Adaptive Histogram Equalization" (CLAHE) technique. Quantification of "image improvement" was hindered by absence of standard features in the images. Effectiveness of post-processing digital enhancement of both thermal and NVD images was evaluated for the available data set by frequency analysis and subjective rating by twenty pairs of original and enhanced images using fifteen volunteer human subjects. Spatial frequency response of the images showed an increase in the higher spatial frequencies with enhancement of edges, and corresponding improvement in detection of detail. This was borne out by the subjective testing in which a majority of the subjects selected CLAHE–enhanced NVD images as improved. For the TIS images, original contrast was close to optimal and little enhancement was observed. The project will continue by developing an image data set including comparable resolution targets in the TIS and NVD images.

THESIS DIRECTED:

Teo, C.K., "Digital Enhancement of Night Vision and Thermal Images," Master's Thesis, Naval Postgraduate School, December 2003.

KEYWORDS: Fusion, Infrared Sensors, TIS, NVD

SPECTRAL IMAGERY IN THE NEAR-ULTRAVIOLET
D.S. Davis, Associate Professor
Department of Physics
Sponsor: National Reconnaissance Office

OBJECTIVE: Upgrading and continued field-testing and calibration of the Lineate Imaging Near-ultraviolet Spectrometer (LINUS).

SUMMARY: All of the projects' objectives for CY03 have been met, except one. The instrument's control and data acquisition LabVIEW computer software were thoroughly revamped and upgraded, and additional optical subsystems were added to make field operation easier and more reliable. The only objective that remained was to install and co-align a visible-light boresight guidance camera system. The LabVIEW software and interface were completed, and the actual installation and field-testing of the guidance camera, operating in concert with the other LINUS systems, will take place during the spring of 2004.

CONFERENCE PUBLICATION:

Davis, D.S., Harkins, R.M., and Olsen, R.C., "The Linus UV Imaging Spectrometer," *Proceedings of the SPIE - Algorithms and Technologies for Multispectral, Hyperspectral and Ultraspectral Imagery IX*, 5093, pp. 748-757, ISBN 0-8194-4953-9, 2003.

PRESENTATION:

Davis, D.S., "The LINUS UV Imaging Spectrometer," SPIE Aerosense Technologies and Systems for Defense and Security Conference, Orlando, FL, 21-25 April 2003.

KEYWORDS: Sensors, Optics, Ultraviolet, Remote Sensing, Atmospheric Gases

ACTIVE MIRROR ALIGNMENT FOR FREE-ELECTRON LASERS ON SHIPS
Bruce Denardo, Associate Professor
Department of Physics
Sponsors: Naval Sea Systems Command, Naval Postgraduate School

OBJECTIVES: Sufficient alignment of the cavity mirrors of any type of laser is critical for the proper operation of the laser. Misalignment of the mirrors causes the gain of the laser to be reduced, and can lead to the laser shutting off. This will be a problem for the proposed free-electron laser weapons on ships, due to vibrations resulting from sea motion, ship machinery, and battlefield environment. The objective of this research was to investigate the use of active control methods to stabilize the vibrations of the mirrors such that the laser continues to operate at full power. Researchers constructed a portable milliwatt laser system that can be used to demonstrate the effectiveness of active alignment and to investigate the feasibility of using active alignment methods for the mirrors of free-electron lasers to be employed on Naval ships at sea.

SUMMARY: Student Aaron Stetler implemented a system (LabVIEW) for the computer control and acquisition of data, and tested a feedback-controlled system that consisted of a noise-driven electric circuit oscillator. Researchers then built a mechanical system of a flexing plate with a clamped end and a mirror attached to the other end. The plate was driven by two small loudspeakers, one was the noise drive and the other the control drive. A laser beam was reflected off the mirror onto a position-sensing detector, whose output was fed to a control system that reduced the vibrations of the mirror. The control system was the standard proportional-integral-derivative (PID) type. Reduction of a vibration of the mirror by an order of magnitude was achieved. Future work will focus on the feasibility of using active control methods for the mirrors of free-electron laser mirrors on ships at sea.

THESIS DIRECTED:

Stetler, A., "Demonstration of Active Vibration Control for Free-Electron Laser Mirrors," Master's Thesis, Naval Postgraduate School, December 2002.

KEYWORDS: Free-electron Lasers, Active Control, Vibration Stabilization

MULTIMODAL WAVE SYSTEMS
Bruce Denardo, Associate Professor
Department of Physics
Sponsor: Naval Postgraduate School

OBJECTIVES: *Mode level repulsion* arises in systems that support different types of waves that are linearly coupled. This name is due to the fact that the dispersion curves (frequency vs. wave number) of the normal modes appear to repel each other. Mode level repulsion phenomena can occur in sound in ocean sediments, sound in water-filled pipes, and many other wave systems. In order to explore the basic physics, researchers created a simple theoretical model that exhibits level repulsion: a one-dimensional lattice of coupled pendulums that swing transversely and translate longitudinally. Because the transverse and longitudinal waves are coupled, as in the Wilberforce mass-and-spring oscillator, researchers refer to this system as the *Wilberforce pendulum lattice*. The objective was to investigate various level repulsion phenomena in this system. One interest was whether or not the effect of spatial beating in the model is analogous to neutrino oscillations in particle physics. Another interest was the response when an end of the

lattice is driven such that a wave packet of one type of wave is propagated. Remarkably, this may split into two wave packets that are effective normal mode disturbances of the system.

SUMMARY: Student John Chauvin analytically and numerically investigated various level repulsion phenomena, including spatial and temporal beating, wave packet splitting, and negative group velocity. He also performed a preliminary investigation of neutrino oscillations. Future work includes the application of these results to a variety of actual systems, including neutrinos. Researchers also plan to investigate effects of nonlinearity in their system.

THESIS DIRECTED:

Chauvin, J., "Fundamental Dynamics of Bimodal Wave Systems," Master's Thesis, Naval Postgraduate School, December 2002.

KEYWORDS: Multimodal Waves, Normal Modes, Mode Level Repulsion

PARAMETRIC EXCITATION
Bruce Denardo, Associate Professor
Department of Physics
Sponsor: Naval Postgraduate School

OBJECTIVE: *Parametric excitation* of an oscillatory system can occur when a source modulates a parameter upon which the resonance frequency of the system depends. The goal was to parametrically excite a sound wave mode in a gas. Once parametric excitation occurs, only a nonlinearity of the system will limit the growth of the amplitude. Large acoustic amplitudes may thus be possible, which has applications to thermo-acoustic refrigerators, acoustic compressors, and acoustic pumps. The Navy is interested in employing all of these devices. A problem is that the parametric drive amplitude must be above a threshold value if any excitation is to occur. In the past, student Paul Varnadore theoretically investigated the feasibility of achieving parametric excitation by different methods, but only the modulation of the length of a longitudinal resonator was found to be feasible.

SUMMARY: Student Derek Smith performed an optimization analysis and built a resonator with a length of four feet, a diameter of one foot, and large-amplitude loudspeakers at either end to modulate the length. Calculations showed that this apparatus should be well above the parametric threshold for sulfur hexafluoride gas (which has a low speed of sound). However, the theory was invalidated because experiments with air showed that the quality factor was much lower than predicted, which was attributed to the presence of the drivers. Surprisingly, numerical simulations of a length-modulated string with constant tension showed that parametric excitation is *not* possible. In the future, researchers plan to perform computational acoustics simulations in order to determine whether parametric excitation by length modulation is possible in principle.

THESIS DIRECTED:

Smith, D., "Parametric Excitation of an Acoustic Standing Wave," Master's Thesis, Naval Postgraduate School, June 2003.

KEYWORDS: Parametric Excitation, Parametric Instability, Nonlinear Oscillations

PHYSICS

DEPARTMENT OF THE NAVY (DON) NETWORK VULNERABILITY TRAINING PROGRAM
Richard M. Harkins, Lecturer
Department of Physics
Sponsor: Department of the Navy Chief Information Officer

SUMMARY: Naval Postgraduate School (NPS) and Cyber Risk Management Office developed a prototype Department of the Navy (DoN) training program to address the education and training of civilian and military personnel with regard to network security and integrity.

KEYWORDS: CRMO, Cyber Risk, Network Security

COMPUTER CONTROLLED OPTICAL DETECTOR CHARACTERIZATION SYSTEM TO SUPPORT THE DESIGN AND EVALUATION OF MULTI-COLOR (IR/LASER) QUANTUM WELL PHOTODETECTOR
LCDR Bryan E. Herdlick, USN
Department of Physics
Sponsor: Space and Naval Warfare Systems Command - San Diego

SUMMARY: Developed a computer controlled optical/infrared detector characterization system to support the design and evaluation of multi-color, quantum well, infrared photodetector sensor material. Specific application of this technology is in the design of single detection capability for infrared imagery and coincident laser-designation.

KEYWORDS: Optical Detector, Quantum Well Photodetector

LASER BEACON PROTOTYPE FOR MISSILE DEFENSE AND RELATED TECHNOLOGY
Major Edward J. Hospodar, Jr, USAF
Department of Physics
Sponsor: Air Force Directorate of Budget Management and Execution Financial Management Budget, Special Programs Office

SUMMARY: Demonstrated value of in-scene laser beacon to current and future missile defense operations.

KEYWORDS: Laser Beacon

INFRARED FACE RECOGNITION SYSTEM FOR HUMAN IDENTIFICATION USING UNCOOLED INFRARED IMAGER
Gamani Karunasiri, Associate Professor
Department of Physics
Monique P. Fargues, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Department of Justice

OJECTIVE: To develop an infrared face recognition system using a highly sensitive, uncooled, infrared (IR) camera for identification of human subjects.

SUMMARY: An infrared face recognition system was successfully developed using an uncooled infrared camera. The images were analyzed using two classic recognition algorithms (principle component analysis (PCA) and linear discriminant analysis (LDA)) for a proof of concept study using a database containing 14 subjects with 420 images. Results showed better performances for LDA- than PCA-based recognition schemes, as expected from their definitions. These findings indicated that the uncooled IR camera has

sufficient temperature resolution to allow for discrimination between the subjects contained in the experimental database collected under controlled conditions.

PUBLICATION:

Pereira, D.C., Fargues, M.P., and Karunasiri, G., "Uncooled Infrared Imagery Face Recognition," *IEEE Sensors*, 2003, (submitted).

KEYWORDS: Infrared, Face recognition, Uncooled

OPTICAL SENSORS OPERATING SIMILAR TO BIOLOGICAL VISION SYSTEMS
Gamani Karunasiri, Associate Professor
Department of Physics
Sponsor: Naval Postgraduate School

OBJECTIVE: To investigate novel infrared and optical sensors using multi-layer semiconductor structures.

SUMMARY: The research on multi-layer semiconductor devices that can convert incident light to a series of large voltage pulses was continued. The generation and termination of pulses were understood using the device parameters. Experimental studies were also carried out to probe the infrared transitions in step quantum well structures to probe the normal incident detection. In addition, tunable spectral bandwidth and dual-band infrared detectors were designed using asymmetric quantum well structures for applications in laser-guided weapons. The work is continuing to experimentally demonstrate the performance of these detectors.

PUBLICATIONS:

Cheah, C.W., Karunasiri, G., and Tan, L.S., "Analysis of AlGaAs/GaAs/InGaAs n-type Step Multiple Quantum Wells for the Optimization of Normal Incident Absorption," *Semiconductor Science and Technology*, 17, 1028-1037, 2002.

Cheah, C.W., Karunasiri, G., Tan, L.S., and Zhou, L.F., "Responsivities of n-type GaAs/InGaAs/AlGaAs Step Multiple-quantum-well Infrared Detectors," *Applied Physics Letters*, 80, 145-147, 2002.

THESES DIRECTED:

Herdlick, B.E., "Development of Computer Controlled Photocurrent Spectroscopy System," Master's Thesis, Naval Postgraduate School, December 2002.

Hickey, T.R., "Characterization of Performance of Quantum Well Photodetector at Various Temperatures," Master's Thesis, Naval Postgraduate School, June 2002.

Konukbay, A., "Design of Quantum Well Photodetector with Variable Bandwidth," Master's Thesis, Naval Postgraduate School, June 2002.

Lantz, K.R., "Two-color Photodetector Using Semiconductor Heterostructures," Master's Thesis, Naval Postgraduate School, June 2002.

KEYWORDS: Photoreceptors, Biological, Multi-Color IR Sensors, Quantum Well Detectors

PHYSICS

BILGE WATER SEPARATION COLUMN USING SOUND
Andrés Larraza, Associate Professor
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: The main aspect of this research was to implement acoustic techniques to enhance separation of oil and water. The design has no moving parts and offers potential applications for the extraction of water in both fuel and lube oil systems and extraction of oil in bilge water.

SUMMARY: An aspect of this design was the use of bubbles for acoustic control. In this case, the air bubbles in a fluid column were used to assist in the separation processes. The bubbles can be segregated in size in the field of a standing wave. For a standing wave with a pressure maximum at the center and a node at the pressure release boundary condition of the column, bubbles smaller than the resonant size migrate to the pressure antinode at the axis of the column, and bubbles larger than the resonant size migrate to the pressure node at the walls.   This segregation technique can thus be used to eliminate the larger bubbles, and enhance the surface to void volume ratio due to a larger small-bubble population moving up along the center of the column, away from the walls. The oil from a water-oil mixture attaches to this bubble stream and it is quickly transported to the top of the separation column where it is taken by the overflow outlet either into a container or into a second stage, for further separation. Once the optimum bubble segregation conditions are achieved in the column, a second appropriately tuned band limited noise field can be used to increase the speed of the bubbles thereby moving the oil to the surface of the column faster.

KEYWORDS: Bilge Water, Oil-Water Separation

FEASIBILITY STUDY ON APPLICATIONS OF UV FILAMENTS TO SURFACE WAVE PROPAGATION
Andrés Larraza, Associate Professor
Department of Physics
David C. Jenn, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Air Warfare Center - Weapons Division

SUMMARY: Conducted a feasibility study on the application of UV laser atmospheric filaments to microwave propagation along the conductive path.

DoD KEY TECHNOLOGY AREA: Directed Energy Weapons

KEYWORDS: UV Filaments, Surface Waves, Microwave

LASER BEACON PROTOTYPE FOR MISSILE DEFENSE AND RELATED TECHNOLOGY
Andrés Larraza, Associate Professor
Department of Physics
Sponsor: Naval Engineering Logistics Office

SUMMARY: Demonstrated value of in-scene laser beacon to current and future missile defense operations. Provided the student with an opportunity to fix the laser beacon to bring it into calibrated operations. Allowed the student to plan and organize proof of concept demonstrations with operational Department of Defense systems and commands for concept of operations (CONOPS) development. Provided the Naval Postgraduate School with a mission-capable laser beacon for future student work and technology development and demonstrations.

KEYWORDS: Laser Beacon, Missile Defense, CONOPS

INFORMATION DYNAMICS
James H. Luscombe
Department of Physics
Sponsor: National Security Agency

RAILGUN TECHNOLOGY
William B. Maier, Senior Lecturer
Department of Physics
Sponsor: Naval Surface Warfare Center - Dahlgren Division

OBJECTIVE: To identify suitable materials and configurations for the projectile, long-range artillery.

KEYWORDS: Information Dynamics, Railgun

FIRST RESPONDER CONSIDERATIONS FOR TERRORISM THREATS AND EVENTS INVOLVING RADIOLOGICAL WEAPONS
Xavier K. Maruyama, Professor
Department of Physics
Sponsor: U.S. Department of Justice

SUMMARY: The guidance given to first responders is nebulous and ad hoc for eventualities such as radiological weapons threats and events. This country has had no experience in dealing with radiological weapons and as a consequence, first responders have almost no experience in dealing with such eventualities. Researchers investigated the technologies, infrastructure capabilities, and jurisdictional issues, as well as the scientific basis required for a reasonable response to radiological weapons ("dirty bomb"). Recommendations for the formulation of sensible guidance to first responders were made. Finding were presented in a format amenable for use in classroom presentation, illustrating the technical aspects of a particular scenario and emphasizing the relationship between first responders and subsequent other state and federal agencies.

KEYWORDS: First Responder, Terrorism, Radiological, Dirty Bomb

COMPLETION OF RAYLEIGH WAVE SONAR RESEARCH FOR DETECTION OF BURIED MINES
Thomas G. Muir, Research Professor
Department of Physics
Sponsor: Office of Naval Research

SUMMARY: Analyzed data and completed reporting on Rayleigh wave sonar research.

DoD KEY TECHNOLOGY AREAS: Amphibious Warfare, Mine Countermeasures

KEYWORDS: Seismic Sonar, Rayleigh Waves, Mine Detection, Minefield Reconnaissance, Surf Zone, Beaches, Amphibious Assault, Buried Mines, Sonar Engineering

PHYSICS

CENTRAL MASINT ORGANIZATION RESEARCH AND DEVELOPMENT TECHNICAL ASSISTANCE
Richard C. Olsen, Associate Professor
Department of Physics
Sponsor: Defense Intelligence Agency Central Measurement and Signature Intelligence (MASINT) Organization

OBJECTIVE: To provide technical assistance to the sponsor in areas of interest as directed. This effort included the support for the Measurement and Signal Intelligence (MASINT) chair at the Naval Postgraduate School.

SUMMARY: The MASINT chair provided support to the Defense Intelligence Agency mission. MASINT design studies were carried out in the national systems classes.

KEYWORDS: MASINT, Measurement and Signal Intelligence

IMAGING SYSTEMS TASKING FOR TEMPORAL SIGNATURES
Richard C. Olsen, Associate Professor
Department of Physics
Sponsor: Navy Tactical Exploitation of National Capabilities

SUMMARY: This research related to the development of non-conventional approaches to the exploitation of remote sensing systems. Non-literal tasking of national technical means and commercial systems were studied to look for time signatures of interest.

KEYWORDS: Remote Sensing, Temporal Signatures

INTELLIGENCE, SURVEILLANCE, AND RECONNAISSANCE ANALYSIS PROGRAM SUPPORT
Richard C. Olsen, Associate Professor
Department of Physics
Sponsor: SAF/FMBMB-AFOY

SUMMARY: This research effort was in support of the Air Force.

KEYWORDS: ISR, Intelligence, Surveillance, Reconnaissance

MULTI-LOOK TECHNIQUES FOR TERRAIN CLASSIFICATION (TERCAT)
Richard C. Olsen, Associate Professor
Department of Physics
Sponsor: Secretary of the Air Force

OBJECTIVE: To study the effects of viewing angle on the interpretation of spectral imagery.

SUMMARY: Data were successfully collected using the Quickbird satellite. This was the first time that a commercial (civilian) remote sensing system made observations at high-spatial resolution at multiple angles. Preliminary data analysis of Bi-Directional Reflectance Function (BDRF) effects showed that classification accuracy is increased.

PUBLICATION:

Tso, B. and Olsen, R.C., "Evaluation of Multi-angle, Multispectral Imagery for Scene Classification Using Hidden Markov Models," *Photogrammetric Engineering and Remote Sensing*, (submitted).

KEYWORDS: TERCAT, Terrain Classification

RESEARCH IN SPECTRAL TEMPORAL IMAGING
Richard C. Olsen, Associate Professor
Department of Physics
Sponsor: National Reconnaissance Office

OBJECTIVE: To provide technical assistance to the sponsor in areas of interest as directed and to conduct research in non-literal imaging techniques.

SUMMARY: The non-literal exploitation of high-spatial resolution imaging was studied for purposes of detecting temporal phenomena.

THESIS DIRECTED:

Hittner, A., "Detecting and Measuring Temporal Phenomenon with High Resolution Satellite Imagery," Master's Thesis, Naval Postgraduate School, September 2003.

KEYWORDS: Non-literal Imaging

SPECTRAL IMAGERY TECHNOLOGY APPLICATIONS CENTER SUPPORT
Richard C. Olsen, Associate Professor
Department of Physics
Sponsor: National Reconnaissance Office

SUMMARY: The research was in the area of high-spatial resolution multi-spectral imagery (MSI) in combination with high-resolution panchromatic imagery. Data from the QUICKBIRD and IKONOS satellites were analyzed for terrain classification (TERCAT) purposes using traditional MSI techniques, combined with texture analysis of the panchromatic imagery.

KEYWORDS: Spectral Imaging, IKONOS, QUICKBIRD

SPECTRAL POLARIMETRIC IMAGERY SUPPORT
Richard C. Olsen, Associate Professor
Department of Physics
Sponsor: Defense Intelligence Agency

OBJECTIVE: To provide technical assistance to the sponsor in areas of interest as directed. This effort included support for the Measurement and Signal Intelligence (MASINT) Chair at the Naval Postgraduate School (NPS). Research in non-literal imaging techniques was conducted.

SUMMARY: Further development of the Naval Postgraduate School ultraviolet (UV) spectrometers was carried out.

PUBLICATIONS:

Tso, B. and Olsen, R.C., "Scene Classification Using Combined Spectral, Textual, and Contextual Information," *IEEE Transactions on Geoscience and Remote Sensing*, (submitted).

Tso, B. and Olsen, R.C., "Unsupervised Classification of IKONOS Multispectral Imagery Using Hidden Markov Models," *International Journal of Remote Sensing*, (submitted).

Tyo, J.S., Konsolakis, A., Diersen, D.I., and Olsen, R.C., "Principal-Components-Based Display Strategy for Spectral Imagery," *IEEE Transactions on Geoscience and Remote Sensing*, Vol. 41, pp. 708-718, March 2003.

PRESENTATION:

Davis, S., Harkins, R.M., and Olsen, R.C., "The LINUS UV Imaging Spectrometer," SPIE Aerosense - Technologies and Systems for Defense and Security, Orlando, FL, 21-25 April 2003.

THESIS DIRECTED:

Humphrey, M., "Texture Analysis of High Resolution Panchromatic Imagery for Terrain Classification," Master's Thesis, Naval Postgraduate School, June 2003.

KEYWORDS: UV Spectrometer, Polarimetric, Remote Sensing, Hyperspectral

SUPPORT OF THE OFFICE OF THE SECRETARY OF DEFENSE (OSD) LIAISON AND OPERATION NOBLE EAGLE
Richard C. Olsen, Associate Professor
Department of Physics
Sponsor: National Reconnaissance Office

SUMMARY: The research supported remote sensing efforts exploiting National Technical Means.

DoD KEY TECHNOLOGY AREA: Remote Sensing

KEYWORDS: Environmental Monitoring, Remote Sensing

TECHNICAL SUPPORT
Richard C. Olsen, Associate Professor
Department of Physics
Sponsor: Secretary of the Air Force

OBJECTIVE: To provide technical assistance to the sponsor in areas of interest as directed and to conduct research in non-literal imaging techniques.

SUMMARY: The utility of imaging and non-imaging systems for surveillance was studied.

KEYWORDS: Surveillance, Non-literal Imaging

TECHNICAL SUPPORT FOR PROCESSING SEGMENT
Richard C. Olsen, Associate Professor
Department of Physics
Sponsor: SAF/FMBMB-AFOY

SUMMARY: Provided support for processing of data from new military systems.

KEYWORDS: Processing Segments

PHYSICS

VISIBLE SENSOR MULTI-LOOK TECHNIQUES
Richard C. Olsen, Associate Professor
Department of Physics
Sponsor: National Reconnaissance Office

SUMMARY: This research was related to the development of non-conventional approaches to the exploitation of remote sensing systems. Multi-look imaging approaches were studied to determine the utility of Bi-Directional Reflectance Function (BDRF). Data were collected using the Quickbird satellite over Fresno, California. Four images taken in sequence by the satellite were study to determine the influence of viewing angle on spectra (color), and only modest influences were seen. Similarly, scene textures were largely independent of viewing angle. BDRF effects in the panchromatic images did prove effective in distinguishing terrain types.

KEYWORDS: Remote Sensing, BDRF, Quickbird

DIRECTIONAL TRANSDUCER MEASUREMENTS
Joseph A. Rice, Engineering Acoustic Chair
Department of Physics
Sponsor: Space and Naval Warfare Systems Command - San Diego

SUMMARY: Implemented a high-fidelity measurement capability in conjunction with the anechoic tanks at the Naval Postgraduate School (NPS). Performed tests and calibrations of experimental telesonar transducers operating in the 8-100khz band. This work was done in collaboration with Navy Small Business Innovation Research (SBIR) Topic N99-011 performers and Office of Naval Research (ONR) 321SS project personnel. This work involved thesis research.

KEYWORDS: Directonal Transducer, SBIR

UNDERSEA ACOUSTIC COMMUNICATIONS FOR NAVAL SPECIAL WARFARE
Joseph A. Rice, Engineering Acoustic Chair
Department of Physics
Sponsor: Office of Naval Research

SUMMARY: This research and development project advanced transmission security for undersea acoustic communications. A planning letter from the Naval Postgraduate School (NPS) to the Office of Naval Research (ONR) dated 15 January 2003, detailed the nature of the core research project and optional tasking. The work was performed as an activity of the NPS Department of Physics and the NPS Undersea Warfare Center. This work involved NPS thesis research. Space and Naval Warfare Systems Center (SCC), San Diego personnel were involved, and SSC San Diego awarded a contract to Benthos, Inc.

KEYWORDS: Undersea Acoustics

REVERBERATION (FY03)/PERTURBATION (FY04) MODELING AND DATA ANALYSIS IN ASIAN SEA INTERNATIONAL ACOUSTIC EXPERIMENT (ASIAEX)
Kevin B. Smith, Associate Professor
Department of Physics
Sponsors: Office of Naval Research, Code 321OA, Naval Postgraduate School

OBJECTIVE: The objective of this on-going research was to model various propagation features within the East China Sea component of the Asian Sea International Acoustic Experiment (ASIAEX) experiment. Specifically, the influence of propagation on both interface and volume reverberation over a large bandwidth of frequencies was examined and compared with data collected, direct path propagation through water volume fluctuations was computed and compared with data collected, and the influence of

environmental variability on effective bottom attenuation was investigated. By understanding the role of the acoustic propagation in such signals, a more clear description of the underlying role of propagation on scattering mechanisms, direct path variability, and bottom attenuation has emerged. This may provide important information on the statistics of the signal, enhancing the use of active systems by accounting for some of the structure in the signal processing.

SUMMARY: In CY03, the main focus of this research was the analysis of generated data and the initial analysis of the measured SUS reverberation data. Additional environmental perturbations and experimental configurations were also incorporated into the model results. Specifically, the influence of water volume turbulence and multiple radial interface/volume perturbations were examined. A model of the SUS source spectrum was also introduced in the post-processing.

For the effective attenuation studies, the same types of bottom perturbations were included. However, different types of perturbation combinations were employed. In some cases, only a single sediment half-space was defined (no subbottom interface). Calculations were then made which examined only the influence of changes in sediment sound speed gradient, which varied from 0.5 – 2.0 m/s/m. The next set of data was generated with no sound speed gradient, but the bottom interface RMS roughness was varied from 1 – 5 m. Next, the interface was flat, but the bottom volume had RMS fluctuations ranging from 5 – 15m/s in sound speed (with corresponding fluctuations in bottom density). The volume fluctuations were then turned off and a subbottom interface was added with RMS fluctuations ranging from 1 – 5 m. Finally, an environment was computed with both interfaces of varying roughness and perturbations in the bottom volume. For each of these perturbed environments, the sediment attenuation was held constant. Subsequent to these calculations, corresponding data were computed for the average environment (without perturbations) with varying levels of sediment attenuation. All data was computed over the frequency range from 10 – 500 Hz. By correlating the results of the perturbed and unperturbed data, the effective sediment attenuation as a function of frequency was estimated.

In order to study the variability of the water-borne propagation path and compare with data collected by Peter Dahl's group at Applied Physics Laboratory, University of Washington, it was necessary to adapt the Monterey-Miami Parabolic Equation (MMPE) model to compute the same type of source response function as used during the experiment. In addition, a model of the water volume turbulence was incorporated. The data computed was then sampled at approximately the appropriate range and depths of the short aperture arrays employed. The vertical coherence of the signals was then computed along the sub-arrays for a variety of turbulent perturbation scales and background sound speed profiles.

PUBLICATION:

Smith, K.B. and Ead, R., "Computing Rough Surface Doppler Effects on Broadband Pulse Propagation Using a Split-Step Fourier Parabolic Equation Model," *Journal of the Acoustical Society of America*, 113, pp. 2185, 2003.

CONFERENCE PUBLICATION:

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

PRESENTATIONS:

Smith, K.B. and Ead, R., "Computing Rough Surface Doppler Effects on Broadband Pulse Propagation Using a Split-Step Fourier Parabolic Equation Model," 145th Meeting of the Acoustical Society of America, Nashville, TN, 28 April-2 May 2003.

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

THESES DIRECTED:

Glover, C.F., "Effects of Turbulence on Short-Range, Direct-Path Acoustic Propagation in Shallow Water," Master's Thesis, Naval Postgraduate School, June 2003.

Hill, R., "Model-Data Comparison of Shallow Water Acoustic Reverberation in the East China Sea," Master's Thesis, Naval Postgraduate School, September 2003.

Pistacchio, D., "Source/Receiver Motion-induced Doppler Influence on the Bandwidth of Sinusoidal Signals," Master's Thesis, Naval Postgraduate School, December 2003.

KEYWORDS: Shallow Water Reverberation, Shallow Water Bottom Attenuation, Shallow Water Volume Variability, Parabolic Equation Modeling

THRESHOLD CATHODE TEST FACILITY (TCTF)
Ryan J. Umstattd, Assistant Professor
Department of Physics
Department of Information Systems
Sponsor: Naval Postgraduate School

OBJECTIVE: To improve the electron emission properties of cathodes used in High Power Microwave Directed Energy weapons.

SUMMARY: In 2003, initial cathode testing began, using the Threshold Cathode Test Facility (TCTF), which was successfully moved from its original location at Kirtland Air Force Base, New Mexico, to the basement of Spanagel Hall on the Naval Postgraduate School (NPS) campus. The existing equipment (on loan from the Air Force Research Lab) was supplemented with new diagnostics and safety materials using NPS NIFR money. Data acquisition was updated with a new oscilloscope and computer. State-of-the-art carbon fiber cathodes were purchased, prepared, and installed for testing. Initial results found excessive arcing that was improved by modification of the anode-cathode geometry. These initial results were reported at the annual meeting of the American Physical Society's Division of Plasma Physics. Additional improvements to the pulsed power that supplies energy to the cathode should result in significant lifetime improvement, allowing for more experiments per cathode. External funding was sought in the form of a technical services agreement.

CONFERENCE PUBLICATION:

Schlise, C. and Umstattd, R., "An Explosive Emission Cathode in a Thermionic Cathode Environment," *Bulletin of the American Physical Society 45th Annual Meeting of the Division of Plasma Physics*, Albuquerque, NM, p. 312, 27-31 October 2003.

THESIS DIRECTED:

Schlise, C., Master's Thesis, Naval Postgraduate School, June 2004, (expected).

KEYWORDS: Directed Energy, Cathodes, High Power Microwaves, Explosive Emission

UNDERWATER WARHEAD TECHNOLOGY HIGH POWER MICROWAVE ATTACK VULNERABILITY AND PROTECTION STUDY FOR DOMESTIC INFRASTRUCTURE
Ryan J. Umstattd, Assistant Professor
Department of Physics
Department of Information Systems
Sponsor: U.S. Air Force Research Laboratory

OBJECTIVE: To assess the vulnerability of a specific domestic infrastructure target to a specific high power microwave (HPM) attack. A small team of Naval Postgraduate School (NPS) students carried out this work (under supervision) in order to assess the feasibility of such an attack by a hypothetical terrorist group.

SUMMARY: An HPM attack on the electronic devices used to monitor and/or control domestic water systems could disrupt the systems' ability to provide water. Timed properly, targeted to a specific site, and in conjunction with a physical attack such as a fire, such an attack could be easily and inexpensively carried out. This research effort was a continuation of last year's study, which found it easy to obtain information about the local water system, the particular infrastructure target selected. Tests performed at NPS proved successful at using HPM to disrupt duplicates of the radio equipment required to operate the local water distribution. Additional tests were performed using a hardware/software combination identical to that used by the water company to monitor and control water flow and pressure. The HPM source was effective at disrupting the software such that the hardware had to be physically reset. Only then could the software be reloaded and normal control/operation restored. Defense against such an attack should include restricting key information on the system's operations, electronic components operating frequency, as well as restricting access to potential target sites. These changes might not be welcomed by the water system operator due to increased operating costs, but they are perhaps a necessary cost of doing business in today's environment.

PRESENTATIONS:

Carter, B., Umstattd, R., Buczynski, P., and Benford, J., "Experiments on SCADA System Vulnerability to DE Attack," 6th Annual Directed Energy Symposium, Albuquerque, NM, 20-24 October 2003.

Umstattd, R.J. and Carter, B., "Foreign Interest in HPM from Open Source and SCADA System Susceptibility," Classified Advanced Technology Update, Monterey, CA, 21-23 July 2003.

THESIS DIRECTED:

Carter, B., "Radio Frequency (RF) Weapons Systems Characteristics Study and Detection Analysis," Master's Thesis, Naval Postgraduate School, September 2003.

KEYWORDS: Directed Energy, Threat Assessment, High Power Microwaves, Infrastructure Vulnerability

DUAL IR COLLECTION AND CALIBRATION
Philip L. Walker, Professor
Department of Physics
Sponsor: National Astronomy and Ionosphere Center

OBJECTIVE: To determine the sensitivity of the DoDSat sensor to calibrated ground-based explosion flashes. DoDSat sensor calibrated by comparison with ground-based and air-based duplicate sensors.

SUMMARY: This was a continuing project expected to be partially funded next year. Calibrated explosions, ground-based sensor measurements and aircraft over-flights were to take place at the Naval Air Warfare Center, China Lake, California. The experiment was performed 11 December 2002. The aircraft was not available. The small particle aerosol sizer, a LASX, was not working. Analysis of atmospheric

influence on observed flash strength is being performed at the Naval Postgraduate School. The absence of the LASX data will lead to some error. The report will be available 1 April 2003. It is expected that this is one of a series of tests.

KEYWORDS: Environment, Transmission

ATMOSPHERIC EFFECTS ON LASER SYSTEMS PERFORMANCE
Donald L. Walters, Professor
Department of Physics
Sponsor: Naval Sea Systems Command

SUMMARY: Study, assessment, data analysis and reporting of atmospheric effects on laser system performance.

KEYWORDS: Atmosphere, Laser Performance

ATMOSPHERIC EFFECTS ON LASER SYSTEMS PERFORMANCE
Donald L. Walters, Professor
Department of Physics
Sponsor: Air Force Research Laboratory

SUMMARY: Study, assessment, data analysis and reporting of atmospheric effects on laser system performance.

KEYWORDS: Atmosphere, Laser Performance

ATMOSPHERIC OPTICAL TURBULENCE MODELING
Donald L. Walters, Professor
Department of Physics
Sponsor: SAF/FMBMB-AFOY

SUMMARY: Investigated and adapted the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) meteorological model to simulate and forecast optical turbulence. Compared the model results with existing micro thermal balloon data and optical measurements. Applied this model to simulate the atmosphere for locations of interest to the sponsor.

KEYWORDS: Atmosphere, Optical Turbulence

MESOSCALE MODELING OF ATMOSPHERIC OPTICAL TURBULENCE
Donald L. Walters, Professor
Department of Physics
Sponsor: Air Force Research Laboratory

SUMMARY: The subtask, numerical modeling of atmospheric turbulence, was part of a larger, coordinated Joint Technology Office program coordinated by the U.S. Air Force Research Laboratory (AFRL), Hanscom Air Force Base. The larger program addressed micro thermal balloon measurements and atmospheric absorption database improvements. Researchers investigated and validated algorithms that employ the U.S. Navy Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) and MM5 mesoscale models to predict atmospheric optical turbulence for laser and optical programs. A key customer was the U.S. Air Force airborne laser.

KEYWORDS: Atmosphere, Optical Turbulence, Mesoscale Modeling

DEPARTMENT OF PHYSICS

2003
Faculty Publications
and Presentations

PHYSICS

JOURNAL ARTICLES

Baker, S.R., Muir, T.G., Gaghan, F.E., Fitzpatrick, S.M., Sheetz, K.E., and Guy, J., "Seismic Sonar Sources for Buried Mine Detection," *Journal of the Acoustical Society of America*, 114, 2456, 2003.

Cheney, M. and Borden B, "Microlocal Structure of Inverse Synthetic Aperture Radar Data," *Inverse Problems,* 19, 173–193, 2003.

Colson, W.B., "Short Wavelength Free Electron Lasers in 2002," *Nuclear Instruments and Methods in Physics Research*, A507, II-61, 2003.

Denardo, B., "Sinking a Body Using Bubbles," *Naval Postgraduate School Research Newsletter*, Vol. 13, No. 1, pp. 6-7, 39-41, February 2003.

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

Denardo, B., Smith, D., Varnadore, P., and Prather, W., "Parametric Excitation of an Acoustic Mode," *Journal of the Acoustical Society of America*, 113, No. 4, Pt. 2, 2282, 2003.

Hansen, U. and Darvennes, C., "Education in Acoustics: Hands-On Demonstrations for High School Students," *Journal of the Acoustical Society of America*, 113, No. 4, Pt. 2, 2281, 2003.

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

Muir, T.G., Baker, S.R., Gaghan, F.E., Fitzpatrick, S.M., Hall, P.W., Sheetz, K.E., et al., "Detection of Buried Mines with Seismic Sonar," *Journal of the Acoustical Society of America*, 114, 2456, 2003.

Natterer, F., Cheney, M., and Borden, B., "Resolution for Radar and X-ray Tomography," *Inverse Problems (special issue on Inverse Problems in Imaging)*, 19, S55–S63, 2003.

Sabatier, J., Korman, M., and Poese, M., "Education in Acoustics, Physical Acoustics, and Noise: Demos for All Ages – 2003," *Journal of the Acoustical Society of America*, 113, No. 4, Pt. 2, 2240, 2003.

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

Smith, K.B. and Ead, R., "Computing Rough Surface Doppler Effects on Broadband Pulse Propagation Using a Split-Step Fourier Parabolic Equation Model," *Journal of the Acoustical Society of America*, 113, pp. 2185, 2003.

REFEREED ARTICLES

Blau, J., Bouras, V., Kalfoutzos, A., Allgaier, G., Fontana, T., Crooker, P.P., et al., "Simulations of High-Power Free Electron Lasers with Strongly-Focused Electron and Optical Beams," *Nuclear Instruments and Methods in Physics Research*, A507, 44-47, 2003.

Colson, W.B., Blau, J., and Armstead, R.L., "The Free Electron Laser Interaction with a Short-Rayleigh-Length Optical Mode," *Nuclear Instruments and Methods in Physics Research*, A507, 48-51, 2003.

Crooker, P.P., Campbell, T., Ossenfort, W., Miller, S., Blau, J., and Colson, W., "A Study of the Stability of a High-Power Free Electron Laser Utilizing a Short Rayleigh Length," *Nuclear Instruments and Methods in Physics Research*, A507, 52-55, 2003.

Heinemann, M., Larraza, A., and Smith, K.B., "Experimental Studies of Applications of Time–Reversal Acoustics to Non-Coherent Underwater Communications," *Journal of the Acoustical Society of America,* 113, 3111, 2003.

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

CONFERENCE PUBLICATIONS

Allgaier, G., Armstead, R.L., Colson, W.B., Blau, J., Crooker, P.P., Fontana, T., et al., "The Short-Rayleigh Length Free Electron: Electron Beam Properties," *Sixth Annual Directed Energy Professional Society Symposium*, Albuquerque, NM, October 2003.

Colson, W.B., "FEL Oscillator Technology Status: The Short Rayleigh Length FEL," *Third Navy MW Free Electron Laser Workshop*, Johns Hopkins University Applied Physics Laboratory, Laurel, MD, 29-31 July 2003, (invited).

Fontana, T., Crooker, P.P., Colson, W.B., Blau, J., Armstead, R.L., Allgaier, G., et al., "The Short-Rayleigh Length Free Electron: Cavity and Undulator Design," *Sixth Annual Directed Energy Professional Society Symposium*, Albuquerque, NM, October 2003.

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

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

Todd, A.M.M., Bluem, H.P., Hughes, M.H., Colson, W.B., Douglas, D.R., Neil, G.R., et al., "Compact High-Power Free Electron Systems," *Sixth Annual Directed Energy Professional Society Symposium*, Albuquerque, NM, October 2003.

PRESENTATIONS

Baker, S.R., Muir, T.G., Gaghan, F.E., Fitzpatrick, S.M., Sheetz, K.E., and Guy, J., "Seismic Sonar Sources for Buried Mine Detection," 146th Meeting of the Acoustical Society of America, Austin, TX, 10-14 November 2003.

Blau, J., Allgaier, G., Miller, S., Fontana, T., Mitchell, E., Williams, B., et al., "Multi-Mode Simulations of a Short-Rayleigh Length FEL," Twenty-Fifth International FEL Conference, Tsukuba, Japan, September 2003.

Borden, B., "ISAR for Low Signal-to-Chaff Environments," Industrial Inverse Problems Workshop, IPAM Inverse Problems Semester, University of California Los Angeles, Los Angeles, CA, 15–19 September 2003.

Borden, B., "Problems in Image Construction from Radar Data," Institute for Pure and Applied Mathematics (IPAM) Conference on Applied Inverse Problems: Theoretical and Computational Aspects (AIP2003), University of California Los Angeles, Los Angeles, CA, 18–23 May 2003, (invited Plenary Talk).

Cheney, M. and Borden, B., "Microlocal Methods in Inverse Synthetic Aperture Radar," Institute for Pure and Applied Mathematics (IPAM) Conference on Applied Inverse Problems: Theoretical and Computational Aspects (AIP2003), University of California Los Angeles, Los Angeles, CA, 18–23 May 2003.

Cheney, M. and Borden, B., "Microlocal High Range Resolution ISAR for Low Signal-to-Noise Environments," SPIE AeroSense, Orlando, FL, 21-25 April 2003.

Cheney, M., Natterer, F., and Borden, B., "Resolution for Radar and X-Ray Tomography," Institute for Pure and Applied Mathematics (IPAM) Conference on Applied Inverse Problems: Theoretical and Computational Aspects (AIP2003), University of California Los Angeles, Los Angeles, CA, 18–23 May 2003.

Denardo, B., Smith, D., Varnadore, P., and Prather, W., "Parametric Excitation of an Acoustic Mode," Physical Acoustics Session on Nonlinear Acoustics and Resonators, Meeting of Acoustical Society of America, Nashville, TN, 28 April-2 May 2003.

Hansen, U. and Darvennes, C., "Education in Acoustics: Hands-On Demonstrations for High School Students," Meeting of Acoustical Society of America, Nashville, TN, 28 April-2 May 2003.

Muir, T.G., Baker, S.R., Gaghan, F.E., Fitzpatrick, S.M., Hall, P.W., Sheetz, K.E., et al., "Detection of Buried Mines with Seismic Sonar," 146th Meeting of the Acoustical Society of America, Austin, TX, 10-14 November 2003.

Sabatier, J., Korman, M., and Poese, M., "Education in Acoustics, Physical Acoustics, and Noise: Demos for All Ages – 2003," Meeting of the Acoustical Society of America, Nashville, TN, 28 April-2 May 2003.

Smith, K.B. and Ead, R., "Computing Rough Surface Doppler Effects on Broadband Pulse Propagation Using a Split-Step Fourier Parabolic Equation Model," 145th Meeting of the Acoustical Society of America, Nashville, TN, 28 April-2 May 2003.

SPACE SYSTEMS ACADEMIC GROUP

RUDOLF PANHOLZER CHAIR

OVERVIEW:

The Space Systems Academic Group (SSAG) along with eight academic departments is an integral part of the Graduate School of Engineering and Applied Sciences. As an interdisciplinary association of professors it provides direction and guidance for two curricula: Space Systems Engineering and Space Systems Operations.

Officer students in the Space Systems curricula fulfill degree requirements for a Master of Science in the department of their choice or in a specialized Engineering Science. A space-oriented thesis is mandatory as well as course work to fulfill the requirements of a space billet. Officer graduates are prepared to manage the technical aspects of a space system life cycle including design, development, installation, and maintenance of spacecraft, space payloads, supporting ground stations, terminals, and C3 connectivity.

The SSAG serves as the focal point for all space-related research performed at the Naval Postgraduate School (NPS). A major goal is to couple NPS space research efforts with the graduate education of military officers. This is typically accomplished through space-related thesis research in several areas and includes small satellite projects created specifically as an educational tool for officer students. The SSAG oversees classified and unclassified student involvement in research activities and helps facilitate their placement in follow-on tours.

CURRICULA SERVED:

- Space Systems Operations
- Space Systems Engineering

DEGREES GRANTED:

- Master of Science in Space Systems Operations
- Master of Science in Astronautical Engineering
- Master of Science in Electrical Engineering
- Master of Science in Mechanical Engineering
- Master of Science in Applied Physics

RESEARCH THRUSTS:

- Military Applications for Space
- Space Reconnaissance and Remote Sensing
- Radiation Hardened Electronics for Space
- Design, Construction and Launching of Small Satellites
- Classified (SCI level) Research
- Satellite Communications Systems
- Military Space Systems and Architectures

RESEARCH CHAIRS:

- Navy Space Technology Program Chair
- Navy Tactical Exploration of National Capabilities (TENCAP) Space Chair
- Space Systems Academic Chair
- NASA Michael J. Smith Space Systems Chair
- National Reconnaissance Office Chair
- Lockheed Martin Space and Missile Operations Chair

RESEARCH CENTERS:

- Spacecraft Research and Design Center
- Center for Reconnaissance Research
- Center for Radiation Hardened Electronics
- Center for Cryptologic Research

RESEARCH FACILITIES:

- Open Site EMI/EMC Facility
- Satellite Ground Station Facility
- Space Warfare Computer Laboratory
- FLTSATCOM Satellite Operations
- Simulation and Test Laboratory
- Spacecraft Attitude Dynamics and Control Laboratory
- Spacecraft Environmental Simulation an Test Laboratory
- Radiation Effects Laboratory
- Solar Simulation Facility
- NPS-AFRL Optical Relay Spacecraft Laboratory
- Flash X-Ray Facility
- Electron Linear Accelerator
- Small Satellite Test and Development Laboratory
- Smart Structures Laboratory

RESEARCH PROGRAM (Research and Academic)-FY2003:

The Naval Postgraduate School's sponsored program exceeded $71 million in FY2003. Sponsored programs included both research and educational activities funded from an external source. A profile of the sponsored program for the Space Systems Academic Group is provided below:
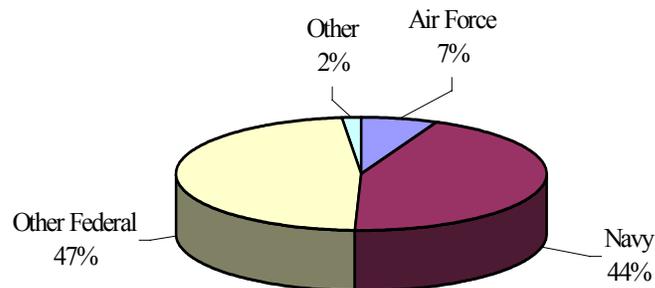
Size of Program: $856K

SPACE SYSTEMS

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PROJECT GUSTY ORIOLE (U)
Herschel H. Loomis, Jr., Professor
Department of Electrical and Computer Engineering and Space Systems Academic Group
RADM Thomas C. Betterton, USN (Ret.), Professor
Alan Ross, Navy Tactical Exploitation of National Capabilities Chair Professor
Space Systems Academic Group
Sponsor: National Reconnaissance Office

OBJECTIVE: (U) To conduct research into architectures and algorithms for the acquisition, processing, and communication of tactical information. To provide support for the course Space Systems 3001, Military Applications of Space and SS4051, Military Space Systems and Technologies.

SUMMARY: (U) Completed work on the following tasks:
a. Transitioned the support for the Configurable Fault-Tolerant Processor experiment to other offices of the National Reconnaissance Office (NRO).
b. Worked with Dr. Michael Price and Maj. Chris Miller (a Ph.D. student in the Department of Electrical and Computer Engineering) on development of high-accuracy geolocation algorithms.
c. Hosted a Maritime Domain Awareness workshop at the Naval Postgraduate School (NPS), which resulted in the development of a proposed fusion experiment that has received significant funding from the NPS Center for Defense Technology and Education for the Military Services (CDTEMS) grant.
d. Incorporated student-written Time Difference of Arrival/ Frequency Distance of Arrival (TDOA/FDOA) geolocation algorithm in the Geolocation Workbench.
e. Supported Courses SS 3001 and SS4051 by the development of geolocation material, the arrangement of field trips to visit contractor sites, and consulting support to the design project of a Measurement and Signature Intelligence (MASINT) architecture for the Central MASINT Organization.
f. Attended meetings of government LPI Communications Committee and hosted a meeting of the committee at NPS in August 2003.

THESES DIRECTED:

Dalbec, G., "Analysis of Modulation Recognition Systems for the Joint Satcom Electro- Magnetic-Interference Geographical-Location Cell," Master's Thesis, Naval Postgraduate School, September 2003.

Hulme, C.A, "Testing and Evaluation of the Configurable Fault Tolerant Processor (CFTP) for Space-Based Applications," Master's Thesis, Naval Postgraduate School, December 2003.

Musselwhite, A.M., "Information Sources and Applications in Support of Maritime Domain Awareness," Master's Thesis, Naval Postgraduate School, September 2003.

Roden, R.E., "Selected Analysis of an E-mail Forwarding System," Master's Thesis, Naval Postgraduate School, September 2003.

Yuan, R., "Triple Modular Redundancy (TMR) in a Configurable Fault Tolerant Processor (CFTP) for Space Applications," Master's Thesis, Naval Postgraduate School, December 2003**.**

KEYWORDS: Space Vehicles

SPACE SYSTEMS

TRIPLE-MODULAR-REDUNDANT ARCHITECTURES FOR RELIABLE SPACE-BASED COMPUTING

Herschel H. Loomis, Jr., Professor
Department of Electrical and Computer Engineering and Space Systems Academic Group
Alan Ross, Navy Tactical Exploitation of National Capabilities Chair Professor
Space Systems Academic Group

OBJECTIVE: To develop a single event upset (SEU) tolerant space-based computer using commercial-off-the-shelf (COTS) field programmable gate arrays (FPGA) to demonstrate the feasibility of using Triple Modular Redundancy (TMR) to correct errors without resort to system reset. To build and fly a TMR mission computer on NPSSAT.

SUMMARY: Radiation in space poses considerable threat to modern microelectronic devices, in particular to the high performance low cost computing capability we enjoy on earth. These effects can be categorized as long-term permanent faults called *total dose effects* and transient temporary effects called *single event upsets* (SEU). [1]

Total dose effects can be relatively easily delayed by semiconductor-manufacturing-process modification, but single-event upsets are more difficult to prevent in modern, high-speed, small-feature-size devices. So, while total dose radiation tolerant modern processors and FPGAs are available, all of the modern current generation processors are very susceptible to SEUs. [1]

It has long been understood that replication of logic with voting circuitry can be used to improve the reliability of digital systems in the presence of transient errors in the logic, such as SEUs. [1, 2]. Researchers at the Naval Postgraduate School (NPS) have been engaged in a project to build an evaluation board for a TMR implementation of a RISC processor to validate the TMR architecture for employment in a high-SEU environment. This research led to the conclusion that the TMR architecture is an effective architecture to enhance the resistance of a processor to SEUs so that the computer can operate reliably in the hostile environment of low earth orbit. [1, 2, 3, 4]

The way that the system works is as follows:

1. In the absence of errors, the three identical computers operate in lock-step, performing whatever control or data-processing function is desired.
2. If a SEU occurs in one of the processors, eventually the error will affect either an address, data bus value, or control line.
3. The voter circuitry will pass on the correct value of the affected lines to memory and/or the I/O, and the voter will signal a Voter Error Interrupt to all three computers.
4. The three CPUs will enter the error interrupt service routine in lockstep.
5. The job of the interrupt service routine will be to save the internal state including all internal registers to SECDED memory. During this process, further interrupts will be disabled and the voters will insure that the correct state values are saved. Next the saved state will be restored to each of the three CPUs.
6. A return from interrupt will be executed and the main program will resume at the point that the error was detected.

This process will thus lose no data and will only suffer the interruption in mission computing required to perform the state save and restore.

The research to date has identified the Xilinx *Virtex* FPGA technology as having the requisite resistance to total-dose effects and the logic power to be able to implement the voting and CPU logic. [1] The layout of the circuit board to hold the two field programmable gate arrays (FPGA), the configuration memory, and the data memory has been completed and the board is in fabrication. All of the parts for the qualification board have been obtained.

The Configurable Fault Tolerant Processor (CFTP) experiment is manifested on two small satellites, NPSAT1 (Naval Postgraduate School) and MidSTAR1 (U.S. Naval Academy), which are to launch in September 2006 into a low-earth orbit. This past year, researchers applied for approval as a recognized experiment through the DoD Space Experiment Review Board for a higher radiation orbit, such as Molnya, MEO, or GTO. This was approved and ranked 29 out of 41.

THESES DIRECTED:

Ebert, D.A., "Design and Development of a Configurable Fault Tolerant Processor (CFTP) for Space Applications," Master's Thesis, Naval Postgraduate School, June 2003.

Hulme, C.A., "Testing and Evaluation of the Configurable Fault Tolerant Processor (CFTP) for Space-Based Applications," Master's Thesis, Naval Postgraduate School, December 2003.

Johnson, S., "Implementation of a Configurable Fault Tolerant Processor (CFTP)," Master's Thesis, Naval Postgraduate School, March 2003.

Yuan, R., "Triple Modular Redundancy (TMR) in a Configurable Fault Tolerant Processor (CFTP) for Space Applications," Master's Thesis, Naval Postgraduate School, December 2003.

KEYWORDS: Space-Based Computing

ADVANCED MULTI-JUNCTION SOLAR CELLS MEASUREMENT SYSTEM FOR NPSAT1 SATELLITE
Rudolf Panholzer, Professor
Space Systems Academic Group
Sponsor: Space Missile Command

SUMMARY: To fund officer student design and development of a measurement system for advanced multi-junction solar cells to be used on the NPSAT1 micro-satellite.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Aerospace Power, Manpower, Personnel, Training, Materials, Processes, and Structures

KEYWORDS: Spacecraft Electrical Power, Multi-junction Solar Cells, Small Satellites

FERROELECTRICITY RESEARCH NEWSLETTER
Rudolf Panholzer, Professor
Space Systems Academic Group
Sponsor: Office of Naval Research

SUMMARY: This project provided two-year funding for a quarterly research newsletter designated to supply information on national and international symposia, conferences, workshops, and meetings dealing with topics of interest to scientists, engineers, and students in the field of integrated ferroelectrics research. The basic research effort was performed by a contractor. The Principal Investigator, Professor Rudolf Panholzer, Chair, Space Systems Academic Group, volunteered his services and assumed responsibility for directing the research effort at quarterly review meetings with research contractor.

DoD KEY TECHNOLOGY AREA: Materials and Processes

KEYWORDS: Integrated Ferroelectrics

SPACE SYSTEMS

NAVAL SPACE SYSTEMS ACADEMIC CHAIR
Rudolf Panholzer, Professor
Space Systems Academic Group
Sponsor: Naval Space Command

SUMMARY: Incumbent of the Naval Space Systems academic chair engaged in instruction and research and acted as a consultant in the area of specialization to students and faculty of the Naval Postgraduate School.

KEYWORDS: Naval Space Systems Support

SPACE SYSTEMS ACADEMIC GROUP
Rudolf Panholzer, Professor
Space Systems Academic Group
Sponsor: National Aeronautics and Space Administration Dryden Flight Research Center

MILITARY APPLICATIONS OF SPACE RESEARCH PROJECT - BASIC FUNDING FOR 2002-2003
Alan Ross, Navy Tactical Exploitation of National Capabilities Chair Professor
Charles Racoosin, Naval Space Command Academic Chair Professor
Space Systems Academic Group
Sponsor: Naval Engineering Logistics Office

OBJECTIVE: The Military Applications of Space (MAS) Research Project managed funds provided for several research projects. This particular task managed and allocated the funds provided by Tactical Exploitation of National Capabilities (TENCAP) for the period 1 June 2002 through 31 May 2003.

KEYWORDS: Space Systems

FIRST PRINCIPLES PREDICTION OF X-RAY IMPULSE
Donald v. Z. Wadsworth, Senior Lecturer
Space Systems Academic Group
Sponsor: Strategic Systems Programs Office

OBJECTIVE: To develop a first-principles physics model for predicting the impulse induced on selected surfaces by an X-ray burst in space. To validate the theoretical model by comparing predictions with available underground test data and other experimental data.

SUMMARY: This multi-year research project supported the Trident Stockpile-to-Target Stewardship program. It was a collaborative effort involving faculty (Ron Brown, Ashok Gopinath, Donald Wadsworth) in the Naval Postgraduate School (NPS) Space Systems Academic Group and the Departments of Physics, Mechanical Engineering, and Electrical and Computer Engineering. Two Navy Master's degree graduates performed thesis research in support of this effort. Accomplishments during 2003 included the modification of a commercial finite-element hydrocode (Century Dynamics' AUTODYN) to model X-ray radiation energy deposition. Blowoff and shock impulse predictions using AUTODYN validated previous 1-D results based on the CTH and XRAY codes and UGT data. The numerical impulse predictions were consistent with those of a well-known analytical impulse model (MBBAY). It was concluded that certain physics-based improvements to the hydrocodes are required to obtain high-fidelity predictions of shock phenomena. These included a revised model of blowoff viscosity to include short time-scale relaxation processes and a more accurate, experimentally verified, EOS for the complex aeroshell materials of interest.

THESIS DIRECTED:

Sylvester, C.A., "Cold X-Ray Radiation Absorption and Material Response: Numerical Model for Predicting Blow-Off and Impulsive Loading in Re-Entry Vehicles," Master's Thesis, Naval Postgraduate School.

KEYWORDS: X-ray, Lasers, Weapons Effects

SPACE SYSTEMS
ACADEMIC GROUP

2003
Faculty Publications
and Presentations

There are no publications included in the Space Systems Academic Group section. Publications for professors associated with Space Systems are listed in each professor's home department.

GRADUATE SCHOOL OF
BUSINESS AND PUBLIC POLICY

DOUGLAS A. BROOK
DEAN

GRADUATE SCHOOL OF BUSINESS AND PUBLIC POLICY

MISSION:

The mission of the Graduate School of Business and Public Policy is:

- To improve the managerial capabilities and leadership qualities of U.S. and international officers and government civilians through graduate education, research, and professional service.
- To develop students' abilities to analyze, think critically, and take intelligent action so they can more effectively carry out their professional responsibilities, and lead their organizations in complex, and sometimes life-threatening, environment.
- To conduct research that supports military decision-making, problem solving, and policy setting, improves administrative processes and organizational effectiveness, contributes knowledge to academic disciplines, and advances the mission of graduate education.
- To provide professional expertise that supports the development of the Naval Postgraduate School, the Departments of Navy and Defense, and other branches of Government, as well as our professional and academic organizations.

RESEARCH MISSION:

Faculty research is an important component of the Graduate School of Business and Public Policy's mission. As such, the school strives to "conduct research that supports military decision making, problem solving, and policy setting, improves administrative processes and organizational effectiveness, contributes knowledge to academic disciplines, and advances the mission of graduate education."

The research program is integrated to the greatest possible extent with the educational process. Students are encouraged to participate in faculty projects, and faculty research results are typically incorporated in classroom instruction.

CURRICULA SERVED:

The Graduate School of Business and Public Policy has primary responsibility for six graduate degrees. The largest degree program is a group of curricula in the Defense-focused Master of Business Administration, with the following curricular concentration areas:
- Acquisition Management
- Logistics Management
- Financial Management
- Information Management
- Defense Management

Another resident program is the Master of Science in Management, with a concentration in manpower analysis.

Distance learning graduate programs offered by the Graduate School of Business and Public Policy include: an Executive Masters of Business Administration degree program (targeting senior Navy Lieutenants through Commanders, particularly from the Unrestricted Line communities, who have middle-management level experience); Contract Management and Program Management (for Department of Defense civilians at designated off-site locations), which award a Master of Science in Contract Management and a Master of Science in Program Management, respectively; and Leadership Education and Development program (for Company Commanders at the U.S. Naval Academy), which awards a Master of Science in Human Resources Management.

The Graduate School of Business and Public Policy also offers two certificate programs: the Practical Comptrollership Course, sponsored by the Assistant Secretary of the Navy (Financial Management and Comptroller), targets individuals (civilian and military) occupying or reporting financial management positions; and the Advanced Acquisition Program, which provides Level III education certificate in Program Management for the Department of Defense acquisition workforce.

The school's graduates programs achieved the distinction of being one of only two graduate management programs in the country earning dual accreditation by AACSB-the Association to Advance

Collegiate Schools of Business and NASPAA-the National Association of Schools of Public Affairs and Administration.

The faculty of the Graduate School of Business and Public Policy are drawn from a wide variety of academic disciplines in business and public sector management. The diverse, multidisciplinary character of the faculty is reflected in the breadth and depth of issues addressed by faculty research, which has historically been concentrated in areas of interest to the Departments of Defense and Navy. Therefore, faculty research directly enriches the instructional materials used in the curricula in the school. The topics and issues can be grouped into five broad areas:

- Acquisition and Contract Management
- Logistics and Transportation Management
- Financial Management
- Manpower Systems Analysis
- Organization, Systems and Management

RESEARCH THRUSTS:

The primary goal of the school's research program is to provide the Navy and the Department of Defense (DoD) with the capability of managing defense organizations and programs efficiently and effectively. Therefore, the objective of the school's research effort is to apply the existing knowledge base in support of resource utilization decisions, to develop new concepts or theory if no such knowledge base exists to support the policy/decision making process, to enhance the relevance of the school's instructional programs, and to involve the students through their thesis or application project work in enhancing their decision making capability.

While concepts and the knowledge base are generally divided into different functional areas or disciplines, actual resource utilization decisions or policies often require multi-disciplinary efforts. Therefore, in addition to pursuing functional area research in those disciplines with a critical mass of faculty, the thrust of the school's research program is to conduct cooperative interdisciplinary research in areas where the school is in a strong position to become a leading force in research. It also places the school in a strong position to assist defense policy makers, since it allows for a coordinated, broad-based program under "one roof"—where researchers from diverse fields can share information and findings in a unified and truly systematic fashion.

FACULTY:

The research thrusts and faculty in each of the functional areas in the Graduate School of Business and Public Policy are discussed in greater detail in the following sections.

Acquisition and Contract Management. Defense acquisition represents a process of critical importance to the military, not only to reduce taxpayer costs, but to ensure the quality and performance of today's increasingly sophisticated weapon systems. Nevertheless, negligible academic research has been applied to systematically investigate, understand, and model the acquisition process; and current innovations in this domain—such as process reengineering and acquisition reform—are uncoordinated, ad-hoc, and performed largely on a trial-and-error basis.

Beginning in 2002, the Graduate School of Business and Public Policy initiated an Acquisition Research Program to provide leadership in innovation, creative problem solving and an on-going dialogue to support the evolution of Department of Defense acquisition strategies. The program goals include:

- Establishing NPS acquisition research as an integral part of policy-making for the Department of Defense (DoD) and Navy officials.
- Creating a stream of relevant information concerning the performance of DoD acquisition policies with viable recommendations for continuous process improvement.
- Preparing the workforce to participate in the continued evolution of the defense acquisition process.

- Collaborating with other universities, think tanks, industry and Government in acquisition research.

Supported primarily by the Graduate School of Business and Public Policy Acquisition Chair, currently held by Rear Admiral Jim Green, USN, (Ret)., this research program initiated fifteen research projects in 2003, with the number increasing to well over 20 in 2004. These projects include several collaborative efforts with Dr. Jacques Gansler (former Under Secretary of Defense for Acquisition, Technology and Logistics) at the University of Maryland. Some research topics completed in 2003 include: transformation in contract closeout (Professor David V. Lamm), centralization of control in the acquisition process (Senior Lecturer John T. Dillard), and reduction of total ownership cost (Senior Lecturer Michael W. Boudreau and Lecturer Brad R. Naegle).

This research represents seminal scholarly work in the area of defense acquisition and draws on expertise in accounting, contracting, economics, information systems, law, organizational design, public policy, and other academic disciplines. A complete description of the Acquisition Research Program, including funded projects and supporting faculty, is available through the acquisition research website (http://www.nps.navy.mil/gsbpp/ACQN/index.htm).

Logistics and Transportation Management. The primary mission of the Logistics and Transportation Management group is to educate military officers and Department of Defense (DoD) civilians in state-of-the-art concepts of logistics and transportation management. Emphasis is placed on understanding both military and non-military applications, so that students will be prepared to perform effectively in a military environment and interact efficiently with civilian contractors and suppliers. The general research perspective of the group is focused on improving DoD logistics and transportation performance as well as management effectiveness. Major research thrusts in this area include:

- DoD inventory policy;
- inventory and cycle time reduction;
- defense transportation and distribution systems;
- modeling and simulation for logistics decision support;
- reduction of manpower in aircraft and ship maintenance;
- aircraft Component Improvement Program (CIP); and
- sea-based logistics for the Navy and the Marine Corps.

Professor Kevin Gue's projects deal with throughput and storage system models for crossdocks and transshipment points, with particular application to sea base design in Sea Based Logistics. Professor Doerr participated in a Return-On-Investment (ROI) analysis for the Advanced Technology Ordinance Surveillance (ATOS) Advanced Concept Technology Demonstration (ACTD). Professor Kraus analyzed strategic inventory stockouts when three is substitution across products by the customers. Senior Lecturer Don Eaton (RADM, USN, Ret.) has been active in investigating the issues and concerns of aging aircraft and tactics of remediation and amelioration.

Financial Management. Research in the area of financial management has become increasingly important since the end of the Cold War, as defense organizations "downsize" and policy makers exercise renewed efforts to gain maximum utility of shrinking resources at minimum cost. The Financial Management (FM) group has identified four major functional areas as targets of opportunity for future research. These are:

- financial resource policy formulation, analysis and management;
- enterprise resource planning systems;
- financial matters of personnel entrusted with sensitive information;
- cost analysis.

The first of these functional areas—financial resource policy formulation, analysis, and management—covers a range of sub-areas: national defense and national security resource policy and management; resource planning, programming, budgeting, and policy under the Planning, Programming, Budgeting System; and relationships between financial management, contracting, acquisition, and other policy fields. Professors Larry Jones, Jerry McCaffery, and Richard Doyle have expertise in this area. Recent research involves assisting the Office of the Comptroller, AIRPAC, in analyzing initiatives for improving command management and management control, cost-reduction and cost avoidance in the Flight Hour Program (FHP) and in accommodating budget reductions, and analyzing the systems used to budget for homeland security.

Resource planning systems cover the development of systems, such activity-based management systems (ABM), enterprise resource planning systems (ERP), capable of generating timely and reliable information for operational decisions, and performance management models (PMM). Professors Ken Euske and Joseph San Miguel continue to be involved in DoN's ERP efforts. Professor Mary Malina is investigating how organizations choose performance measurement models and whether the performance measurement models exhibit internal causality. She is also involved in a field study to build a causal performance model (CPM), which is the conceptual foundation of a performance management model (PMM).

Recent events of high profile security breach have heightened interest in the financial matter of those entrusted with sensitive information. Since 1998, Professor San Miguel has provided financial expertise to the National Security Agency, U.S. Customs, and the Central Intelligence Agency on the design and evaluation of employee financial disclosures for identifying unexplained affluence and financial stress. His current project applied financial analysis techniques to live data obtained from federal employees in positions of national security in attempt to highlight abnormality. Professor Carmelita Troy is conducting research on managerial and strategic factors contributing to accounting fraud.

The research area of cost analysis and return on investment covers weapon systems and software cost estimation, resource requirement analysis, the cost of new technologies, and cost analysis of major system modifications. Presently, Professor Bill Gates is active in this area. Professor Juliette Webb is also conducting research to determine if investments in information technology have direct or marginal effects on supply chain management performance.

Manpower Systems Analysis. The focus of research in the Manpower Systems Analysis (MSA) group is on *human* resources. Defense manpower policy makers have been faced with many challenges since the end of the Cold War. Key among these challenges were a reduction of the active-duty force by over 30 percent, budget reductions in recruiting and advertising, a steady operational tempo and deployment schedule with fewer people, new missions, declining levels of public and congressional support for the military, increasing pressure to change the "culture" of military service, renewed efforts toward population representation of women and racial/ethnic minorities throughout the force, a seemingly immovable, high rate of first-term attrition among new recruits, declining levels of personnel retention in certain critical areas, a number of high-profile "scandals," and others. As the active-duty force was reduced and missions changed, it soon became clear that a smaller military had to be even more skilled and adaptable than the one that witnessed the end of compulsory service and performed so successfully throughout the early 1980s and early 1990s. These challenges confronting defense manpower policy makers are recognized by the MSA group as opportunities for research that will have a lasting impact on the future of the force. MSA research areas can be summarized as follows:

- requirements and recruiting
- LCS manning study
- research into ship officer staffing guide analysis of recruiting station location analysis of recruiter productivity recruiter intelligent-agent modeling analysis of no-prior-service reservists
- attrition
- CNRC's recruit quality matrix (screen) analysis of DEP attrition success of GED recruits
- reduction of first-term enlisted attrition rates
- officer career paths
- analysis of performance of the officer lateral transfer and redesignation process
- selection and classification of enlisted personnel
- comparison of officer promotion systems
- commissioning source and officer promotion and performance
- distribution and force shaping
- agents and web-based markets for detailing personnel
- force structure and cost analysis
- force management and planning, including reserve components
- separation pay options
- effectiveness of equal opportunity and diversity management programs
- civil-military relations and the all-volunteer force

Professors Mark Eitelberg, Armando Estrada, Bill Gates, Janice Laurence, Stephen Mehay, Elda Pema, Senior Lecturer Alice Crawford, and CDR Bill Hatch are involved in this area.

Organization, Systems and Management. Faculty in this functional area pursue basic and applied research on key management issues at a variety of organizational levels. Individual faculty members are acknowledged experts who publish leading-edge research on a variety of issues. Top management issues include strategic planning, change management, stakeholder analysis, organizational design and the development of culture. Human resource management issues include the design of strategic reward systems, managing gender and diversity issues, managing stress, forming career identities, and alternative strategies to training and education (including distance learning). There is a strong expertise in leadership issues, change management, intrinsic motivation, motivational strategies, empowerment, coaching, communications strategies, conflict management, and constructive uses of power.

Organization, systems and management research areas during 2003 included the following:

- analyzing development and adoption processes for radio frequency identification tags within the Department of Defense (DoD) environment,
- analyzing how information technology can improve communication, coordination and collaboration among organizations during complex emergencies and peace operations,
- using longitudinal research and organizational development to design and test a theory of positive organizational change over time in an organizational setting,
- examining attitudes toward the war in Iraq to understand how affect and memory may be impacted during times of crisis,
- modeling and simulating collocation and interpersonal trust in military integrated product and acquisitions teams when they are collocated compared to when they are distributed,
- designing flexible, collaborative networks for interagency coordination in homeland security,
- using appreciative inquiry and transformational-organizational design to foster positive organizational change.
- Professors Frank Barrett, Nick Dew, Susan Hocevar, Nancy Roberts, Leslie Sekerka, Gail Fann Thomas, and Roxanne Zolin

RESEARCH PROGRAM (Research and Academic)-FY2003:

The Naval Postgraduate School's sponsored program exceeded $71 million in FY2003. Sponsored programs include both research and educational activities funded from an external source. A profile of the sponsored program for the Graduate School of Business and Public Policy is provided below.
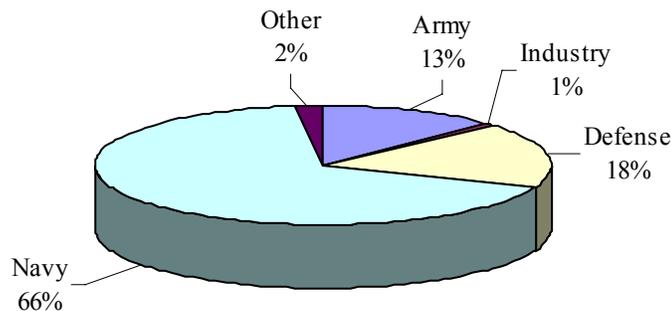
Size of Program: $4,021K

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GRADUATE SCHOOL OF BUSINESS AND PUBLIC POLICY

REDUCTION OF TOTAL OWNERSHIP COST
Michael W. Boudreau, Senior Lecturer
Brad R. Naegle, Lecturer
Graduate School of Business and Public Policy
Sponsor: Naval Sea Systems Command

OBJECTIVE: To analyze the underlying causes for poor Total Ownership Cost performance within weapon systems acquired through the Department of Defense (DoD) Acquisition Management System.

SUMMARY: As a weapon system progresses from early concept, through prototyping, into production, and finally reaches the sustainment phase, the opportunities to significantly reduce the Total Ownership Cost (TOC) diminish. This clearly indicates that Reduction in Total Ownership Cost (R-TOC) efforts are most effective early in the developmental cycle where changes are least expensive and easiest to implement. The DoD acquisition process emphasizes the need for TOC efficient weapon system development, but clearly focuses technical performance measurement on *what the weapon system will do*, not on *how much it will cost to do it*. System Key Performance Parameters rarely include TOC elements, leaving system functions and features that would improve TOC performance in the "trade space" for the inevitable trade-off analyses that are performed.

TECHNICAL REPORT:

Boudreau, M.W. and B.R. Naegle, "Reduction of Total Ownership Cost," Naval Postgraduate School Technical Report, NPS-GSBPP-03-004, September 2003.

DoD KEY TECHNOLOGY AREAS: System Acquisition, Total Ownership Cost, Performance Based Logistics, Acquisition Logistics, Cost as an Independent Variable

KEYWORDS: Total Ownership Cost, TOC, CAIV, Performance Based Logistics, PBL, Weapon System Supportability, Acquisition Logistics

THE EFFECT OF COMPUTER-MEDIATED COMMUNICATIONS ON GRADUATE STUDENT INTERACTIONS
Douglas E. Brinkley, Lecturer
Graduate School of Business and Public Policy
Sponsor: Naval Postgraduate School

OBJECTIVE: This dissertation research was completed in partial fulfillment of the requirements for the degree of Doctor of Education from Nova Southeastern University.

SUMMARY: There is a significant body of research that supports the hypothesis that interaction is a key enabler of the learning process. This study measured the effect of computer-mediated communication (CMC) on student interactions in traditional classroom courses at the graduate level. A secondary investigation also assessed the impact of CMC on student perceptions of classroom interaction.

The site of the study was the Naval Postgraduate School, Monterey, California. The method of research employed a quasi-experimental design with two groups completing a course titled "Fundamentals of Information Technology." The same instructor taught the same material to both sections and in the same classroom. The only difference in instruction between the control group and the treatment group was that the treatment group had the option of using CMC discussion board tools in addition to their normal verbal and written communications to interact with the instructor and/or other students. Quantitative data analysis was conducted on observed interactive events and measures of perception were assessed through a verified reliable self-report survey.

Analysis of the data revealed that CMC had a statistically significant effect on graduate classroom interactions. Both the number of student-student and overall interactive events were increased, as well as the student's perception of classroom interaction.

GRADUATE SCHOOL OF BUSINESS AND PUBLIC POLICY

CONFERENCE PUBLICATION:

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

PRESENTATION:

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

KEYWORDS: Computer Interaction, Graduate Students

ACQUISITION CHAIR OF MANAGEMENT
Douglas A. Brook, Dean
Graduate School of Business and Public Policy
Sponsor: Naval Sea Systems Command

DEVELOPMENT AND ADOPTION OF RADIO FREQUENCY IDENTIFICATION (RFID) TECHNOLOGY IN THE DEPARTMENT OF DEFENSE (DOD)
Nick Dew, Assistant Professor
Graduate School of Business and Public Policy
Sponsor: Naval Postgraduate School

SUMMARY: Radio Frequency Identification (RFID) technology appears to be an increasingly important technology in the Department of Defense (DoD) environment. Whether it takes the form of a transponder embedded in the uniform of the "Soldier of the Future," an electronic tag/seal used for tracking and securing container shipments of critical supplies, or as "sensor nets" picking up vital on-ground information in theater operations, RFID is one of the technologies that is at the heart of being smart in modern warfare. RFID closes the gap between information systems and physical objects by attaching RFID tags to objects, allowing their identification, allowing them to be tracked and monitored, and allowing the feedback of sensory input from the environment. In short, RFID enables computers to sense things. The purpose of this research was to investigate the development and adoption processes for RFID within the DoD environment.

KEYWORDS: RFID, Radio Frequency Identification, Soldier of Future

ECONOMIC AND RETURN-ON-INVESTMENT (ROI) ANALYSIS FOR ADVANCED TECHNOLOGY ORDINANCE SURVEILLANCE
Kenneth Doerr, Assistant Professor
William R. Gates, Associate Professor
John Mutty, Senior Lecturer
Graduate School of Business and Public Policy
Sponsor: Naval Surface Warfare Center – Indian Head

OBJECTIVE: To perform an independent economic and Return-on-Investment (ROI) analysis for the Advanced Technology Ordinance Surveillance (ATOS) Advanced Concept Technology Demonstration (ACTD). An independent ATOS economic and ROI analysis will help validate whether the benefits of ATOS exceed their costs, and help justify program funding.

SUMMARY: Advanced Technology Ordinance Surveillance (ATOS) is an Advanced Concept Technology Demonstration (ACTD) involving a system of electronic tags with sensors affixed to ordnance items that automatically collects and reports inventory and environmental data on individual items

throughout their lifecycle. ATOS will improve inventory accountability, reduce manpower requirements, reduce overall inventory investment and enhance safe shelf-life and service-life predictions.

This analysis compared the ATOS investment costs to the expected ATOS benefits to estimate an ATOS ROI. Investment costs included developing hardware/software components, manufacturing test quantities, demonstrating military utility, modifying and maintaining hardware/software as necessary, and operational production, implementation, and operation. Benefits involved inventory accuracy, reduced opportunity cost of the inventory investment (holding cost), improved service-life prediction and shelf-life safety, and the associated manpower savings. The economic and ROI analysis used simulation models to explicitly incorporate uncertainty, and provided the capability to perform sensitivity analysis on investment costs and other key components. The analysis developed the appropriate cost models and analyzed the model results. A multi-attribute decision model was also used to evaluate non-monetary benefits of ATOS technology. A working cost model was delivered, along with the project report, to allow the sponsor to explore further sensitivities as necessary.

OTHER:

Doerr, K., Gates, W., and Mutty, J., "Economic Analysis, Return-on-Investment, Cost-Benefit Analysis, Advanced Technology Ordinance Surveillance (ATOS), Advanced Concept Technology Demonstration (ACTD)," unpublished report to sponsor, 2003.

Garretty, E., MAJ, USMC, Developed an initial economic and ROI analysis model as well as a preliminary Ordnance Management Survey as part of the ATOS analysis in a directed readings class, Fall AY2003.

DoD KEY TECHNOLOGY AREAS: Logistics, Computing and Software

KEYWORDS: Economic Analysis, Return-On-Investment, Cost-Benefit Analysis, Advanced Technology Ordinance Surveillance, ATOS, Advanced Concept Technology Demonstration, ACTD

ADMIRAL STANLEY ARTHUR CHAIR OF LOGISTICS AT THE NAVAL POSTGRADUATE SCHOOL
Donald R. Eaton, Senior Lecturer
Graduate School of Business and Public Policy
Sponsor: Naval Air Systems Command

SUMMARY: To provide a direct relationship between the Naval Air Systems Command (NAVAIR) and the Naval Postgraduate School (NPS) to manage relevant research supportive of NAVAIR requirements and to provide opportunities for professional development of both faculty and students in logistics and related currricula at NPS. The specific research objective was to ensure that research in topics of interest to NAVAIR was carried out and to stimulate and coordinate continuing relevant research by NPS faculty and students. The specific educational objective was to enhance the capabilities of graduates to assume management and policy-making positions within the Department of Defense.

KEYWORDS: Logistics, Admiral Arthur Chair

COMPREHENSIVE STUDY OF JUNIOR RESERVE OFFICER TRAINING CORPS (ROTC)
Armando X. Estrada, Research Associate Professor
Janice H. Laurence, Research Associate Professor
Alice M. Crawford, Senior Lecturer
Gail Fann Thomas, Associate Professor
Mark Eitelberg, Professor
Graduate School of Business and Public Policy
Sponsor: Office of the Assistant Secretary of Defense

OBJECTIVE: This study examined the structure and function of the Junior Reserve Officer Training Program with particular emphasis on curricular consolidation; program budget and instructor pay; and enlistment behavior of JROTC participants.

SUMMARY: This study reviewed JROTC curricula for possible consolidation across the services, examined budget and pay concerns for instructors, and examined military outcomes of the program. Review of JROTC service curricula suggested that there are commonalities in content that should be considered for consolidation. These commonalities include citizenship (e.g., history and government), communications, health and wellness, and leadership. Examination of the instructor compensation system indicated that the system fails to consider instructor qualification, is not integrated with the local school's pay system, and offers no way to adjust compensation for hard-to-fill positions. Finally, though military recruiting was not one of the program's goals, results indicated that the program is a major benefit to recruiting in many respects.

THESES DIRECTED:

Kern, Y., "Study of the Junior Reserve Officers' Training Corps: Should the Services' Four Curricula Be Merged?" Master's Thesis, Naval Postgraduate School, March 2003.

Walls, T., "Junior Reserve Officers' Training Corps: A Comparison with Other Successful Youth Development Programs and an Analysis of Military Recruits who Participated in JROTC," Master's Thesis, Naval Postgraduate School, June 2003.

KEYWORDS: JROTC

INTELLIGENT AGENTS AND WEB-BASED MARKETS FOR DETAILING NAVAL PERSONNEL
William R. Gates, Associate Professor
Graduate School of Business and Public Policy
Sponsor: Naval Postgraduate School

OBJECTIVE: To analyze the technological and operational feasibility of establishing a web-based market, using intelligent agents, to match Naval enlisted personnel to specific Navy billets.

SUMMARY: This multi-year research analyzed the technological and operational feasibility of establishing a web-based market, using intelligent agents, to match Naval enlisted personnel to specific Navy billets. This system will be part of a general Department of the Navy (DoN) Sailor Career Management System that manages cradle-to-grave career paths to facilitate both recruiting and retention by enhancing the quality of life within DoN.

This is the fourth year of research on this project. During FY03, researchers continued exploratory experiments to assess the performance of alternative employment market designs, including two-sided matching, optimization, and humans. Using a quasi-price measure examining social welfare to assess market-design alternatives, researchers developed novel insight into the balance required between technologically enabled efficiency and economically principled effectiveness of markets. Results pointed to a Pareto superior increase in total welfare through market design, which can dramatically increase employee morale and retention, and increase overall labor market efficiency.

Researchers also developed a simulation model to test alternative business rules for DoN's emerging Assignment Incentive Pay auctions. These results indicated the tradeoffs between costs, quality of the sailor billet match, candidate pool size, and preference list length. The simulation model can help inform policy decisions regarding this high visibility initiative.

PUBLICATIONS:

Gates, W.R. and Nissen, M.E., "Experimental Analysis of e-Employment Market Design," *Journal of Organizational Computing and Electronic Commerce*, 14(3), 2004, (forthcoming).

Gates, W.R. and Nissen, M.E., "An Overview of Agent- and Web-Based Employment Marketspaces in the U.S. Department of Defense," *Encyclopedia of Information Science and Technology*, (under second review).

Gates, W.R. and Nissen, M.E., "Two-Sided Matching Agents for Electronic Employment Market Design: Social Welfare Implications," (under review).

PRESENTATIONS:

Gates, W.R. and Nissen, M.E., "Social Welfare Implications of Two-Sided Matching Agents," Western Economics Association International Meetings, Denver, CO, 11-15 July 2003.

Gates, W.R., Nissen, M.E., Ho, J.H., and Low, E.H., "Two-Sided Matching for the U.S. Navy's Enlisted Detailing Process: A Comparison of Deferred Acceptance and Linear Programming via Simulation," Navy Manpower Research and Analysis Conference, Center for Naval Analysis, Alexandria, VA, 31 March-1 April 2003.

Logemann, K.P., Gates, W.R., and Nissen, M.E., "Simulation Analysis for Distribution Incentive Pay in the U.S. Navy Enlisted Personnel Assignment Process," Institute for Operations Research and the Management Sciences (INFORMS), Atlanta, GA, 19-22 October 2003.

THESES DIRECTED:

Logemann, K., "Sensitivity Analysis for an Assignment Incentive Pay in the United States Navy Enlisted Personnel Assignment Process in a Simulation Environment," Master's Thesis, Naval Postgraduate School, December 2003.

Penrod, D., "Economics Experiments to Examine the Impact of Information and Algorithm-Based Decision Processes for U.S. Navy Enlisted Detailing," Master's Thesis, Naval Postgraduate School, December 2003.

Ramirez, M.A. and Park, D.H., "U.S. Marine Corps Enlisted Distribution and Assignment Process: The Customer's Perspective," Master's Thesis, Naval Postgraduate School, March 2003.

DoD KEY TECHNOLOGY AREAS: Manpower, Personnel and Training, Computing and Software, Modeling and Simulation

KEYWORDS: Intelligent Agents, Web-Based Markets, Two-Sided Matching Games

PUBLICNESS IN ALLIANCE DEFENSE EXPENDITURES
William R. Gates, Associate Professor
Graduate School of Business and Public Policy
Sponsor: None

OBJECTIVE: To analyze burden sharing issues in defense alliances and the implications for alliance stability and cohesion.

SUMMARY: Over the past several decades, NATO allies have debated the relative burdens and benefits of NATO membership. Recently this concern surfaced as members debated the magnitude and distribution of NATO expansion costs. This paper presented an economic model of defense alliances to identify the benefits and burdens of alliance membership. It suggested that defense expenditures provide public benefits if alliance members share common interests and mutual commitment; defense expenditures provide private benefits if countries lack common interests and mutual commitment. The model's results were used to discuss NATO's evolving roles and missions, NATO expansion, and burden sharing across NATO members.

PUBLICATIONS:

Gates, W.R. and Terasawa, K.L., "Reconsidering Publicness in Alliance Defense Expenditures: NATO Expansion and Burden Sharing," *Journal of Defence and Peace Economics*, pp. 369-383, October 2003.

Terasawa, K.L. and Gates, W.R., "NATO Stability: A Difference Equation Perspective," 2004, (to be submitted).

DoD KEY TECHNOLOGY AREA: Other

KEYWORDS: Burden Sharing, Defense Alliances, NATO, Public Goods

SHIP OFFICER STAFFING GUIDE (SOSG)
William R. Gates, Associate Professor
CDR William D. Hatch, II, USN, Military Instructor
Graduate School of Business and Public Policy
Sponsor: Chief of Naval Operations (N12)

OBJECTIVE: To develop a standardized methodology for the identification of officer manpower requirements for use in Ship Manpower Documents (SMD) and Fleet Manpower Documents (FMD).

SUMMARY: Prior to 1996, officer manpower requirements were entered into Ship Manpower Documents (SMD) as directed requirements from a document called the Ship Officer Staffing Guide (SOSG). This Guide was reviewed and updated based on new mission requirements, community management issues, and required changes in skills due to technology improvements and changes in the Navy Officer Occupational Classification System (NOOCS). On 6 June 1996, as a part of the Paperwork Reduction Act, the Navy Manpower Steering Working Group Committee (MSWGC) canceled the SOSG. In response to the cancellation of the SOSG, the Navy Manpower Analysis Center (NAVMAC) developed a process in which officer manpower requirements were determined based on three criteria: 1) Positional Authority (Commanding Officer, Executive Officer, Department Head), 2) Operational Watch Standing (Tactical Action Officer, Officer of the Deck), and 3) Special Skills or Knowledge (Judge Advocate General, Nurse). While this process is useful, it is still very subjective. Because of its inherent subjectivity and the necessity to account for community management concerns, an important unanswered question is whether the process should be managed at the Chief of Naval Operations (CNO) executive level or at the field activity level. This research developed a new Officer Staffing Guide to identify specific officer classification requirements for display in manpower documents for fleet units.

TECHNICAL REPORT:

Hatch, W.D., Ohanian, A., and Simon, C., "Ship's Officer Staffing Guide: Report of Findings and Recommendations," Naval Postgraduate School Technical Report, NPS-GSBPP-03-005, October 2003.

DoD KEY TECHNOLOGY AREA: Capable Manpower

KEYWORDS: Ship Officer Staffing, Ship Manpower, Fleet Manpower

OPTIMAL SLOTTING OF FORWARD PICK AREAS FOR THE DEFENSE DISTRIBUTION CENTER
Kevin R. Gue, Associate Professor
Graduate School of Business and Public Policy
Sponsor: Office of Naval Research

OBJECTIVE: To develop slotting tools to help Defense Logistics Agency (DLA) choose the right products in the right amounts to be stored in the forward pick areas of the Defense Distribution Centers.

SUMMARY: This project sought to apply existing theoretical models for assigning products to pick locations within a warehouse in order to reduce total labor costs. The theoretical models sought to assign products to a fast pick area—one for which pick costs and retrieval time are lowest—in such quantities that the area was most economically used. This was a constrained, non-linear resource allocation problem that yielded itself to an elegant heuristic for solution. The project used those models on data from the Defense Distribution Depots in Tracy, California (DDJC), and in Susquehanna, Pennsylvania (DDSP).

PUBLICATION:

Gue, K.R., "A Dynamic Distribution Model for Combat Logistics," *Computers and Operations Research,* Vol. 30, pp. 367-381, 2003.

DoD KEY TECHNOLOGY AREA: Logistics and Transportation

KEYWORDS: Logistics, Warehousing, Distribution, Optimization, Order Picking

SEA BASED WAREHOUSING
Kevin R. Gue, Associate Professor
Graduate School of Business and Public Policy
Sponsor: Office of Naval Research

OBJECTIVE: To develop throughput and storage system models for cross-docks and transshipment points, with particular application to sea base design in Sea Based Logistics.

SUMMARY: Researchers developed throughput models for unit-load cross-docking systems, including a new type of queue called a *staging queue*. Analytical results were obtained with a continuous-time Markov chain model of the system, and simulation models were built for more complex systems. Proposed uses of the model in in-stream off-load operations and for the future sea based warehouse platform were presented.

DoD KEY TECHNOLOGY AREA: Logistics and Transportation

KEYWORDS: Distribution, Logistics, Warehousing, Cross Docking, Simulation

ANALYSIS OF BUDGET REDUCTION, COST-AVOIDANCE, AND FINANCIAL MANAGEMENT INITIATIVES IN COMMANDER, NAVAL AIR FORCE, U.S. PACIFIC FLEET (COMNAVAIRPAC)
Lawrence R. Jones, Professor
Jerry L. McCaffery, Professor
Graduate School of Business and Public Policy
Sponsors: Commander, Naval Air Force, U.S. Pacific Fleet (COMNAVAIRPAC)
Naval Postgraduate School

OBJECTIVE: To provide assistance to the Office of the Comptroller, AIRPAC, in analysis of initiatives for improving command management and management control, cost-reduction and cost avoidance in the Flight Hour Program (FHP) and in accommodating budget reduction.

SUMMARY: The project provided analytical assistance to the Office of the Comptroller, AIRPAC, in responding to the necessity for reviewing and assessing options for improving command management and management control, achieving cost-reduction and avoidance in the Flight Hour Program (FHP), and accommodating budget redirection in the period FY 2003 and beyond.

PUBLICATIONS:

Jones, L.R., McCaffery, J.L., and Kettl, D., "Assessing Public Management Reform in an International Context," *International Public Management Review*, 1 April 2003.

Jones, L.R., McCaffery, J.L., Kelman, S., Thompson, F., and Schedler, K., "Dialogue on Definition and Evolution of the Field of Public Management," *International Public Management Review*, 2 April.

BOOK:

Jones, L.R. and McCaffery, J.L., "Budgeting and Financial Management for National Defense," Greenwich, CT: Information Age Publishing, 2003.

THESIS DIRECTED:

Forero, J., Lamoureax, G., Martin, R., and Martinezdias, A., "Navy/Marine Corps TACAIR Integration: Impact of Operational and Support Activities," Master's Thesis, Naval Postgraduate School, December 2003.

DoD KEY TECHNOLOGY AREAS: Resource Management, Financial Management

KEYWORDS: Resource Management, Financial Management, Public Budgeting, Defense Budgeting, Defense Management Reform, Public Sector Management Reform

WAGNER CHAIR PROFESSOR OF PUBLIC MANAGEMENT
Laurence R. Jones, Professor
Graduate School of Business and Public Policy
Sponsor: Space and Naval Warfare Systems Command

MODELING AND ANALYSIS OF MARITIME SECURITY PROGRAM POLICY DECISION MAKING
Keebom Kang, Associate Professor
Graduate School of Business and Public Policy
Sponsor: U.S. Transportation Command

SUMMARY: Assessed the benefits to the Department of Defense (DoD) on the reauthorization of the Maritime Security Program in 2005, and measured the impact on readiness with either the current or proposed Maritime Security Program.

KEYWORDS: Maritime Security Program, 2005, Readiness

GRADUATE SCHOOL OF BUSINESS AND PUBLIC POLICY

INCORPORATING PRODUCT LINE DESIGN, PRODUCTION, AND MARKETING IN SUPPLY CHAIN OPERATIONS
Ursula G. Kraus, Assistant Professor
Graduate School of Business and Public Policy
Sponsor: Naval Postgraduate School

SUMMARY: Developed an analytical model to capture and analyze "Strategic Inventory Stockouts in the Presence of Customer Substitution." In particular, the model was concerned with the fact that retail stores do not keep all products within a product category in stock at all times, even when the products are non-seasonal commodity goods. Sometimes products are out of stock at the retailer because of shortages at the wholesaler or distributor, or because of inaccurate forecasts of demand, or simply because of inattention to ordering. There may, however, be reasons for stockouts beyond those that arise from unintended circumstances. The purpose of this research was to describe when a retailer should plan for strategic stockouts of some products within a category of (fully or partially) substitutable products in view of customer choice behavior, the impact of prices on customer choices, and the cost of holding inventory. The first results of this research were presented at the annual Institute for Operations Research and the Management Sciences (INFORMS) Conference in Atlanta, Georgia, in October 2003.

In addition, this line of research also compared product line selections and product prices obtained from optimum-seeking procedures under different customer choice models. A solution method was developed for the probabilistic Bradley-Terry-Luce (BTL) choice model under which customers within a segment choose products with positive surplus in proportion to the degree to which that product is surplus. The consequences of using the "wrong" choice model were analyzed. Results that provided insights into the implications of these choice models were derived. The first results on this research were successfully published in the *European Journal of Operational Research* in 2003.

PUBLICATION:

Kraus, U.G. and Yano, C.A., "Product Line Selection and Pricing Under a Share-of-Surplus Choice Rule," *European Journal of Operational Research*, 150, 653-671, 2003.

PRESENTATION:

Kraus, U.G., "Strategic Inventory Stockouts Under Customer Substitution," Annual Institute for Operations Research and the Management Sciences (INFORMS) Conference, Atlanta, GA, 19 October 2003.

KEYWORDS: Supply Chain, Marketing

CHAIR OF ACQUISITION
David V. Lamm, Associate Professor
Graduate School of Business and Public Policy
Sponsor: Naval Sea Systems Command

CHAIR OF ACQUISITION MANAGEMENT AND ACQUISITION RESEARCH
David V. Lamm, Associate Professor
Graduate School of Business and Public Policy
Sponsor: Office of the Assistant Secretary of the Navy (Research, Development, and Acquisition)

SUMMARY: The Acquisition Chair is responsible for, among other things, managing acquisition research for the deputy assistant secretary of the Navy for acquisition management (DASN ACQ) and the Naval Postgraduate School (NPS), including brokering research opportunities for NPS faculty, stimulating and supervising research projects by selected opportunities for NPS faculty, stimulating and supervising research projects by selected graduate students, traveling as necessary to support research objectives, and providing quarterly reports regarding research progress and accomplishments. In consultation with DASN (ACQ), the Acquisition Chair has developed a list of potential research projects.

KEYWORDS: Naval Space Systems Support

ANALYSIS OF THE DEFENSE ADVISORY COUNCIL ON WOMEN IN THE SERVICES (DACOWITS) SITE VISIT REPORTS (1995-2001)
Janice H. Laurence, Research Associate Professor
Graduate School of Business and Public Policy
Sponsor: Office of the Assistant Secretary of Defense

SUMMARY: Content analysis of previously conducted Defense Advisory Council on Women in the Services (DACOWITS) focus groups.

DoD KEY TECHOLOGY AREAS: Manpower, Personnel, Training

KEYWORDS: DACOWITS, EO, Military Women

DEFENSE ADVISORY COUNCIL ON WOMEN IN THE SERVICES (DACOWITS) FOCUS GROUP TRAINING
Janice H. Laurence, Research Associate Professor
Graduate School of Business and Public Policy
Sponsor: Office of the Undersecretary of Defense

SUMMARY: For over 50 years the Department of Defense (DoD) Advisory Committee on Women in the Services (DACOWITS) has advised the Secretary of Defense on issues related to women in the military. Under a revised charter, DACOWITS can be expected to contribute in more efficient and effective ways. Site visits by DACOWITS members have served as a primary means of information gathering. To improve the content and quality of information obtained through site visits and to facilitate dissemination of that information to policy makers, training in qualitative data collection methods (i.e., focus groups) is needed.

DACOWITS members and staff attended a one and one-half day course of instruction devoted to the focus group process. The training was tailored to DACOWITS issues and included practical exercises that will prepare them for such systematic data collection and reporting in the field. Among the topics included in the instruction were focus group participant selection, protocol development, session facilitations, data recording, transcription and analysis, and report preparation.

Specific tasks included:

- **Designing a tailored course of instruction on preparing for and conducting focus groups.** Naval Postgraduate School (NPS) researchers met with DACOWITS staff regarding agenda items and operating procedures. The course was conducted to coincide with the convening of DACOWITS new member training (3-6 December 2002). Existing guidelines and previous DACOWITS reports were examined for possible inclusion of items in the training program. Training/instruction was planned for one and one-half days with DACOWITS committee members, staff members, and service representatives.
- **Developing a "Student" manual describing the focus group process.** A short manual (i.e., 10 pages) was developed. This manual was formatted for easy use in the field to reinforce training.
- **Conducting focus group training with DACOWITS members and staff**. An interactive training session for DACOWITS and DACOWITS staff members was delivered by researchers experienced in the focus group methodology and process. Training occurred over a one and one-half day period in facilities provided by the Department of Defense.

KEYWORDS: DACOWITS, EO, Military Women

**DESCRIPTION AND ASSESSMENT OF PERSONNEL SECURITY PROCESS AND
PROCEDURES FOR MILITARY PERSONNEL**
Janice H. Laurence, Research Associate Professor
Graduate School of Business and Public Policy
Sponsor: Defense Personnel Security Research Center

SUMMARY: With hundreds of thousands of new recruits entering military service each year, coordinating personnel security needs is no small task. Recruits must be screened and otherwise properly vetted for collateral and TS/SCI clearances for classified training and job assignments. The Defense Personnel Security Research Center (PERSEREC) wishes to review and assess the screening processes with attention to training and job assignment that require TS/SCI access.

By documenting the process and magnitude of the personnel security needs of the services, PERSEREC hopes to understand service needs and identify strengths and weakness of the system so as to improve readiness through potential system modifications.

Tracking personnel security needs and identifying logjams will lead to improved planning and management and thus personnel readiness. This description is expected to enhance understanding of Department of Defense needs within the intelligence community. Further, this study supports other PERSEREC studies related to clearance reciprocity, quality of investigations, interim access requirements, and so forth.

Tasks included:

- **Literature review:** A targeted review of the literature with regard to military moral character screening. Technical reports and policy documents/instructions served as the principal sources.
- **Meeting with service points of contact:** Interviews with strength planners, assignment specialists, and personnel security specialists within each service were conducted to document the personnel security needs, concerns, processes, and so forth.
- **Collecting relevant data on personnel security needs and trends:** Existing personnel security and other relevant databases were identified so as to identify the scope of security needs (and any potential problems or concerns).

KEYWORDS: Personnel Security, PERSEREC

EVALUATION OF EFFICIENT OFFICER COMMISSIONING SOURCE
Janice H. Laurence, Research Associate Professor
Stephen L. Mehay, Professor
Graduate School of Business and Public Policy
Sponsor: Office of the Secretary of Defense

SUMMARY: The main officer commissioning sources include: 1) the service academies, 2) Reserve Officer Training Corps (ROTC) programs at host colleges and universities, and 3) Officer Candidate/Training School (OCS/OTS) programs. These sources vary considerably with regard to scope, enrollment flexibility, and cost. Although total officer accession requirements continue to be satisfied, the recent tendency for OCS/OTS-type programs to operate at close to maximum capacity provides evidence of system strain. This effort was intended to assess potential alternative commissioning programs so as to improve the efficiency and effectiveness of the officer accession process.

Overview and Expected Results. This effort described the goals, objectives, operation, logistics, recruiting, and throughput trends of each commissioning source. Further, the study identified alternative officer accession management strategies to efficiently and effectively meet future officer strength and quality needs. The study updated information on expected longevity of officers by accession source: it also proposed and evaluated alternative accession program designs that might enhance the Department's ability to respond to rising or falling officer production demands.

Although the service academies were not excluded from consideration, this effort focused on ROTC and OCS/OTS trade-offs. The review evaluated means to enhance the viability of ROTC units, perhaps by expanding on-campus programs (e.g., a combination of short ROTC scholarships or "internships" with follow-on attendance at OCS-type programs). Furthermore, ideas regarding similar and innovative commissioning sources were elicited from the services. Criteria for consideration were determined based

on commissioning program and officer development goals and objectives. Criteria (i.e., quality or acceptability dimensions) were vetted by commissioning source proponents and other stakeholders as identified by the sponsor and service contacts. Cost-effectiveness considerations and the ability to meet overall service requirements were part of the evaluation strategy.

In considering costs, measures of program impact were used to evaluate the effectiveness of alternative commissioning programs. These measures served as the base for assessing the value of these programs to the organization. However, this effort was not designed to "pit" one source against the other in terms of relative officer performance. Rather, "effectiveness" was assessed on dimensions derived from expert judgment of the value of the "source" to meet strength needs within the operational constraints of the services.

KEYWORDS: Officer Commissioning, ROTC

BUILDING PERFORMANCE MODELS FROM EXPERT KNOWLEDGE
Mary A. Malina, Assistant Professor
Graduate School of Business and Public Policy
Margaret Abernethy, University of Melbourne
Malcolm Horne, Monash University
Anne Lillis, University of Melbourne
Frank Selto, University of Colorado at Boulder
Sponsor: None

OBJECTIVE: To demonstrate that it is feasible to tap the causal knowledge of individual experts in the field and advantageous to triangulate various methods of qualitative data analysis.

SUMMARY: This paper reported the results of a field study to build a causal performance model (CPM), which is the conceptual foundation of a performance management model (PMM). The study used three qualitative methods to identify the performance drivers and causal structure of the CPM from interviews with a major hospital's administrators, physicians, and nurses. This was a particularly critical first step to building valid performance management models.

PRESENTATIONS:

Abernethy, M., European Accounting Association Annual Congress, Seville, Spain, April 2003.

Lillis, A., 8th Biennial Management Accounting Research Conference, Sydney, Australia, February 2003.

Malina, M., 2nd Conference on Performance Measurement and Management Control, Nice, France, September 2003.

Selto, F., AIMA Conference on Management Accounting Research, Monterey, CA, May 2003.

KEYWORDS: Causal Model, Qualitative Method, Expert Knowledge, Validation

CAUSALITY IN PERFORMANCE MEASUREMENT MODELS
Mary A. Malina, Assistant Professor
Graduate School of Business and Public Policy
Frank Selto, University of Colorado at Boulder
Sponsor: None

OBJECTIVE: To test for internal causality among measures in a Fortune 500 company's performance measurement model.

SUMMARY: This research paper described the efforts of a large U.S. manufacturing company to improve profitability by creating a performance measurement model that reflects managers' understanding of causal relations among key strategic and operational activities and desired financial outcomes. Research questions addressed how the performance measurement model measures were chosen and whether the performance measurement model exhibited internal causality.

KEYWORDS: Performance Measurement, Strategy, Causality

DIFFERENCES IN FIRMS' RESPONSIVENESS TO SEXUAL ORIENTATION DIVERSITY ISSUES

Mary A. Malina, Assistant Professor
Graduate School of Business and Public Policy
Sponsor: None

OBJECTIVE: To determine what factors influence the corporate response to sexual orientation issues.

SUMMARY: The purpose of this study was to determine what factors cause U.S. companies to differ in their degree of responsiveness to sexual orientation issues in the workplace. Some companies have responded dramatically to the needs of their employees while others have yet to act. The study explored factors or characteristics that might affect a company's responsiveness based on a review of the literature and on conversations with experts on diversity issues. Results showed that industry and regional differences affect responsiveness, as well as the percent of minorities on the Board of Directors, whether the company has a Diversity Officer, and the level of sales.

KEYWORDS: Human Resources, Corporate Responsibility, Diversity

SAFE SCHOOLS PROJECT

Mary A. Malina, Assistant Professor
Alice M. Crawford, Senior Lecturer
Kenneth J. Euske, Professor
Stephen L. Mehay, Professor
Graduate School of Business and Public Policy
Sponsor: Salinas Union High School

OBJECTIVE: To help improve the learning experience of Salinas middle and high school students.

SUMMARY: The Salinas Safe Schools/Healthy Students project is a partnership to improve school safety as well as reduce violence in the city of Salinas. The partnership includes the U.S. Departments of Education, Health and Human Services, and Justice. The agencies have united to provide grants to assist students, schools, and communities. The aim is to promote healthy childhood development and to prevent violence and alcohol/drug abuse with enhanced educational, mental health, social service, law enforcement and juvenile justice system services.

THESIS DIRECTED:

Brinkerhoff, E., Govea, E., Gustin, S., and Zerbo, M. "Cost Avoidance Analysis, Safe Schools Environment Program, City of Salinas, California," Master's Thesis, Naval Postgraduate School, December 2003.

KEYWORDS: Education, Human Capital

SEXUAL ORIENTATION DIVERSITY AND FIRM VALUE: AN EVENT STUDY
Mary A. Malina, Assistant Professor
Graduate School of Business and Public Policy
Derek Johnston, Colorado State University
Sponsor: None

OBJECTIVE: To determine if the stock market reacted to the announcement of the Corporate Equality Index (CEI) ratings in August 2002.

SUMMARY: The purpose of this study was to determine if there are economic gains associated with formally recognizing sexual orientation diversity. It was found that release of the CEI score triggered a stock market reaction. In particular, researchers documented a positive relation between CEI scores and abnormal returns on the release date of the scores. It was also found that the CEI score relative to the industry average explained cross-section differences in abnormal returns on the event date. By demonstrating support for both hypotheses, researchers showed that the stock market appears to view sexual orientation diversity as increasing firm value. As such, this study may be of interest to managers as they evaluate possible strategic human resource policies aimed at increasing firm value.

KEYWORDS: Event Study, Corporate Responsibility, Diversity

ANALYSIS OF SYSTEMS USED TO BUDGET FOR HOMELAND SECURITY
Jerry L. McCaffery, Professor
Graduate School of Business and Public Policy
Sponsor: U.S. Department of Justice

OBJECTIVE: In the fall of 2002, it was not clear how homeland security efforts would be organized and what budget process would be created. Subsequently, the Department of Homeland Security (DHS) was created and it moved to create and establish a personnel/payroll/budget (PPB) system similar to the system employed in the Department of Defense (DoD). The objective of this research was to review the historical record and see what lessons learned from DoD's experience with PPB would be of value to the DHS.

SUMMARY: This technical report examined DoD's experience with the PPB system over the last 40 years and provided lessons learned from that experience for consideration by DHS budget planners. Research began with the consolidation of DoD during and after World War II. The Navy was probably the service that considered itself the most unique and was most opposed to the concept of one department and one budget system. The PPB system was not fully deployed until 1964 under Robert McNamara, but from then on the process was fixed within a PPB framework. Nonetheless, major reforms occurred under Secretary Melvin Laird, as a result of Goldwater-Nichols, and under Secretary Donald Rumsfeld. The primary lesson of all of this seeming turmoil was that the PPB system has always been in an evolutionary mode, with constant improvements along a generalized conceptual path. It was not created once and for all and operated as a fixed template. This means that system designers need not get caught up in the desire to be perfect at the start. History indicates that beginning with a satisfying model and upgrading it will work. While PPB is an expensive system to operate in terms of people and time, no other system appears to solve the requirement for planning for and resourcing systems and personnel to meet the threat posed to U.S. homeland security. DHS did not need to choose a PPB system; it could have chosen a performance- or program-based budgeting system focused on inputs and outputs and driven by changes in the lines presented to Congress for appropriation. To its credit, DHS did not do this; faced with a threat, it chose a threat-based budget system. Problems remain in making the system operate in a timely fashion, in ensuring that top-down threat guidance comes prior to programming guidance, and that the many cultures melded into DHS will interpret instructions and directions in the same way. More research is need on implementation.

GRADUATE SCHOOL OF BUSINESS AND PUBLIC POLICY

PRESENTATION:

McCaffery, J., "Homeland Security Seminar on Budget Issues in Homeland Security," Guest Lecture to CS 4920, April 2003.

TECHNICAL REPORT:

McCaffery, J., "Issues in Homeland Security Budgeting," Naval Postgraduate School Technical Report, January 2004.

KEYWORDS: Homeland Security, Budgeting

ADMIRAL BOORDA CHAIR OF MANAGEMENT AND ANALYSIS AT THE NAVAL POSTGRADUATE SCHOOL
Stephen L. Mehay, Professor
Graduate School of Business and Public Policy
Sponsor: U.S. Transportation Command

SUPPORT TO MSA CURRICULUM FROM CHIEF OF NAVAL PERSONNEL
Stephen L. Mehay, Professor
Graduate School of Business and Public Policy
Sponsor: Chief of Naval Personnel (N-1)

OBJECTIVE: To support research efforts by students and faculty in the manpower and systems analysis curriculum that supports the chief of naval personnel.

SUMMARY: The funds supported a number of research efforts related to Navy manpower and personnel issues. Projects included the following:

- An analysis of rate of return on the Navy's investment in early graduate education programs
- Trends and analysis of technical skills in the URL junior officer corps
- An analysis of handicapping in the U.S. Navy officer corps
- Construction of Navy officer cohort files
- A cost analysis of officer commissioning programs

PRESENTATION:

Bowman, W. and Mehay, S.L., "An Analysis of Technical Skills of the Navy's Officer Corps, Annual Navy Workforce Conference," Center for Naval Analyses, Alexandria, VA, March 2003.

TECHNICAL REPORT:

Mehay, S.L., "A Survey of Navy Retention and Compensation Models," prepared for Navy Personnel Research, Studies and Technology Center, Millington, TN, July 2001.

THESIS DIRECTED:

Milner, C., "An Analysis of U.S. Navy's Early Graduate Education Programs," Master's Thesis, Naval Postgraduate School, December 2003.

DoD KEY TECHNOLOGY AREAS: Manpower, Personnel, Training

KEYWORDS: Retention, Officer Performance, Promotion, Graduate Education

GRADUATE SCHOOL OF BUSINESS AND PUBLIC POLICY

KNOWLEDGE-FLOW THEORY FOR VERY LARGE ENTERPRISES
Mark E. Nissen, Associate Professor
Graduate School of Business and Public Policy
Sponsor: Office of Naval Research, Young Investigator Program

OBJECTIVE: To develop scientific knowledge and understanding (i.e., theory) pertaining to the phenomenon of knowledge flow.

SUMMARY: This three-year project was funded by the Office of Naval Research (ONR) through its Young Investigator (YI) Program. The YI program is highly competitive, and winning the corresponding grant award brought national recognition to the Naval Postgraduate School. The basic science associated with this project addressed poor understanding of how knowledge—viewed as distinct from information and data—flows through the enterprise. To improve this understanding, a program of theory building and testing was conducted through a three-pronged technical approach: 1) develop and refine a model of knowledge-flow theory, emphasizing the very-large enterprise (e.g., Navy, Department of Defense); 2) develop a contingency model for matching the most-appropriate process and system designs to enterprise knowledge-flow patterns; and 3) assess the performance effects of alternative knowledge system and process designs through simulation (e.g., of naval warfare, personnel processes).

   The year 2003 represented the third year of this project. In this third year, research built upon previous work. In addition, the researcher was exposed to new learning about computational organization theory while at Stanford. The integration of new and prior work enabled development of a computational model for the military Joint Task Force and an examination of several research propositions pertaining to knowledge flows. Through this three-year project, part of the original basic science question was answered, multiple lines for additional basic research opened up, some follow-on lines for applied research surfaced, and the researcher's ideas spread noticeably through both the academic and military communities.

PUBLICATIONS:

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

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

CONFERENCE PUBLICATIONS:

Nissen, M. and Ibrahim, R., "Emerging Technology to Model Dynamic Knowledge Creation and Flow Among Construction Industry Stakeholders During the Critical Feasibility-Entitlements Phase," *Proceedings Joint Symposium on Information Technology in Civil Engineering*, Nashville, TN, November 2003.

Nissen, M. and Levitt, R., "Dynamic Models of Knowledge-Flow Dynamics," *Proceedings Minnesota Knowledge Management Symposium*, Minneapolis, MN, March 2003.

Nissen, M. and Levitt, R., "The Virtual Design Team (VDT): A Multi-Agent Analysis Framework for Designing Project Organizations," *Proceedings International Conference on the Integration of Knowledge Intensive Multi-Agent Systems*, Boston, MA, October 2003.

PRESENTATIONS:

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

Nissen, M., "Dynamic Knowledge Organization – Insights from a Year on the Farm," Graduate School of Business and Public Policy Research Seminar, Naval Postgraduate School, October 2003.

Nissen, M., "Dynamic Models of Organizational Learning," Virtual Design Team Research Group Seminar, Stanford University, CA, February 2003, (invited).

Nissen, M., "Understanding Knowledge Flow in Large Distributed Organizations," Center for Work, Technology and Organizations Research Colloquium, Stanford University, CA, March 2003, (invited).

Nissen, M., "A Workday in the Life of an Artificial Learning Agent," James March Monday Lunch Seminar, Stanford University, CA, February 2003, (invited).

Nissen, M. and Levitt, R., "Dynamic Models of Knowledge-Flow Dynamics," Minnesota Knowledge Management Symposium, Minneapolis, MN, March 2003.

WORKING PAPERS:

Nissen, M., "Defense Project Management Knowledge Flow through Lessons Learned Systems," *Story of Project Management*, E. Carayannis and Y. Kwak (Eds.), (forthcoming 2004).

Nissen, M., "Experimental Assessment of a Redesign Knowledge System for Decision Support," (in review).

Nissen, M., "An Overview of Inducing Enterprise Knowledge Flows," *Encyclopedia of Information Science and Technology*, Volume I-III, M. Khosrow-Pour (Ed.), (forthcoming 2004).

Nissen, M., "Understanding Knowledge-Flow Patterns for Design," (in review).

Nissen, M. and Buettner, R., "An Agent-Based Environment for Computational Experimentation in C2," (in review).

Nissen, M. and Buettner, R., "Computational Experimentation: Bridging the Chasm Between Laboratory and Field Research in C2," (in review).

Nissen, M. and Levitt, R., "Agent-Based Modeling of Knowledge Dynamics," (in review).

Nissen, M. and Levitt, R., "Streams of Shared Knowledge," (in review).

Nissen, M., Jansen, E., Jones, C., and Thomas, G.F., "Contextual Criticality of Knowledge-Flow Dynamics: Understanding a U.S. Tragedy of Friendly Fire," (in review).

TECHNICAL REPORT:

Nissen, M., Jansen, E., Jones, C., and Thomas, G.F., "Contextual Criticality of Knowledge-Flow Dynamics: The Tragedy of Friendly Fire," Naval Postgraduate School Technical Report, NPS-GSBPP-03-002, 2003.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation

KEYWORDS: Knowledge, Knowledge Flow, Knowledge Management, Knowledge Superiority, Modeling and Simulation

APPLICATION OF INFORMATION TECHNOLOGY TO PEACE OPERATIONS AND COMPLEX EMERGENCIES
Nancy C. Roberts, Professor
Graduate School of Business and Public Policy
School of International Graduate Studies (Joint Appointment)
Sponsor: None

OBJECTIVE: To apply information technology to complex, joint, and combined operations in all stages of peace operations, including complex emergencies.

SUMMARY: Great strides have been made in information technology. Yet its application lags in settings that require the coordination and collaboration of joint and combined forces, especially in crisis countries that do not have the infrastructure to support the new technology. In addition, military, non governmental organizations (NGO), and UN organizations each have their own systems that do not interface with one another. Communication and collaboration are very difficult when computer systems and software are not compatible among the parties.

This line of research asks how information technology can improve the communication, coordination, and collaboration among military, NGO, and UN organizations during complex emergencies and peace operations. A specific issue addressed is how the Internet can be used to link the players and reduce the communication barriers across all sectors.

THESES DIRECTED:

Adonis, M., "Exploring of Wireless Technology to Providing Information Sharing Among Military, United Nations and Civilian Organizations During Complex Humanitarian Emergencies and Peace Operations," Master's Thesis, Naval Postgraduate School, 2003.

Bridges, D.M., "Exploring of Wireless Technology to Providing Information Sharing Among Military, United Nations and Civilian Organizations During Complex Humanitarian Emergencies and Peace Operations," Master's Thesis, Naval Postgraduate School, 2003.

Politov, G.D., "United Nations Peacekeeping: Reliance on Centralized or Regional Systems," Master's Thesis, Naval Postgraduate School, 2003

DoD KEY TECHNOLOGY AREAS: Information Technology, Internet, Peace Operations, Complex Emergencies

KEYWORDS: Internet, Peace Operations, Complex Emergencies, Information Technology

FINANCIAL REPORTING AND ANALYSIS RESEARCH FOR THE DEPARTMENT OF DEFENSE PERSONNEL SECURITY RESEARCH CENTER
Joseph G. San Miguel, Professor
Graduate School of Business and Public Policy
Sponsor: Personnel Security Research Center, Department of Defense

OBJECTIVE: The objective of the research during the fourth year of this program was to assist the security agencies in applying financial analysis techniques to live data obtained from federal employees in positions of national security. Prior work recommended new tools for uncovering unexplained affluence or financial distress. The results have financial implications for security policies and programs of the Defense Security Service, the National Security Agency, the Central Intelligence Agency, and U.S. Customs.

SUMMARY: Although National Security has always been a major concern for U.S. federal officials, the September 11 attack has added more importance to this major area. Numerous initiatives are underway to evaluate the quality of financial and non-financial information for purposes of deterring or detecting security threats. Prior investigation and research has established that financial incentives and payments are

generally the primary motives for acts of spying by U.S. citizens. The well-known spy cases involving Aldrich Ames and John Walker are examples. This project considered the use of financial information as a predictor of potential security risks and the need for security investigations. Financial information included unexplained increases or decreases in an individual's net worth. The various sources of net worth, such as earned income, inheritance, or sale of personal assets, as well as the use of net worth for investments and asset acquisitions, are variables that must be considered.

CLASSIFIED REPORTS:

Due to the sensitivity of the subject, the reports prepared for the sponsor and the other federal agencies are CLASSIFIED.

DoD KEY TECHNOLOGY AREA: National Security

KEYWORDS: National Security, Financial Analysis, Cost Analysis, Cost Estimation

FINANCIAL REPORTING AND ANALYSIS RESEARCH FOR THE DEPARTMENT OF DEFENSE PERSONNEL SECURITY RESEARCH CENTER
Joseph G. San Miguel, Professor
Graduate School of Business and Public Policy
Sponsor: Defense Logistics Agency

SUMMARY: To provide financial reporting and analysis expertise to national security research projects of the Personnel Security Research Center of the Department of Defense, especially the automated financial disclosure analysis system for federal employees.

KEYWORDS: DACOWITS, EO, Military Women

ATTITUDES TOWARD THE WAR IN IRAQ: MEMORY BIAS DUE TO AFFECT
Leslie E. Sekerka, Assistant Professor
Graduate School of Business and Public Policy

OBJECTIVE: To examine how affect and memory may be impacted during times of crisis.

SUMMARY: In the second quarter of the year, in concert with scholars at Boston College, a research study was conducted to examine the influence of emotion on people's recollection of their attitudes toward the war in Iraq. Participants included 395 North American individuals who completed a longitudinal web-based study. Researchers looked at how emotional reactions and attitudes at the beginning of the Iraq War (T1) influenced people's recollections of those attitudes at the war's conclusion, defined by the official withdrawal of U.S. troops from combat (T2). Researchers predicted and found that emotional reactions to the war at T1 highly correlate with attitudes at T1, and in some cases influenced the recall of those initial attitudes at T2 (e.g., the more angry participants were about the War at its start, the more they remembered holding President Bush responsible for it when it ended, over and above what their attitude actually was at T1).

KEYWORDS: Emotions, Affect, Memory, Attitudes

**A LONGITUDINAL RESEARCH AND ORGANIZATIONAL DEVELOPMENT PROGRAM:
TOWARD A THEORY OF POSITIVE ORGANIZATIONAL CHANGE**
Leslie E. Sekerka, Assistant Professor
Graduate School of Business and Public Policy
Sponsor: Naval Postgraduate School

OBJECTIVE: To design and test a theory of positive organizational change over time in an organizational setting.

SUMMARY: The goal of this research program was to explicate the process of positive organizational change. The research considered what factors contribute to employee and organizational changes over time as a result of members' engagement in an *Appreciative Inquiry* organizational development and change program. This study looked at both the organization and its membership before and after engagement in a strength-based intervention program. The research combined logical positivist rigor with an Action Research orientation.

BOOK:

Sekerka, L.E. and Cooperrider, D., "Elevation of Inquiry into the Appreciable World: Toward a Theory of Positive Organizational Change," *Positive Organizational Scholarship*, K. Cameron, J. Dutton, and R. Quinn (Eds.).

PRESENTATIONS:

Sekerka, L.E., "Changing Values, Changing Organizations: The Implications and Potential of Empowerment and Democracy," All Academy Symposium, Academy of Management Annual Meeting, Seattle, WA, August 2003.

Sekerka, L.E., "Positive Organizational Change: How Positive Emotions Broaden and Build Transformative Cooperation," Conference on Transformational Cooperation, Case Western Reserve University, Cleveland, OH, October 2003.

KEYWORDS: Organizational Change and Development, Positive Organizational Scholarship, Appreciative Inquiry

**INTERAGENCY COORDINATION FOR HOMELAND SECURITY: BUILDING FLEXIBLE,
COLLABORATIVE NETWORKS**
Gail Fann Thomas, Associate Professor
Graduate School of Business and Public Policy
Sponsor: U.S. Department of Justice

SUMMARY: The threat to the United States' national security has become increasingly diverse and complex over the past years. In response to these threats and the attack of September 11, President Bush signed the Homeland Security Act of 2002 into law. The new Act, in conjunction with the newly established Homeland Security Department, focused on the prevention of, protecting against, and response to acts of terrorism on U.S. soil. In service to this mission, the Act reorganized numerous government agencies, all of which need to coordinate their efforts if they are to successfully meet the emergent threats posed by terrorism.

Recent General Accounting Office (GAO) studies stress the criticality of coordinating the efforts of federal, state, local, and private sectors, yet studies show that current efforts must be improved significantly if the U.S. is to successfully win the War on Terrorism. Documented barriers to inter-organizational coordination include:
- Missions that are at odds with one another
- Unclear roles and responsibilities
- Agencies' desire to protect their jurisdiction and control their resources

- Incompatible procedures, processes, data and information systems
- Disparate organizational cultures
- Lack of accountability
- Mistrust and skepticism
- Lack of knowledge of others' capabilities

The goal of this project was to provide a relevant, conceptual framework about inter-organizational coordination to assist local, state, and federal officials in their tasks of managing homeland security. Field-based research allowed researchers to customize the theoretical model for home security and develop relevant training materials. Recommendations for enhancing existing coordination capabilities were also provided.

KEYWORDS: Agency Collaboration, Homeland Security

AUTO-REDACTION OF ELECTRONIC DATA SYSTEMS IN CONJUNCTION WITH THE ELECTRONIC FREEDOM OF INFORMATION ACT AND THE NAVY – AIR FORCE INTERCHANGE
Ron Tudor, Lecturer
Graduate School of Business and Public Policy
Sponsor: Navy Acquisition Executive

OBJECTIVE: To establish a system of procedures and system objectives for an auto-redaction capability within the Navy – Air Force Interchange.

SUMMARY: Significant pressure is coming from Congress and the Small Business Administration to make the federal government contracting process more visible to the public. Electronic data storage systems exist that contain electronic copies of Navy and Air Force contracts. However, the Electronic Freedom of Information Act (EFOIA) of 1996 opened the door for public access to electronic data.

While electronic systems simplify and speed up the data release process, there are security concerns that such data can be mined for operational information. For example, comparing the bulk purchase of plywood by the Defense Logistics Agency with increased purchasing at a major military installation can indicate that the units at that installation are about to engage in a contingency operation. Further, knowing what types of units are at that installation can identify the potential mission. Cross-indexing that knowledge with current news events can accurately predict where the Department of Defense is about to engage in operations.

To prevent an enemy from data mining electronic systems for this type of information, an auto-redaction system must be developed. Auto-redaction is the process of removing information from electronic databases on a global transaction basis rather than as a manual search and redact function – as is normally done with Freedom of Information Act requests. To do this, a software system, or a new data architecture, must be developed.

KEYWORDS: Acquisition, Contracting, Internet

CREATION OF A PURE ELECTRONIC CONTRACTING AND PROPERTY DISPOSAL SYSTEMS UTILIZING THE INTERNET
Ron Tudor, Lecturer
Graduate School of Business and Public Policy
Sponsor: None

OBJECTIVE: To create a pure electronic, Internet-based system for the purchase of commercial-off-the-shelf (COTS) supplies and services for the federal government. To create a pure electronic property disposal system for the disposal of non-excess property, and the repurchase of similar items through the purchasing system.

SUMMARY: The premise of the research was that the Internet marketplace appears to be adaptable to commercial-off-the-shelf supply items and services routinely purchased by the government. For example,

within the United States Army Training and Doctrine Command there are seventeen major installations. They are spread across the U.S. and they purchase the daily supply type items they need through the local vendor base. If the government's internal information concerning the type and quantity of items purchased, and from which vendors, is made available to industry, industry could arrange for the vendors to provide their items through an electronic system.

In addition, various Internet companies have developed electronic ordering, billing, shipping, and tracking systems that are superior to government systems. Generally, when a government activity wants to make a purchase, it turns to a contracting system that takes months to complete the transaction. While there are some systems that are more efficient, the majority of systems are of the type that take an inordinate amount of time. The Internet systems offer the government the opportunity to increase the speed and efficiency of its procurement and finance systems.

Another aspect of government contracting is volume purchasing. The government typically gets the best prices because it purchases the largest amounts. A research concept in this area is whether the volume pricing the government enjoys can be improved if the commercial world is able to buy through a government contract. By purchasing from government suppliers, the commercial world can enjoy the government's prices. The government then receives even better prices from its suppliers because commercial industry is purchasing from them as well. This concept can be extended to city, county, and state government purchases.

The primary research methodology was for the Naval Postgraduate School to use an existing contract system, create a concept for a new one, study it to determine the baseline, create a new contract, and award it to a contractor.

The function of the new contract was likewise studied to determine what efficiencies, if any, have been created. The focus was not on the qualitative expressions of acquisition reform such as "better, faster, cheaper, smarter," but on the quantitative aspects: how much faster supplies are provided to users and the amount of savings.

Another research area was disposal or exchange of excess or ineffective supplies or equipment. For example, if a program manager has five D-7 Caterpillar bulldozers and they are insufficient to perform the mission, the manager can request the auctioning of those bulldozers and apply the revenue to the purchase of a new D-9 bulldozer. While this concept is fairly simple and straightforward, it envisions an electronic auctioning system that sells the D-7 bulldozers and then immediately purchases the new D-9.

THESES DIRECTED:

Chavis, J.T., "Examination of the Open Market Corridor," Master's Thesis, Naval Postgraduate School, December 2003.

Cheatham, J., "Examination of the Open Market Corridor," Master's Thesis, Naval Postgraduate School, December 2003.

Clark, J.H., "A Strategic Analysis of the Open Market Corridor," Master's Thesis, Naval Postgraduate School, June 2003.

Gonzalez, V., "Examination of the Open Market Corridor," Master's Thesis, Naval Postgraduate School, December 2003.

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Nalwasky, R., "Examination of the Open Market Corridor," Master's Thesis, Naval Postgraduate School, December 2003.

Rios, M., "Examination of the Open Market Corridor," Master's Thesis, Naval Postgraduate School, December 2003.

Tucker, J.L., "A Strategic Analysis of the Open Market Corridor," Master's Thesis, Naval Postgraduate School, June 2003.

Turner, M.A., "Examination of the Open Market Corridor," Master's Thesis, Naval Postgraduate School, December 2003.

OTHER:

This is an applied research project that will be Beta tested by various activities within the Department of Defense (DoD) and the federal government. If successful, these activities have expressed a willingness to adopt the processes for their daily acquisition operations. If so, DoD and the federal government will realize significant savings in terms of cost and productivity of its contracting system.

DoD KEY TECHNOLOGY AREA: Government Acquisition

KEYWORDS: Acquisition, Contracting, Disposal, Reform, Internet

THE PERFORMANCE ENABLING EFFECTS BETWEEN INFORMATION TECHNOLOGY AND SUPPLY CHAIN MANAGEMENT
Juliette Webb, Assistant Professor
Graduate School of Business and Public Policy
Buck K.W. Pei, Arizona State University
Yuhchang Hwang, Arizona State University
Benjamin Shao, Arizona State University
Sponsor: Naval Postgraduate School Research Initiation Proposal

OBJECTIVE: To examine whether or not there are performance-enabling effects between information technology and supply chain management.

SUMMARY: This paper developed a view of investments in information technology and supply chain management. The research question addressed whether these investments had direct or marginal effects on performance. Plant-level performance data from companies in durable manufacturing industries were used to examine the question.

KEYWORDS: Supply Chain Management, Information Technology, Performance

COLLOCATION AND TRUST IN ALPHA CONTRACTING
Roxanne Zolin, Assistant Professor
Graduate School of Business and Public Policy
Sponsors: Naval Postgraduate School Research Initiation Proposal,
U.S. Marine Corps Advanced Amphibious Attack Vehicle Tech Ctr

OBJECTIVE: To determine the relationship between interpersonal trust and performance in military integrated product teams when they are collocated compared to when they are distributed.

SUMMARY: The research team gathered data from the AAAV Program Office using interviews and questionnaires at two points in time. Analysis was performed and indicated differences in trust between military and civilian personnel. The results were briefed to the director of acquisition-career management (DACM).

KEYWORDS: Interpersonal Trust, Geographically Distributed Work, Cross-Functional Work, Military Culture

GRADUATE SCHOOL OF BUSINESS AND PUBLIC POLICY

2003 Faculty Publications and Presentations

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

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Bowman, W. and Mehay, S., "An Analysis of Technical Skills of the Navy's Officer Corps," Third Annual Navy Workforce Research and Analysis Conference, Alexandria, VA, 31 March-1 April 2003.

Coard, H.F. and Estrada, A.X., "Trends in Content, Design and Analysis of Military Psychology," American Psychological Association, Toronto, Canada, August 2003, (poster presentation).

Doerr, K. and Gue, K., "A Tune-able Performance Metric and Goal Setting Procedure for a Warehouse," Smith School of Business, 20 August 2003.

Eaton, D.R., "Enablers to Ensure a Future Logistics Enterprise," Department of Defense Conference on Education and Training for the Future Logistics Enterprise, Washington, D.C., 24-25 March 2003.

Eitelberg, M., "Confessions of a Cranky Journal Editor, Panel on Tips for Academic Writers," Biennial Conference of the Inter-University Seminar on Armed Forces and Society, Chicago, IL, October 2003.

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Engelbeck, R.M., "World-Class Contracting: How Winning Companies Build Successful Partnerships in the e-Business Age," Philadelphia Chapter of the National Contract Management Association, Philadelphia, PA, 24 February 2003.

Estrada, A.X. and Laurence, J.H., "Preventing Sexual Orientation Based Harassment Among Military Personnel," American Psychological Association, Toronto, Canada, August 2003.

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

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

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

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Levitt, R.E. and Nissen, M.E., "Dynamic Models of Knowledge-Flow Dynamics," Minnesota Knowledge Management Symposium, Minneapolis, MN, March 2003.

Logemann, K.P., Gates, W.R., and Nissen, M.E., "Simulation Analysis for Assignment Incentive Pay in the U.S. Navy Enlisted Personnel Assignment Process," Institute for Operations Research and the Management Sciences (INFORMS) Annual Meeting, Atlanta, GA, October 2003.

Mehay, S., "Cost-Benefit Analysis of Drug Prevention Policies," Institute for Economic Research, University of Neuchatel, Switzerland, 2 July 2003.

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Nissen, M.E., "Container-Managed ETL Applications for Integrating Data in Near Real-Time - Discussion," International Conference on Information Systems, Seattle, WA, December 2003.

Nissen, M.E., "Container-Managed ETL Applications for Integrating Data in Near Real-Time - Discussion," International Conference on Information Systems, Seattle, WA, December 2003.

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Nissen, M.E., "Dynamic Knowledge Organization – Insights from a Year on the Farm," Graduate School of Business and Public Policy Research Seminar, Naval Postgraduate School, October 2003.

Nissen, M.E., "Dynamic Models of Organizational Learning," Virtual Design Team Research Group Seminar, Stanford University, CA, February 2003, (invited).

Nissen, M.E., "Understanding Knowledge Flow in Large Distributed Organizations," Center for Work, Technology and Organizations Research Colloquium, Stanford University, CA, March 2003, (invited).

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Roberts, N.C., "Arenas and Forms of Citizen Participation: Building a Theory," 7th National Public Management Research Conference, Georgetown University, Washington, D.C., 9-11 October 2003.

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Sekerka, L., "Changing Values, Changing Organizations: The Implications and Potential of Empowerment and Democracy," Academy of Management Annual Meeting, Seattle, WA, August 2003.

Sekerka, L., "Positive Organizational Change: How Positive Emotions Broaden and Build Transformative Cooperation," Conference on Transformational Cooperation, Case Western Reserve University, Cleveland, OH, October 2003.

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INSTITUTES AND CENTERS

The Cebrowski Institute for Information Innovation and Superiority (CIIIS)

Wayne E. Meyer Institute of Systems Engineering (MISE)

The MOVES Institute (Modeling, Virtual Environments, and Simulation)

Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS)

CEBROWSKI INSTITUTE
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OVERVIEW:

The Institute for Information Superiority and Innovation was established 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. The Institute provides a venue for interdisciplinary research in a wide variety of areas related to the capture, processing, display and storage of information in a warfighting environment. Research and educational activities within the Institute are intended to support both immediate and long-term objectives for the effective use of computers and networks within the military.

CURRICULA SERVED:

The Institute for Information Superiority and Innovation does not manage its own curriculum. Instead, students from any curriculum at the Naval Postgraduate School can participate in the Institute's wide range of research and educational programs.

RESEARCH THRUSTS:

- Signals Intelligence
- Electronic Communications Systems
- Electronic Warfare
- Information Warfare
- Information Operations
- Computer and Network Security
- Threat and Risk Analysis and Countermeasures
- System Certification and Accreditation
- Motivations and Operations of Information Threats

For faculty members investigating these areas, see the research summaries for each faculty member's home department.

RESEARCH CENTERS:

Cryptologic Research Center (CRC)
Center for Information Security (INFOSEC) Studies and Research (CISR)
Center for the Study of Terrorism and Irregular Warfare

RESEARCH PROGRAM (Research and Academic)-FY2003:

The Naval Postgraduate School's sponsored program exceeded $71 million in FY2003. Sponsored programs included both research and educational activities funded from an external source. A profile of the sponsored program for the Institute for Information Superiority and Innovation (I2SI) is provided below:

Other Federal 1%
Navy 4%
National Science Foundation 95%

Size of Program: $767K
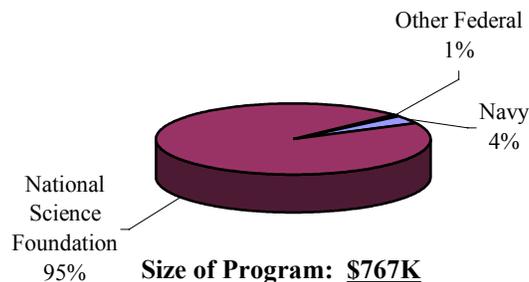
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INFORMATION OPERATIONS (IO) RESEARCH
Joanne B. Kim, Cryptologic Innovation Chair
Cebrowski Institute
Sponsor: Naval Security Group Command

JOINT ONLINE THESIS AND RESEARCH SYSTEM (JOTARS)
Joanne B. Kim, Cryptologic Innovation Chair
Cebrowski Institute
Sponsor: National Security Agency

SUMMARY: Established a baseline website on an SCI network and attracted other sponsors to this multi-phased interdisciplinary research initiative. Research and development was incremental, and led to an SCI knowledge portal for the defense and intelligence communities. Once at a level of a knowledge portal, the development will be evolutionary. This provides the Naval Postgraduate School (NPS) with opportunities for research into the communal aspects of knowledge sharing where value is created from the web. This is different from the "connective" aspect of knowledge management that simply supplies a communications mechanism.

KEYWORDS: IO, Information Operations, JOTARS

JOTARS: JOINT ONLINE THESIS AND RESEARCH SYSTEM
Joanne B. Kim, Cryptologic Innovation Chair
Cebrowski Institute
Sponsor: Space and Naval Warfare Systems Command

SUMMARY: Established a baseline website on an SCI network and attracted other sponsors to this multi-phased inter-disciplinary research initiative. Research and development was incremental, and led to an SCI knowledge portal for the defense and intelligence communities. Once at the level of knowledge portal, the development will be evolutionary. This provides the Naval Postgraduate School with opportunities for research into the communal aspects of knowledge sharing where value is created from the web. This is different from the "connective" aspect of knowledge management that simply supplies a communications mechanism. Presenting classified (SCI) research and thesis reports in a cyber domain has never been done before.

KEYWORDS: Thesis Website, JOTARS

SEMINAR AND RESEARCH INTO COMPLEX FUTURE SCENARIOS FOR TRANSFORMATIONAL STRATEGIC THINKING AND DECISION MAKING
Joanne B. Kim, Cryptologic Innovation Chair
Cebrowski Institute
Sponsor: National Imagery and Mapping Agency

SUMMARY: Conducted a National Imagery and Mapping Agency (NIMA)/Naval Postgraduate School (NPS) future world/situational environment(s), challenges, and solution strategies workshop; conducted a NIMA/NPS faculty seminar to shape the NPS research questions for the future world/situational environment(s) workshop.

KEYWORDS: Complex Future Scenarios, Strategic Thinking, Decision Making

CEBROWSKI INSTITUTE FOR INFORMATION INNOVATION AND SUPERIORITY (CIIIS)

2003
Faculty Publications
and Presentations

All faculty affiliated with the Cebrowski Institute have home departments. See the research summaries for each faculty member's home department for Institute member's presentations and publications.

WAYNE E. MEYER
INSTITUTE OF
SYSTEMS ENGINEERING
(MISE)

PHIL E. DEPOY
DIRECTOR

WAYNE E. MEYER INSTITUTE OF SYSTEMS ENGINEERING

OVERVIEW:

The Wayne E. Meyer Institute of Systems Engineering was first established as the Institute of Defense Systems Engineering and Analysis in 2001. In May 2002, the Institute was renamed the "Wayne E. Meyer Institute of Systems Engineering" after RADM Wayne E. Meyer, USN (Ret.) who was the founding Program Manager of the Aegis combat system, the first large Navy acquisition program in which a total systems approach was used in the system development and design.

The mission of the Institute is to provide an interdisciplinary education and research center, matrixed across the four academic schools at the Naval Postgraduate School. Faculty and students are drawn from various schools and departments to form interdisciplinary research teams, and courses from various departments are combined to offer interdisciplinary curricula in systems engineering.

Research projects recently completed or currently being conducted in the Meyer Institute include analysis support for Fleet Battle Experiment-Juliet, systems engineering support for the Joint Fires Network (JFN), analysis of the Joint Force Maritime Component Commander's Maritime Planning Process, and experimentation with Force Protection concepts.

CURRICULA SERVED:

- Total Ship Systems Engineering (TSSE)
- Systems Engineering and Analysis (SEA)
- Master of Science in Systems Engineering (MSSE)
- Product Development for the 21st Century-Systems Engineering Management (PD-SEM)
- Undersea Warfare (USW)

RESEARCH THRUSTS:

- Mine Warfare
- Anti-Terrorism/Force Protection
- Data Collection and Analysis for Fleet Battle Experiments
- Joint Warfare
- Concept and Process Modeling
- Evolutionary Computing
- Unconventional Weapons of Mass Destruction
- Sparse Optical Array Radar
- Dealing with Islamic Terrorists

RESEARCH CHAIRS:

- Expeditionary Warfare
- Undersea Warfare
- Mine Warfare
- Northrop Grumman Systems Engineering
- Northrop Grumman Professor of Systems Integration

RESEARCH FACILITIES:

- Three Integrated Student Design Labs

RESEARCH PROGRAM (Research and Academic)-FY2003:

A profile of the sponsored program for the Wayne E. Meyer Institute Systems Engineering (MISE) is provided below:

Other Federal
12%

Defense
8%

Navy
80%
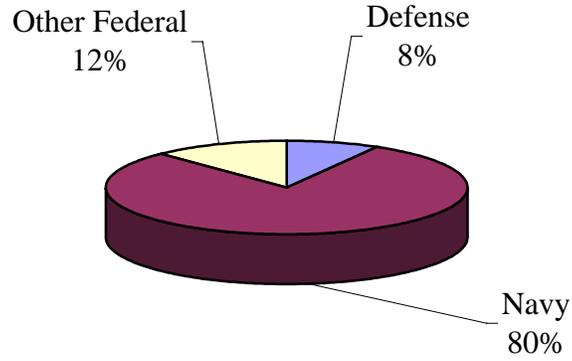
Size of Program: $3,591K

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WAYNE E. MEYER INSTITUTE OF SYSTEMS ENGINEERING

SIXTH MONTEREY INTERNATIONAL SYMPOSIUM OF TECHNOLOGY AND THE MINE PROBLEM
Donald P. Brutzman, Associate Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Office of Naval Research

SUMMARY: The Naval Postgraduate School hosted the International Symposium Series, Technology and the Mine Problem. There have been five such symposia to date, in April 1995, November 1996, April 1998, March 2000, and April 2002. These symposia covered the five pillars of the "mine problem:" mine technology, naval mine warfare, land mine warfare, humanitarian and peacekeeping demining (including unexploded ordnance), and emerging technology. These symposia have been nationally and internationally acclaimed and have been well recognized by the policy and executive levels in DoD and in the military departments. Each symposium has been attended by 350-450 individuals, who have been drawn from the DoD, operating forces, industry, academia, the international community, and by senior DoD, Navy, Army, and Marine Corps officials.

KEYWORDS: Mine Problem, Symposium

NAVY SHIP DESIGN
Charles N. Calvano, Professor
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Northrop Grumman

SUMMARY: The Total Ship Systems Engineering (TSSE) program, instituted at the Naval Postgraduate School in 1991, provides education in systems engineering methods and Navy ship design processes to students in the mechanical engineering, electrical engineering, and combat systems engineering curricula. The students perform a capstone, interdisciplinary team design of a Navy ship. Previous design projects have provided innovative and provocative insights into evolving Navy mission needs. In addition, in the course of their various course studies, the students perform shorter-term design studies and must complete a research thesis. By their nature, many of these studies and designs can complement independent research and development (IRAD) projects conducted at Northrop Grumman Ship Systems.

KEYWORDS: TSSE, Total Ship, Northrup Grumman

SATELLITE ALTIMETRY DATA ANALYSIS FOR UNDERSEA WARFARE
Peter C. Chu, Professor
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Space and Naval Warfare Systems Command

SUMMARY: This was the continuation of the long-term effort of the principal investigator and his students (Naval officers) on the effort to evaluate the value-aided of the altimetry data to undersea warfare. Mark-48 Table Group was used as the criterion to verify the sound velocity profiles (SVP) from the modular ocean data assimilation system (MODAS) and from the generalized digital environmental model (GDEM) dataset (climatology). If SVP from MODAS is closer to Mark-48 Table Group than SVP from GDEM, the MODAS product is superior to climatology. Since the satellite altimetry data are used in MODAS, the altimetry dataset is important for the undersea warfare.

KEYWORDS: Satellite Altimetry, Undersea Warfare, SVP, MODAS

WAYNE E. MEYER INSTITUTE OF SYSTEMS ENGINEERING

CAPTURING THE WEAPON SYSTEMS RESEARCH AND DEVELOPMENT
Phil E. Depoy, Visiting Professor and Director
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Naval Sea Systems Command

SUMMARY: This was a continuing effort to document experiences that occurred during the Cold War. An initial symposium was held at the Naval Postgraduate School (NPS) in June 2001 and was documented in an NPS report prepared by Dr. Phil Depoy and Dr. James Colvard. Another symposium was held in 2003 and the results were documented.

DoD KEY TECHNOLOGY AREAS: Other, System Acquisition, Research and Development

KEYWORDS: Weapons Systems Research, Cold War

CHAIR OF NAVAL EXPEDITIONARY WARFARE NAVAL POSTGRADUATE SCHOOL (NPS)
Phil E. Depoy, Visiting Professor and Director
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Office of Naval Research

CHAIR OF UNDERSEA WARFARE
Phil E. Depoy, Visiting Professor and Director
Roger F. Bacon, Chair Professor of Undersea Warfare and Director, Undersea Warfare Center
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Naval Undersea Warfare Center - Newport Division

SUMMARY: Created a chair for undersea warfare at the Naval Postgraduate School.

KEYWORDS: Undersea Warfare Chair

A STRATEGY FOR DEALING WITH ISLAMIC TERRORISM
Phil E. Depoy, Visiting Professor and Director
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Office of the Secretary of Defense

SUMMARY: Created a team to develop an overall long-run strategy for dealing with terrorist threats. This team was one of several independent teams participating in an overall effort to explore alternative competitive strategies.

KEYWORDS: Anti-Terrorism, Threat Strategies

TEMESEK-JOINT DEFENSE TECHNOLOGY AND SYSTEMS CURRICULUM
Phil E. Depoy, Visiting Professor and Director
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Office of Naval Research

SUMMARY: The U.S. Navy students from the Naval Postgraduate School (NPS) were sent to Singapore for the first six months of the Temesek program. The remaining twelve months will be spent at NPS. Support was provided for transportation, per diem, and supplies for these U.S. Navy students.

DoD KEY TECHNOLOGY AREAS: Temesek, Systems Engineering, Expeditionary Warfare

WAYNE E. MEYER INSTITUTE OF SYSTEMS ENGINEERING

ANTI-TERRORISM INFORMATION SYSTEM TESTING
Shelley P. Gallup, Research Associate Professor
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Naval Criminal Investigative Service

SUMMARY: The Institute for Joint Warfare Analysis provided data-capture, analysis planning and execution, and reporting for Fleet Battle Experiments.

KEYWORDS: FBE, Fleet Battle Expeirments, JWA, Anti-Terrorism

DATA AND ANALYSIS SUPPORT FOR FLEET BATTLE EXPERIMENTS AND NAVY WARFARE DEVELOPMENT COMMAND (NWDC) EXPERIMENTATION
Shelley P. Gallup, Research Associate Professor
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Navy Warfare Development Command

SUMMARY: The Institute for Joint Warfare Analysis provided data-capture, analysis planning and execution, and reporting for Fleet Battle Experiments.

DoD KEY TECHNOLOGY AREAS: Experimentation, Operations Research, Modeling and Simulation, Command and Control

KEYWORDS: Experimentation, Operations Analysis, Knowledge Management, Concept Based Analysis, Network Centric Warfare, Time Critical Strike, Maritime Access, Ballistic Missile Defense

FLEET BATTLE EXPERIMENT
Shelley P. Gallup, Research Associate Professor
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Maritime Battle Center

MARITIME PLANNING PROCESS (MPP) MODEL AND SIMULATION EXPERIMENTATION
Shelley P. Gallup, Research Associate Professor
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Navy Warfare Development Command

SUMMARY: Continued analysis of Maritime Planning Process (MPP) data from Fleet Battle Experiment Juliet as input to construction of an extend-based process model. This model was used to simulate the performance of the MPP under different conditions. Analysis results were provided to Navy Warfare Development Command (NWDC). NWDC will use these results as input to determining courses of action for future MPP experimentation, wargames, and studies.

KEYWORDS: Maritime Planning, MPP, Juliet

WAYNE E. MEYER INSTITUTE OF SYSTEMS ENGINEERING

NETWORK AND BANDWIDTH DATA AND ANALYSIS FOR AFLOAT COMMAND AND CONTROL (C2) IN SUPPORT OF JOINT FORCE MARITIME COMPONENT COMMANDER (JFMCC) AND JOINT TASK FORCE HEADQUARTERS (JTFQ) IN FLEET BATTLE EXPERIMENT JULIET AND IN MILLENIUM CHALLENGE 2002
Shelley P. Gallup, Research Associate Professor
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Navy Warfare Development Command

SUMMARY: The Institute for Defense Systems Engineering and Analysis (IDSEA) managed data-capture, analysis planning, data reduction, and reporting of results of network and bandwidth measurements, and the context for those measurements, in Fleet Battle Experiment Juliet aboard *USS CORONADO*. Naval Surface Warfare Center (NSWC) Corona provided technical support, specialized expertise, reduction of data, reconstruction of context, and initial results reporting.

DoD KEY TECHNOLOGY AREAS: Experimentation, Operations Research, Command and Control, Joint Command and Control, Network Centric Operations

KEYWORDS: Experimentation, Operations Analysis, Knowledge Management, Concept Based Analysis, Network Centric Warfare, Network Management, Bandwidth Management, Command and Control, C2

RESEARCH SUPPORT FOR THE NAVY FIRES IN FLEET BATTLE EXPERIMENT-KILO
Shelley P. Gallup, Research Associate Professor
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Navy Warfare Development Command, Operations

SUMMARY: This research program supported a specific experiment event conducted by the Navy Warfare Development Command (NWDC) and Commander, Seventh Fleet, in the SEVENTH Fleet area of responsibility (AOR). This event supported, by extension, further development and refinement of the Chief of Naval Operation's (CNO) Sea Power 21 initiative, NWDC Fires Thread, and aspects of the Navy Fires Network (NFN) program. Included in this event were documentation of system architecture requirements, interoperability, human factors, training, CONOPS, and tactics, techniques, and procedures. A systems engineering methodology was used, detailing current Seventh Fleet and potential Expeditionary Strike Group (ESG) processes and architecture and system/process/human factor interactions within the constraints of the Fleet Battle Experiment (FBE) Kilo Fires initiative and the underlying exercise. Systems analysis within FBE Kilo was limited to process definition, which also produced additional data for construction of operational modeling and simulation as part of the Program Office-sponsored NFN project at the Naval Postgraduate School (NPS). This research also included experiment design to maximize experiment objectives. Officer students, through class systems engineering projects and theses, and faculty in Systems Engineering supported the FBE Kilo project.

KEYWORDS: FBE Kilo, NWDC, Sea Power 21

FORCENET IPD 03 FIRES ANALYSIS
Nelson Irvine, Research Assistant Professor
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Naval Network Warfare Command

SUMMARY: This research program developed a plan for data collection and analysis in support of the Fires Initiative in the ForceNET 03 IPD/Expeditionary Strike Group (ESG) Limited Objective Experiment (LOE). Meyer Institute researchers, operating as observers, collected contextual fires data in the IPD and preceding events. Actual analysis of the collected data will be addressed in a follow-on scope of work (SOW) for fiscal year 2004.

KEYWORDS: Experimentation, Operations Analysis

FORCENET IPD 03 FIRES ANALYSIS
Nelson Irvine, Research Assistant Professor
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Space and Naval Warfare Systems Command

SUMMARY: This research program developed a plan for data collection and analysis in support of the fires initiative in the ForceNET 03 IPD/ Expeditionary Strike Group (ESG) limited-objective experiment (LOE). Meyer Institute researchers, operating as observers, collected contextual fires data in the IPD and preceding events. Actual analysis of the collected data will be addressed in a follow-on scope of work for fiscal year 2004.

KEYWORDS: FORCENET, Fires Initiative, ESG

NAVY FIRES NETWORK (NFN) FLEET IMPLEMENTATION, SYSTEMS, AND PROCESS ANALYSIS
William G. Kemple, Associate Professor
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Naval Sea Systems Command

SUMMARY: The Institute of Defense Systems Engineering and Analysis (IDSEA) planned, managed, and participated in a series of studies directly related to the modeling, analysis, and fielding of the Navy Fires Network (NFN) system. In the first year of the program, fiscal year 2002, IDSEA coordinated with the Program Office and Third Fleet to develop a set of project objectives and design the study plan to meet those objectives. A broad range of objectives was addressed, from system interoperability and performance to tactics, techniques, and procedures (TTPS) and training. Project results were applicable to NFN inclusion in all fleets.

KEYWORDS: Navy Fires Network, IDSEA, Third Fleet

RESEARCH SUPPORT FOR THE NAVY FIRES NETWORK (NFN) PROGRAM
William G. Kemple, Associate Professor
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Naval Sea Systems Command

SUMMARY: This research program supported a broad range of Navy Fires Network (NFN) program needs; system architecture requirements, interoperability, human factors, training, concept of operations (CONOPS), and TTPS. This was a full systems engineering program, including current and optimized architecture definitions, scenario development, operational evaluation, tradeoff analysis, and system/process/human factor interactions. These activities were carried out through process modeling, operational modeling and simulation, a series of workshops and operational limited-objective experiments, and operations analysis. The program was supported by officer students through class systems engineering projects.

KEYWORDS: Navy Fires Network, IDSEA, Third Fleet, NFN

CHAIR OF WARFARE INNOVATION
CAPT Jeffrey E. Kline, USN, Military Faculty
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Office of Naval Research

SUMMARY: Established a chair in warfare innovation at NPS.

KEYWORDS: Warfare Innovation, Chair

RESEARCH AND TESTING UNMANNED SURFACE VEHICLE (USV) CONCEPT OF OPERATIONS
CAPT Jeffrey E. Kline, USN, Military Faculty
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Naval Security Group Command

OBJECTIVE: In Afghanistan and Iraq, the U.S. armed forces' use of unmanned vehicles for reconnaissance, support, and as a weapons platform foreshadows these systems' transformational potential on American defense operations.

The Naval Postgraduate School (NPS) is a leader in unmanned vehicle research, particularly in the areas of ground vehicles, underwater vehicles, and unmanned aircraft's support to tactical operations. NPS hosts a fleet of UAVs, two UUVs, and a UGV for research and testing. NPS did not possess an unmanned surface vehicle (USV) for researching concept of operations in the maritime environment. This work supported purchase of an 18-foot rigid hull inflatable boat (RHIB) with outboard motor and control system to act as a USV testing platform.

SUMMARY: NPS acquired an 18-foot RHIB with outboard motor, trailer, and control system to act as a USV testing platform. The USV supports research as follows:

- Anti-terrorism/force protection of ships in U.S. and foreign harbors
- U.S. port security measures as port surveillance and intercept
- Use in maritime interdiction operations as a surveillance craft
- Use in maritime preparation of the battle space in enemy littoral waters
- Use as a communications relay for UUV operations
- Use as an element in an unmanned autonomous net

The RHIB, outboard, and trailer are maintained with the UUVs at NPS. This equipment is controlled and operated by the UV Center within the Meyer Institute of Systems Engineering.

KEYWORDS: Unmanned Surface Vehicle, USV, UAV, Rigid Hull

INNOVATION IN NAVAL WARFARE SYSTEMS - NAVAL AIR DEFENSE SYSTEMS: SYSTEM COMPONENT STUDIES FISCAL YEAR 2002
Michael E. Melich, Research Professor
David C. Jenn, Professor
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Naval Sea Systems Command

OBJECTIVE: To experimentally verify the computed performance of a dual frequency, steerable phased array antenna with randomly located and spatially constrained elements. The results of this verification will form the technology basis for systems studies of novel monostatic and bistatic radars conceived under the FY97-99 research efforts. The usefulness of mass-produced Rf and signal processing chips designed for wireless local area networks and cellular telephones in constructing these systems will be examined.

KEYWORDS: Warfare Innovation, Air Defense, Array Antenna

WAYNE E. MEYER INSTITUTE OF SYSTEMS ENGINEERING

UNCONVENTIONAL WEAPONS OF MASS DESTRUCTION (UWMD): AN ASSESSMENT OF THE TECHNICAL, SYSTEMS ENGINEERING, RESOURCE, OPERATIONAL, AND CULTURAL FEASIBILITY

Michael E. Melich, Research Professor
Robert C. Harney, Associate Professor
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Office of the Secretary of Defense

SUMMARY: Translated and transcribed the information obtained from recent interviews with activists. Pursued the novel fissile material control system discussed in a 1 December 2002 memorandum to Net Assessment. Developed, in greater detail, the countermeasures to the novel poisoning vector that was discovered under last year's study.

KEYWORDS: UWMD, Unconventional Weapons, Fissile Material, Poison

DIRECTIONAL TRANSDUCER MEASUREMENT FACILITY

Joseph A. Rice, Engineering Acoustic Chair
Department of Physics
Sponsor: Space and Naval Warfare Systems Command - San Diego

SUMMARY: Implemented a high-fidelity measurement capability in conjunction with the anechoic tanks in Spanagel Hall at the Naval Postgraduate School. The purpose of the facility was to test and calibrate experimental telesonar transducers operating in the 8-100 khz band. This work was performed in collaboration with Navy Small Business Innovation Research (SBIR) Topic N99-011 Performers, Office of Naval Research (ONR) 321SS project personnel. This work was performed as an activity of the NPS Undersea Warfare Center and involved thesis research.

KEYWORDS: Directional Transducer, SBIR

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

MICHAEL ZYDA
DIRECTOR

MODELING, VIRTUAL ENVIRONMENTS, AND SIMULATION

OVERVIEW:

Our mission is research, application and education in the grand challenges of Modeling, Virtual Environments, and Simulation (MOVES).

The MOVES Institute operates independently and in collaboration with various U.S. Navy and defense modeling and simulation centers to:

- Carry out basic and applied research
- Analyze continuing Modeling, Virtual Environments, and Simulation programs
- Create advanced prototypes
- Develop real technologies and applications for the defense community

CURRICULUM SERVED:

- Modeling, Virtual Environments, and Simulation

DEGREE GRANTED:

- Master of Science in Modeling, Virtual Environments, and Simulation

FACULTY EXPERTISE:

- Virtual Environments:
  Professor Michael Zyda, Military Instructor CDR Russell Shilling, Lecturer Perry McDowell, Senior Lecturer John Falby, Associate Professor Rudolph Darken, Professor Peter Chu, Research Assistant Professor Michael Capps, and Associate Professor Donald Brutzman
- Modeling Simulation:
  Research Associate Professor Wolfgang Baer, Research Associate Curtis Blais, Professor Gordon Bradley, Distinguished Professor Donald Gaver, Research Professor John Hiles, Professor Patricia Jacobs, Associate Professor Thomas Lucas, Associate Professor Neil Rowe, Professor James Taylor, and Associate Professor Xiaoping Yun
- Human Factors:
  Research Assistant Barry Peterson, Professor Robert McGhee, Lecturer Eric Bachmann, Associate Professor Rudolph Darken
- Security:
  Associate Professor Cynthia Irvine
- Communications/Networks:
  Assistant Professor Geoffrey Xie and Professor Nancy Roberts

RESEARCH THRUSTS:

3D VISUAL SIMULATION

- **3D Visual Simulation** - Virtual naval gunfire support. Immersive ship walkthroughs - damage control virtual environments. Littoral zone warfare. Building and Urban Walkthroughs - urban warfare, hostage extraction, operations other than war. Ocean environment tactical visualization. C4I/IW information visualization. Game-engine utilization and handheld visual simulation delivery systems. Synthetic ocean environment simulations.
- **XML/X3D** - Use of Extensible Markup Language (XML) for deploying 3D M&S products over Department of Defense (DoD) messaging systems, creating interoperable behavior streams, gaining database schema interoperability, and defining ontologies for software agent interactions compatible with deployed C4I and combat control systems.

NETWORKED VIRTUAL ENVIRONMENTS

- **Multicast and Area of Interest Managers** - Software architectures for facilitating the development of large-scale, media-rich, interactive, networked VEs.
- **High Bandwidth Networks** - Experimentation and utilization of next-generation Internet technologies for large-scale, networked virtual environments, and collaborative M&S development and application.
- **Wireless** - Handheld delivery systems.
- **Latency-reduction** - Techniques for predictive modeling in distributed simulations.
- **VE Architectures for Interoperability** - Network software architectures for scalability, composability and dynamic extensibility.
- **Standards for Interoperability** – High Level Architecture; Next Generation RTI; Web-based interoperability. Standards for streamed interactive 3D as an automatically created component for joint message systems. Guiding M&S standards interoperability efforts with the Web3D Consortium, World Wide Web Consortium and MPEG4 Streaming Group.

COMPUTER-GENERATED AUTONOMY

- **Agent-based Simulation** - Computer-generated characters that accurately portray the actions and responses of individual participants in a simulation. Adaptability - computer generated characters that can modify their behavior automatically. Learning - computer generated characters that can modify their behavior over time. Organizational modeling.
- **Story Line Engines** - Content production and simulation prototyping. Technologies for autonomous, real-time story direction and interaction.
- **Human Representations and Models** - Authentic avatars that look, move, and speak like humans.
- **Modeling Human and Organizational Behavior** - Integrative architectures for modeling of individuals, including neural networks; rule-based systems, attention and multitasking phenomena, memory and learning, human decision-making, situation awareness, planning, behavior moderators, modeling of behavior of organizational units, modeling of military operations, and modeling of information warfare.

HUMAN-COMPUTER INTERACTION

- **Training in the Virtual Environment** - Fidelity requirements for wayfinding in the virtual environment. Developing virtual environments for training. Evaluating virtual environments for their utility in training.
- **Intelligent Tutoring Systems** - Developing experts via the use of computer-based virtual environments.
- **Human Factors in Virtual Environments** - Multimodal interfaces, task analysis, spatial orientation and navigation, performance evaluation, interaction techniques, interaction devices, virtual ergonomics, cybersickness, usability engineering, training transfer, human perception.

TECHNOLOGIES FOR IMMERSION

- **Image Generation** - Real-time, computer graphic generation of complex imagery, HDTV, DVD, next generation delivery systems, novel display technologies, handheld and body-worn devices.
- **Tracking** - Technologies for keeping track of human participants in virtual environments.
- **Locomotion** - Technologies that allow participants to walk through virtual environments while experiencing hills, bumps, obstructions, etc.
- **Full Sensory Interfaces** - Technologies for providing a wide range of sensory stimuli: visual, auditory, olfactory, and haptic.
- **Novel Sound Systems** – The generation and delivery for both interactive and recorded media. Spatial sound. Immersive sound and psychoacoustics.

MODELING, VIRTUAL ENVIRONMENTS, AND SIMULATION

DEFENSE AND ENTERTAINMENT COLLABORATION

- **Technology Transition** - Adapt technologies and capabilities from the entertainment industry.
- **Game-Based Learning** - Distance learning via the use of game technology and development.
- **Internet and Game Delivery Systems** - SimNavy, Army Game Project, SimClinic, SimSecurity.

NEXT GENERATION MODELING

- **Modeling and Simulation** - Dynamic and state space modeling for information warfare and information operations. High-resolution combat models. High-level aggregate models. Network centric warfare. Agent-based simulation. Physically-based modeling to insure physical realism underlies the VR. Theater, tactical and campaign level modeling. Sensor modeling. Architectures for future combat modeling systems.
- **Navy Cyberspace** - Full end-to-end simulation of the ocean environment including subsurface surface, air and space. Oceanographic data sets and models. Tactical databases. Interoperability with live ship tracking message systems. Reusable, in the small or in the large, by fleet assets. Underwater robots. Interoperability with global command and control systems.
- **Current Programs in Combat Modeling** – JSIMS Maritime Battlespace, Naval Simulation System, JSIMS, JWARS, JMASS, OneSAF, HLA, Computer-Generated Forces.

TECHNOLOGY TRANSITION

- Technology transition is part of the MOVES Institute. CRADAs with industry are encouraged as well as the licensing of institute generated intellectual property.

RESEARCH PROGRAM (Research and Academic)-FY2003:

The Naval Postgraduate School's sponsored program exceeded $71 million in FY2003. Sponsored programs included both research and educational activities funded from an external source. A profile of the sponsored program for the Modeling, Virtual Environments, and Simulation Institute is provided below:
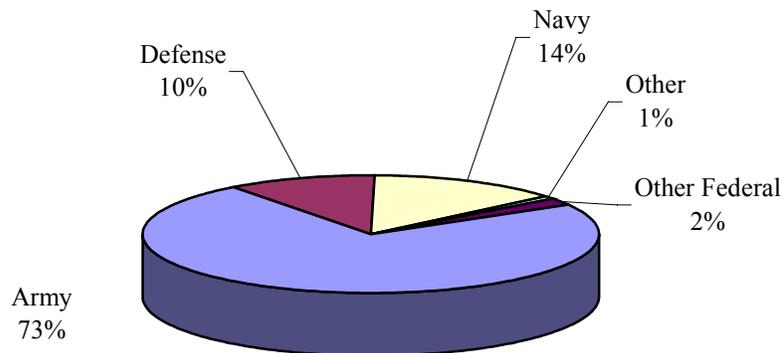
Size of Program: $10,593K

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INERTIAL AND MAGNETIC MOTION TRACKING FOR INSERTING HUMANS INTO NETWORKED VIRTUAL ENVIRONMENTS

Eric R. Bachmann, Lecturer
Robert B. McGhee, Professor
Xiaoping Yun, Associate Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Chief of Naval Operations (N61M)

OBJECTIVE: To create new human body motion-tracking technology for immersive applications in networked virtual environments. Unlike existing body tracking technologies, this system does not depend on any externally generated sources, thus creating a "sourceless" tracking system that can be used in large areas and by multiple users. The two key components of the new motion tracking systems are a novel nine-axis Magnetic, Angular Rate, and Gravity (MARG) sensor and a quaternion-based complimentary filter. A MARG sensor was attached to each of fifteen body segments. This enabled the system to track the user's posture in real time without any singularities. Integration of wireless local area networks (LANs) with the tracking system made it possible to track users' motions in any areas where wireless LAN infrastructure exists.

KEYWORDS: Motion Tracking, Networked Virtual Environments, MARG Sensor

EXTENSIBLE MODELING AND SIMULATION FRAMEWORK (XMSF)

Curtis L. Blais, Research Associate
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Commander Operational Test and Evaluation Force (COMOPTEVFOR)

EXTENSIBLE MODELING AND SIMULATION FRAMEWORK (XMSF): ESTABLISH REQUIREMENTS, DEVELOP EXEMPLARS

Donald P. Brutzman, Associate Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Defense Modeling and Simulation Office

SUMMARY: Web-based technologies applied within an extensible execution framework will enable a new generation of modeling and simulation applications to emerge, develop, and interoperate. Support for operational tactical systems is a currently missing, but nevertheless essential, requirement for such application frameworks. An Extensible Markup Language (XML)-based framework can provide a bridge between forthcoming modeling and simulation requirements and open/commercial web standards. A web approach for technology, software tools, content production, and broad use makes great sense technically, and also provides best business cases from an enterprises-wide perspective.

The nascent Extensible Modeling and Simulation Framework (XMSF) can become the basis for this fundamentally important framework. A series of workshops explored technical opportunities and strategic priorities, inviting broad comment and possible consensus on requirements. This work was grounded by demonstrations showing current and forthcoming web technologies supporting exemplar XMSF applications. The Naval Postgraduate School (NPS) conducted this research and development in partnership with investigators from the George Mason University (GMU) and the Science Applications International Corporation (SAIC).

KEYWORDS: Extensible, XMSF, XML, SAIC, GMU

EXTENSIBLE MODELING AND SIMULATION FRAMEWORK (XMSF): ESTABLISH REQUIREMENTS, DEVELOP EXEMPLARS
Donald P. Brutzman, Associate Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Defense Threat Reduction Agency

SUMMARY: Web-based technologies applied within an extensible execution framework will enable a new generation of modeling and simulation applications to emerge, develop, and interoperate. Support for operational tactical systems is a currently missing, but nevertheless essential, requirement for such application frameworks. An Extensible Markup Language (XML)-based framework can provide a bridge between forthcoming modeling and simulation requirements and open/commercial web standards. A web approach for technology, software tools, content production, and broad use makes great sense technically, and also provides best business cases from an enterprise-wide perspective.

KEYWORDS: Extensible, XMSF, XML, Open Standards

EXTENSIBLE MODELING AND SIMULATION FRAMEWORK (XMSF) VIEWER FOR THE DISTRIBUTED CONTINUOUS EXPERIMENTATION ENVIRONMENT (DCEE)
Donald P. Brutzman, Associate Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: U.S. Joint Forces Command

MULTI-PLATFORM UNDERSEA WARFARE MODELING/SIMULATION USING NETCENTRIC TECHNIQUES: SONAR VISUALIZATION SUPPORT
Donald P. Brutzman, Associate Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Sonalysts, Inc.

SUMMARY: The Naval Postgraduate School (NPS) has extensive experience in the construction of networked physics-based virtual environments for tactical applications. In support of Sonalysts, Inc.'s efforts to establish multi-platform undersea warfare modeling and simulation for network-centric techniques, researchers investigated and developed both 2D and 3D graphical user interfaces (GUI) for real-time interactive visualization of sonar propagation models. This work was compatible with the extensible 3D (X3D) graphics specification and the recursive ray acoustics (RRA) computational model, and adapted to Sonalysts' forthcoming modeling and decision engine (MDE). Unclassified and non-sensitive software products and models were placed in the public domain as part of the growing 3D archive, Scenario Authoring and Visualization for Advanced Graphic Environments (SAVAGE).

KEYWORDS: SAVAGE, Sonar, Undersea Warfare Modeling

NPSNET-V - SEMANTIC INTEROPERABILITY FOR LARGE-SCALE, NETWORKED VIRTUAL ENVIRONMENTS
Donald P. Brutzman, Associate Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Chief of Naval Operations (N6M)

SUMMARY: Development of Java-based component architecture for networked virtual environment applications: clients, servers, peers, and standalone products. NPSNET-V applications consist of hierarchical federations of loosely coupled modules rooted at an invariant microkernel. New modules may be downloaded from the web and introduced to the federation at any time, and existing modules may be hot-swapped: that is, seamlessly upgraded when new versions become available. Modules included with the NPSNET-V distribution include those designed to provide system-level functionality, such as resource management, as well as modules specific to collaborative virtual environment applications, such as entity

models, graphical views, and network controllers.

KEYWORDS: NPSNET-V, Java Component Architecture, Open Source

ONLINE MENTORS FOR LANGUAGE TRAINING AND CULTURAL FAMILIARIZATION
Donald P. Brutzman, Associate Professor
Curtis L. Blais, Research Associate
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Defense Logistics Agency (DLA)

SUMMARY: Military personnel are increasingly sent into unfamiliar environments to conduct operations other than war, including peacekeeping, humanitarian assistance, evacuation of non-combatant personnel, and deterrence of local hostilities. These missions require that U.S. soldiers interact with local populations. Indeed, the diverse nature of current and possible future Department of Defense (DoD) missions requires that a much larger population receive basic training in foreign languages and cultures. According to a report from the General Accounting Office (GAO 2002), there is a shortfall of 50% for Army translators and interpreters of the Arabic language. There are similar shortfalls in critical languages, and in other government agencies and military services. Moreover, certified linguists and other trained personnel require refresher training to maintain basic skills and learn local variations. In the Arab world, especially, there are significant variations in dialect, gestures, and formalities. Basic language training and cultural familiarization will enable U.S. forces to perform their diverse missions more effectively, and with the potential for saving lives while deployed to foreign shores.

The scope of the research effort was a 12-month proof-of-concept project with demonstration and evaluation of prototype web-based instructional content for language training and cultural familiarization. The project team was comprised of the Naval Postgraduate School (NPS) MOVES Institute (Modeling, Virtual Environments, and Simulation), the Defense Language Institute (DLI), and commercial partner VCM3D. Target audience for this technology, over the long term, includes: DLI students, DLI graduates maintaining proficiency, non-DLI military members deploying to another country, and other agencies and individuals with an overseas presence.

The proposal prototype incorporated H-ANIM humanoid avatars with extended behaviors relating to language, gesture, and expression applicable to language training (mentor teaches a segment, student responds to a learning situation, software assesses the response, and feedback is provided to the student). Learning content and development products included spoken phrases (initially, American English and Iraqi Arabic), data representations (single Extensible Markup Language (XML) schema describing multilingual instructional content), tools for rapid production of learning components, quantitative measures of the effort needed to develop the content, and demonstration of web delivery through a learning management system (LMS). Arabic (Iraqi dialect) was selected for the proposed prototype. Considerations behind this section included:

- instruction in the Arabic language is in great demand by agencies using DLI training
- standard (as opposed to dialectic) Arabic has limited use as a spoken language
- Arabic is considered a "cat 4" language; i.e., one of the most challenging yet important to learn

The proposed effort integrated proven capabilities XML schema, XML internationalization (118n) and localization (LION), the x3D graphics standard (web 3d graphics in XML), the H-ANIM standard for interchangeable body and behavior definitions, text-to-speech and speech-to-text (as appropriate), and matching voice recordings. The work produced a human models library of two to four new characters, including native dress, a human behavior/gestures library to support multilingual/multinational project scenarios, an authoring tool environment for assisting curriculum designers, and a prototype playback and participation application for users.

This is a long-term need requiring broad strategic planning and funding. The work will produce quantitative cost and capability assessments as a basis for such Department of Defense (and government) strategies.

KEYWORDS: Online Mentors, Arabic, Language Training, Culture

MODELING, VIRTUAL ENVIRONMENTS, AND SIMULATION

OPERATIONS OTHER THAN WAR (OOTW) TOOLBOX RESEARCH AND PROTOTYPE DEVELOPMENT
Donald P. Brutzman, Associate Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Defense Modeling and Simulation Office

SUMMARY: The Naval Postgraduate School (NPS) MOVES Institute (Modeling, Virtual Environments, and Simulation) performed research and prototype development to examine the extensible markup language (XML) data interchange format (DIF) to determine necessary extensions to accommodate agent-based frameworks. NPS developed a prototype implementation of the interface using NPS agent-based framework research and the extended XML DIF.

KEYWORDS: Operations Other Than War, OOTW, XML

RENDERING DYNAMIC STRUCTURES USING WEB-CAPABLE 3D MODELS FOR MILITARY SIMULATIONS
Donald P. Brutzman, Associate Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Training and Doctrine Analysis Center

SUMMARY: Training and Doctrine (TRADOC) Analysis Center (TRAC) sponsored research in computer technologies/methodologies for rendering deformable surfaces in Army simulations. The primary purpose of this research was to determine the best approach to model complex geometry for dynamic interactions with entities in distributed military simulations. Interactions of interest included the firing of various direct-fire munitions at terrain and complex structures, thereby causing physics-based deformations and/or collateral effects.

This research provided a suitable approach for describing complex structures that can be dynamically modified based on interactions with entities. Constraints included suitability for use with web-based 3D graphics, applicability to diverse physically based models, and networked entity communications.

The end product will facilitate doctrine training and development, including a simulation-based acquisition (SBA) tool for assets used in military operations on urban terrain (MOUT).

KEYWORDS: MOUT, TRADOC, TRAC Monterey, Web-Capable 3D

A TRANSFORMATIONAL FRAMEWORK FOR DESIGN, DEVELOPMENT, AND INTEGRATION OF ANALYTICAL MODELS
Donald P. Brutzman, Associate Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: To initiate research and development of a transformational analytical modeling framework and representative functional capability to establish a foundation for ongoing development and integration of model components in a flexible, scalable, extensible architecture. Following the programmatic model of the XMSF effort, the work was informed by creation of early functioning exemplars demonstrating the concepts.

KEYWORDS: Analytical Models, XMSF

A TOOLKIT FOR EVALUATING ALGORITHMS FOR INTERNETTING OF FIRES
Arnold H. Buss, Assistant Professor
Department of Operations Research
Modeling, Virtual Environments, and Simulation Institute
Sponsor: U.S. Army Training and Doctrine Analysis Command

OBJECTIVE: To develop a decision support algorithm which will dynamically allocate both human and weapons resources for use in future combat systems.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Future Combat Systems, Army Objective Force Concept, Decision Support Tools, Dynamic Allocation of Weapons Resources, Human Performance in Combat Situations, Psychological Predictors of Human Decision Making

NAVAL SIMULATION SYSTEM
Alexander J. Callahan, Jr., Research Assistant Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Chief of Naval Operations (N61M)

CONTEXT-DRIVEN ARCHITECTURE FOR NATURAL LANGUAGE PROCESSING
Christian J. Darken, Associate Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Chief of Naval Operations (N61M)

OBJECTIVE: To design and document an architecture for natural language processing. This architecture must respect many practicalities with regard to computational complexity, bandwidth, and the characteristics of candidate algorithms to perform the subtasks of generating or understanding human language. The design should be sufficiently detailed to support prototyping.

KEYWORDS: Context-Driven Architechture, Natural Language

THE DEVELOPMENT OF FULL-SCALE MILITARY VISUAL SIMULATIONS
Rudolph P. Darken, Associate Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Chief of Naval Operations (N61M)

HIGH FIDELITY SENSOR SIMULATION FOR MILITARY TRAINING SYSTEMS ON LOW-COST GRAPHICS HARDWARE USING REAL-TIME SHADING/ILLUMINATION LANGUAGES
Rudolph P. Darken, Associate Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Chief of Naval Operations (N61M)

OBJECTIVE: To determine the current capabilities and potential of personal computer based sensor simulation training systems. Additionally, the research attempted to determine the level of realism required to achieve positive training transfer for various training tasks, and applied lessons learned to other Modeling, Virtual Environments, and Simulation Institute and Navy-Marine Corps efforts.

KEYWORDS: Sensor Simulation Training, Real-Time Shading

INVESTIGATING ATC PROCEDURES FOR SIMULTANEOUS NON-INTERFERING FLIGHT WITHIN THE NATIONAL AIRSPACE SYSTEM
Rudolph P. Darken, Associate Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Federal Aviation Administration

SUMMARY: This research was performed in cooperation with Dr. J. Mulligan of the National Aeronautics and Space Administration (NASA) Ames Research Center. The operating hypothesis for this research is that current air-traffic-control procedures for handling simultaneous flight operations of fixed and rotary wing aircraft are suboptimal, and that the use of burgeoning technologies such as GPS can be used to improve the current situation in terms of air traffic volume and safety. Researchers related physically validated human performance metrics in the air to performance in a simulator built specifically for this program.

KEYWORDS: Non_Interfering Flight, NASA Ames, Air Traffic Control

MV-22 CREW TRAINING FOR DEPLOYED EXPEDITIONARY FORCES: MARINE CORPS AIR TO GROUND OPERATIONS
Rudolph P. Darken, Associate Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Office of Naval Research

SUMMARY: The goal was to develop a deployable training device for the MV-22 platform capable of performing air to ground operations. The trainer will be deployable, interoperable with other trainers, cost effective, and reconfigurable. Researchers will also conduct training assessment evaluation to assure positive training transfer.

KEYWORDS: MV-22, Training, Expeditionary Forces

A "SIMULATION ENGINE" BASED ON GAMING TECHNOLOGY AND OPEN SOURCE SOFTWARE
Rudolph P. Darken, Associate Professor
CDR Joseph A. Sullivan, USN, Military Faculty
Erik Johnson, Research Associate
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Chief of Naval Operations (N61M)

SUMMARY: Recently, there has been much interest in the use of gaming technologies as a potential replacement for traditional visual simulation tools in military simulation and training. A growing interest in gaming engines is not so much an endorsement of gaming technologies for military simulations as much as it is an indicator of serious dissatisfaction with currently available visual simulation tools. While there is much benefit from investigating the use of these technologies, the direct use of gaming engines is problematic for several reasons:

- Gaming companies are not in the business of selling or supporting development software – they make games. Their gaming engines are their "edge" on other gamers. They guard them closely and want tight control on their use.
- The requirements of making a successful game vice making a successful training or simulation system are vastly different.

   The question remains: How to reap the benefits of gaming technologies without limiting capabilities to produce effective training and simulation systems? Researchers suggested a two-pronged approach to solving this problem.

1. Develop a software framework for the systems that supports the software development model used by gamers. A gamer's approach to developing simulation and training software is needed, but a gaming engine is not necessarily the solution.

2. Integrate the functions of constructing a simulation (e.g., identifying what is in it and how it all looks or sounds) and specifying behaviors (e.g., typical combat modeling tools such as JSAF or OneSAF for scenario development).

It seems clear that neither gaming companies nor visual simulation tool vendors have a scalable, usable solution that adequately fits the need. It also seems clear that the interests in gaming engines for military simulation and the slow progress in using them is evidence that even the gamers do not have the right answer. This is not surprising as this is not their business model. The question is how to combine the positive elements of gaming engines with the positive elements of visual simulation tools and SAF tools towards a better solution for military simulation in general.

KEYWORDS: Simulation Engine, Gaming Technology, Open Source

VALIDATION AND EVALUATION OF COGNITIVE MODELS FOR COMBAT SIMULATION
Rudolph P. Darken, Associate Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Chief of Naval Operations (N61M)

SUMMARY: As the role of modeling and simulation expands from training and analysis to acquisition and possibly new applications not yet envisioned, issues regarding the validity of models are more important than ever. It has long been recognized that if models that represent real world entities or phenomena are to be built, they must be accurate representations as required by the specific application in question. While significant advancements have been made in the area of validation and verification (V&V) with regard to combat models of vehicles and battlefield phenomena (largely physically-based models), this cannot be said of cognitive models, which are representations of human behavior. This is a critical issue that the Defense Modeling and Simulation Office (DMSO) is currently grappling with.

The process of V&V for cognitive models is not nearly as well defined as the formal methods used for V&V of physically-based models, nor is the process extensible to meet requirements for validating the varied and complex behavioral models in use or under development for Department of Defense (DoD) simulations. This is the result of an imperfect understanding of when a model needs to be validated or evaluated, a limited understanding of whether or not a specific model can be validated (or to what extent it can be validated), inadequate quantitative measures for validating or evaluating cognitive models, lack of a robust unbiased environment to provide a level playing field to exercise behavioral models, and the absence of standard tools or processes for validating or evaluating cognitive models.

The intended outcome of any validation process applied to models of human behavior is to assure that simulated human behavior is consistent with actual human behavior under the constraints and context of a specific combat scenario. A characterization of what constitutes "reasonable" or "consistent" behavior under a set of conditions is the fundamental question addressed by this research. Two assumptions are made with regard to this issue: full understanding or complete validation of human behavior models cannot be accomplished by observation of overt behavior alone. It is necessary to understand the cognitive decision making processes on which overt behavior is based to determine if a simulated behavior is consistent with actual behavior. In the same way that the theory of Naturalistic Decision Making (NDM) asserts that one cannot fully understand human behavior in other than the environments and situations in which it naturally occurs, is it impossible to validate or evaluate models of human behavior that are embedded in "trivial" environments of limited complexity. Human behavior of interest to the military community happens in complex, multi-dimensional environments with an abundance of stimuli and in a time, space continuum. Therefore, the environments developed for study of human behavior models must also reflect these complexities.

KEYWORDS: Combat Simulation, Cognitive Models

AGENT BASED SIMULATION OF U.S. NAVY ANTI-TERRORISM/FORCE PROTECTION DOCTRINE IN WEB 3D ENVIRONMENTS
LT James Harney, USN
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Space and Naval Warfare Systems Command - San Diego

SUMMARY: This research had one primary goal - to research existing technologies and investigate integration techniques for those to develop an effective framework for bringing cutting edge research to the tactical fleet level for planning and training in the anti-terrorism/force protection context.

KEYWORDS: Web 3D, Naval Anti-Terrorism, Agent-Based Simulation

A CONNECTOR-BASED MULTI-AGENT SYSTEM ARCHITECTURE FOR INVESTIGATING HUMAN DECISION MAKING THROUGH CONSTRUCTION OF BLENDED MENTAL SPACES
John E. Hiles, Research Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Chief of Naval Operations (N61M)

NAVAL POSTGRADUATE SCHOOL (NPS) - MOVES INSTITUTE (MODELING, VIRTUAL ENVIRONMENTS, AND SIMULATION) AGENT ARCHITECTURE
John E. Hiles, Research Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Defense Advanced Research Projects Agency

SUMMARY: The Naval Postgraduate School (NPS) performed research into modeling of complex and adaptive behaviors for application to military modeling and simulation (M&S) and command and control (C2). The work focused on evaluation of the NPS multi-agent system architecture in relation to the Defense Advanced Research Projects Agency (DARPA) control of agent-based system (COABS) program approach. NPS provided consultation to the DARPA COABS program on complementary areas on research and where NPS concepts can enhance previous and ongoing COABS agent-based research.

KEYWORDS: Agent Architecture, DARPA, COABS

MULTI-AGENT ROBOT SWARM SIMULATION (MARSS) SUPPORT
Gary K. Hout
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Sandia National Laboratories

OBJECTIVE: To assist Principle Investigators at Sandia National Laboratories with research into the use of robotics in military systems using a multi-agent robot swarm simulation (MARSS).

KEYWORDS: MARSS, Robot Swarm

WEB BASED 3D VISUALIZATION OF OPERATIONAL PLANNING DATA USING EXTENSIBLE MARKUP LANGUAGE (XML), X3D, SCALABLE VECTOR GRAPHICS (SVG) AND JAVA BASED TECHNOLOGIES
CAPT Claude O. Hutton, Jr., USMC
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Space and Naval Warfare Systems Command - San Diego

SUMMARY: Researched and developed technologies needed to provide operational forces with web based 3D visualization of operational planning data.

KEYWORDS: XML, X3D, Vector Graphics, Java, Web 3D

NAVAL POSTGRADUATE SCHOOL MOVES INSTITUTE EVALUATION OF DAMAGE CONTROL (DC) TRAINER EFFECTIVENESS
Perry McDowell, Lecturer
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Office of Naval Research

SUMMARY: The Naval Postgraduate School (NPS) performed testing on damage control training software created for use in Navy training establishments and on ships.

KEYWORDS: MOVES, Damage Control

NPSNET-V
Donald R. McGregor, Computer Specialist
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Chief of Naval Operations (N61M)

DEVELOPING EXTENSIBLE MARKUP LANGUAGE (XML) ONTOLOGIES FOR USE BY NAVY AND MARINE CORPS COMMAND AND CONTROL SOFTWARE
CAPT James Neushul, USMC
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Space and Naval Warfare Systems Command - San Diego

SUMMARY: Developed baseline Extensible Markup Language (XML) ontology for use in extending the capabilities of current command and control software systems in order to enable interoperability and improve battlespace visualization.

KEYWORDS: XML, Ontologies, Command and Control

AUDIO DESIGN PRINCIPLES FROM THE ENTERTAINMENT INDUSTRY AND HIGH END AUDIO SERVERS APPLIED TO NAVY AND MARINE CORPS TRAINING
LCDR Russell D. Shilling, USN
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Office of Naval Research

SUMMARY: Researchers compiled a library of professional sound effects and sound ambiences for both Demo I and Demo II. The goal was to enhance the training effectiveness and sense of immersion and realism of the simulation. Pertinent sound effects that are not available in professional sound libraries were identified and custom recordings were made as appropriate. Additionally, two audio servers, the Ausim Goldserver and the Lake Huron were evaluated to ascertain whether they meet the needs of Demo II for producing a realistic sound environment in a multi-user system.

KEYWORDS: Audio Design, Sound Effects, Ambience, Training Effectiveness

AUDIO TECHNOLOGY AND MANAGEMENT IN MODERN NAVY SYSTEMS
LCDR Russell D. Shilling, USN
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Office of Naval Research

OBJECTIVE: The goal of this research was to develop and test advanced audio technology and an interactive audio management user interface for advanced operational Navy workstations and other Navy applications.

KEYWORDS: Audio Technology, Interactive Audio

DEVELOPING AN AUDIOMETRIC MEASURE TO ASSESS LOCALIZATION PERFORMANCE FOR VIRTUAL ENVIRONMENTS AND SPATIALIZED AUDITORY DISPLAYS
LCDR Russell D. Shilling, USN
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Office of Naval Research

OBJECTIVE: Spatial auditory displays play an integral role in virtual environments and will increasingly become a common part of radar, sonar, and cockpit displays. Spatial audio has already been shown to be an effective supplement in air traffic control and TCAS displays. Traditional audiometry does not assess the ability to localize sounds over headphones, thus there are no tests to assess how well an individual can use these displays. Such a standard task would have the additional benefit of allowing researchers to test the localizability of auditory signals to be used in displays and VE and to assess the benefits of different types of filter functions, e.g., head related transfer functions, on the ability to localize sound. Although expensive sound server technology is available, most sound servers cost in excess of $12K. The goal of this research was to devise testing techniques that can run on a standard personal computer (PC) using off-the-shelf audio technology.

KEYWORDS: Audiometric, Localization in VE, Auditory Space

THEORETICAL AND EMPIRICAL ANALYSIS OF WIRELESS SIMULATION
CDR Joseph A. Sullivan, USN, Military Faculty
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Department of the Navy Chief Information Officer

SUMMARY: A study was conducted of the impact of wireless network infrastructures to support large-scale simulations involving expeditionary warfare forces in deployed settings.

KEYWORDS: Wireless Simulation, Network Infrastructure, Expeditionary Warfare

AUTONOMOUS AGENT-BASED ROBOT CONTROL AND MANIPULATION OF COMPLEX GOAL ORIENTED TASK
LT Manoleto Z. Williams, USN
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Space and Naval Warfare Systems Command - San Diego

SUMMARY: The goal of this thesis was to develop agent-based control of autonomous tactical mobile robots (ATMRS) in a virtual environment to test the behavior of a single robot and the coordination of multiple robots.

KEYWORDS: Autonomous Robot, ATMRS, VE

MODELING, VIRTUAL ENVIRONMENTS, AND SIMULATION

AMERICA'S ARMY
Michael J. Zyda, Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Office of the Assistant Secretary of the Army

SUMMARY: The Army is actively seeking means to more effectively market its career opportunities to America's youth. One method is through a set of web-based, instrumented, and networked video or computer games to attract youth so they may be informed of various aspects of Army life and Army career opportunities.

KEYWORDS: Army Recuitment, PC Games

AMERICA'S ARMY - COMBAT MEDIC
Michael J. Zyda, Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: U.S. Military Academy

SUMMARY: The Naval Postgraduate School added a combat medic as part of team dynamics in *America's Army - Operations.* The research goal of the project was to answer the question of whether a part task trainer can be constructed using a commercial game engine and a commercial quality personal computer (PC) game, *America's Army.*

KEYWORDS: *America's Army*, Game, Trainer

AMERICA'S ARMY GAME ENHANCEMENTS USING PICATINNY SYSTEMS FUTURE WEAPONS
Michael J. Zyda, Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: U.S. Tank-Automotive and Armaments Command (TACOM)

SUMMARY: The Ground Combat Simulation Laboratory and the United States Military Academy (USMA) at West Point, and USMA's research partner, the MOVES Institute (Modeling, Virtual Environments, and Simulation) jointly proposed the enhancement of the *America's Army* game to include additional Picatinny weapon systems. Specifically, researchers proposed the inclusion of an existing system as an enhancement of the current game and to research its utility for deployment in the future.

KEYWORDS: AA, *America's Army*, Picatinny

AMERICA'S ARMY GAME ENHANCEMENTS - VIRTUAL IMMERSION PERSONNEL READINESS
Michael J. Zyda, Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: U.S. Air Force Force Protection

SUMMARY: The Air Force's Force Protection Battlelab desired a convoy force protection scenario built into the *America's Army* personal computer (PC) game. The purpose of that enhancement was as a part-task trainer for force protection. The developed scenario will be integrated into the publicly releasable *America's Army* game.

KEYWORDS: Trainer, Games, *America's Army*, AA

AMERICA'S ARMY: OPERATIONS AND SOLDIERS MARKETING SUPPORT
Michael J. Zyda, Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: U.S. Army Recruiting Command

SUMMARY: The Army is actively seeking means to more effectively market its career opportunities to America's youth. One method is through a set of web-based, instrumented, and networked video or computer games to attract youth so they may be informed of various aspects of Army life and Army career opportunities. The games are designed to complement the Army's current internet web page - goarmy.com. Using a computer game, the Army can provide information via an entertaining virtual Army career experience on stand-alone systems or on the internet. Marketing of the game is key to meeting the goals stated in the original memorandum of agreement.

KEYWORDS: *America's Army*, Recruitment, Games, Army Career

AMERICA'S ARMY: OPERATIONS AND SOLDIERS MARKETING SUPPORT
Michael J. Zyda, Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Office of the Assistant Secretary of the Army

SUMMARY: The Army is actively seeking means to more effectively market its career opportunities to America's youth. One method is through a set of web-based, instrumented, and networked video or computer games to attract youth so they may be informed of various aspects of Army life and Army career opportunities. The games are designed to complement the Army's current internet web page - go army.com. Using a computer game, the Army can provide information via an entertaining virtual Army career experience on stand-alone systems or on the internet. Marketing of the game is key to meeting the goals stated in the original memorandum of agreement.

KEYWORDS: Army Recruitment, PC Game

AMERICA'S ARMY: OPERATIONS AND SOLDIERS MARKETING SUPPORT
Michael J. Zyda, Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Office of the Assistant Secretary of the Army

SUMMARY: The U.S. Army has a shortfall in recruiting. There is the potential for improving recruiting through the use of a web-based, instrumented, set of networked videogames or computer games (both of which are hereafter referred to as videogames). The web-based videogames will attract people to the Army, provide high fidelity feedback about potential recruits, obtain leads for recruiting, and deliver strategic communications about the Army to the potential recruit. The Naval Postgraduate School MOVES Institute (Modeling, Virtual Environments, and Simulation) academic group proposes to develop intrumented, networked videogames to improve Army recruiting.

KEYWORDS: Army Recruitment, PC Game

APPLICABILITY OF PERSONALITY TRAIT THEORIES AND CROSS-CULTURAL PSYCHOLOGICAL RESEARCH TO BEHAVIORAL MODELING AND TERRORISM ANALYSIS
Michael J. Zyda, Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Defense Modeling and Simulation Office

SUMMARY: Understanding the perspectives of foreign leaders and cultures is an important aspect of homeland defense, foreign policy, military operations, and counter-terrorism. Military officers and policy makers are often surprised by the actions of foreign nations, not because they are unpredictable, but because they are applying the incorrect model of human behavior. Cultural influences shape views of reality, personality profiles, values, one's place in the world, and even basic perceptual processes.

KEYWORDS: Personality, Cultural, Behavioral Modeling

ARMY GAME PROJECT
Michael J. Zyda, Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Office of the Assistant Secretary of the Army

SUMMARY: The Army is actively seeking means to more effectively market its career opportunities to America's youth. One method is through a set of web-based, instrumented, and networked video games to attract youth so they may be informed of various aspects of Army life and Army career opportunities.

KEYWORDS: Army Career, Game, *America's Army*

ARMY GAME PROJECT
Michael J. Zyda, Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Office of the Assistant Secretary of the Army

SUMMARY: The U.S. Army has a shortfall in recruiting. There is the potential for improving recruiting through the use of a web-based, instrumented, set of networked videogames or computer games (both of which are hereafter referred to as videogames). The web-based videogames will attract people to the Army, provide high fidelity feedback about potential recruits, obtain leads for recruiting, and deliver strategic communications about the Army to the potential recruit. The Naval Postgraduate School MOVES Institute (Modeling, Virtual Environments, and Simulation) academic group proposes to develop instrumented, networked videogames to improve Army recruiting.

KEYWORDS: Army Career, Game, *America's Army*

ARMY GAME PROJECT
Michael J. Zyda, Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Office of the Assistant Secretary of the Army

SUMMARY: The U.S. Army has a shortfall in recruiting. There is the potential for improving recruiting through the use of a web-based, instrumented, set of networked videogames or computer games (both of which are hereafter referred to as videogames). The web-based videogames will attract people to the Army, provide high fidelity feedback about potential recruits, obtain leads for recruiting, and deliver strategic communications about the Army to the potential recruit. The Naval Postgraduate School MOVES Institute (Modeling, Virtual Environments, and Simulation) academic group proposes to develop instrumented, networked videogames to improve Army recruiting.

KEYWORDS: Army Career, Game, *America's Army*

THE CONTEXT MACHINE
Michael J. Zyda, Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Defense Advanced Research Projects Agency

SUMMARY: The Defense Advanced Research Projects Agency (DARPA) augmented cognition program is looking at ways in which an electronic prosthesis can be developed that augments cognitive processing. One way to think about such a machine might be that it is like the annoying help feature of Microsoft word that tells you "I think you are trying to write a business letter. Would you like me to suggest to you how?" What is desired is something grander than help with the written page. Researchers would like something that watches over a writer's shoulder and provides appropriate information (guidance, warning, help) when it senses the current context. This machine will be called a context machine. This research included developing a plan for constructing such a machine, a timeline for its construction, and an elucidation of the technologies (sensors, computing, displays) required for the construction of a portable context machine.

KEYWORDS: Context Machine, Electronic Prosthesis, Help

GAME ENGINE SUBLICENSE AND COLLABORATION
Michael J. Zyda, Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: U.S. Department of Energy – Los Alamos National Laboratory

SUMMARY: The Naval Postgraduate School's MOVES Institute (Modeling, Virtual Environments, and Simulation) is developing a collaboration with Los Alamos National Laboratory (LANL) in the area of game engine utilization for non-proliferation verification. The purpose of this research was to sublicense the Unreal game engine to LANL for use in that study. Funding received from that sublicense was utilized to support additional programming staff for the MOVES Institute's game engine internal research and development efforts and to support a programming interface to the game engine.

KEYWORDS: Non-Proliferation, Verification, PC Game, Game Engine

INERTIAL MOTION TRACKING FOR INSERTING HUMANS INTO A NETWORKED SYNTHETIC ENVIRONMENT
Michael J. Zyda, Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: U.S. Army Research Office

SUMMARY: Inertial motion tracking can enable users to insert themselves into a game environment through sensors that record the position and posture fo the user's body. Combined with artifices such as treadmills, the user can experience a high degree of verisimilitude in networked gaming.

KEYWORDS: Motion Tracking, Networked VE

**MOVES INSTITUTE (MODELING, VIRTUAL ENVIRONMENTS, AND SIMULATION) –
FISCAL YEAR 2003
Michael J. Zyda, Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Chief of Naval Operations (N61M)**

SUMMARY: The Naval Postgraduate School, in conjunction with N61M, established a degree program, the MOVES Institute (Modeling, Virtual Environments, and Simulation) curriculum, and a research institute, the MOVES Institute. The degree program generates officers who are capable of filling XX99-P/6202-P coded billets upon graduation. The degree program is roughly half computer science and half operations analysis, with the goal of producing officers with an understanding of the mathematics and technology behind modern modeling, virtual environments, and simulation systems. 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 goal of this research was to provide faculty support on mid-term and long-term issues of interest to the N61M sponsor and to couple student theses to N61M programs.

KEYWORDS: Modeling, VE, Simulation, Curriculum, MOVES

**MOVES INSTITUTE – FISCAL YEAR 2002
Michael J. Zyda, Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Chief of Naval Operations (N6M)**

SUMMARY: The Naval Postgraduate School, in conjunction with N6M, established a degree program, the MOVES curriculum, and a research institute, the MOVES Institute. The degree program generates officers who are capable of filling XX99-P/6202-P coded billets upon graduation. The degree program is roughly half computer science and half operations analysis, with the goal of producing officers with an understanding of the mathematics and technology behind modern modeling, virtual environments, and simulation systems. 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 goal of this research was to provide faculty support on mid-term and long-term issues of interest to the N6M sponsor and to couple student theses to N6 programs.

KEYWORDS: MOVES Institute, Curriculum

**VIRTUAL VAUDEVILLE
Michael J. Zyda, Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: University of Georgia**

**YOU'RE IN THE ARMY NOW! RECRUITING GAMES
Michael J. Zyda, Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: Office of the Assistant Secretary of the Army**

SUMMARY: Explored use of gaming technology in recruitment and learning through Virtual Vaudeville (with the Univeristy of Illinois) and Army recruitment game.

KEYWORDS: Recruiting, Games, Vaudeville

THE MOVES INSTITUTE (MODELING, VIRTUAL ENVIRONMENTS AND SIMULATION)

2003
**Faculty Publications
and Presentations**

MODELING, VIRTUAL ENVIRONMENTS, AND SIMULATION

PUBLICATIONS

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CENTER FOR INTERDISCIPLINARY REMOTELY PILOTED AIRCRAFT STUDIES (CIRPAS)

ROBERT BLUTH
DIRECTOR

CENTER FOR INTERDISCIPLINARY REMOTELY PILOTED AIRCRAFT STUDIES

OVERVIEW:

The Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) is a research center at the Naval Postgraduate School. The Office of Naval Research established CIRPAS in the spring of 1996. CIRPAS provides measurements from an array of airborne and grounds based meteorological, aerosol and cloud particle sensors, radiation and remote sensors to the scientific community. The data are reduced at the facility and provided to the user groups as coherent data sets. The measurements are supported by a ground based calibration facility. CIRPAS conducts payload integration, reviews flight safety and provides logistical planning and support as a part of its research and test projects around the world. The center operates a variety of manned aircraft and Unmanned Aerial Vehicles. CIRPAS is also a National Research Facility of UNOLS.

The facility provides unique flight operation and scientific measurement services by:
- Providing access to manned aircraft, UAVs and support equipment, as well as to scientific instruments, to spare users the cost of ownership, guaranteeing equal access by all interested parties on a first-come, first-served basis.
- Instrumenting and operating aircraft to meet the requirements of a variety of individual research and test programs.
- Developing new instrumentation to meet increasing challenges for improvements in meteorological and oceanographic measurements.
- Calibrating, maintaining, and operating the facility's airborne instruments in accordance with individual mission specifications.
- Integrating auxiliary payloads, as required, and handling flight safety and logistics tasks, allowing the user to concentrate on his specific mission goals.

The facility has unique UAV flight services, which include:
- An available and centralized repository of diverse UAV assets to meet the needs of individual programs.
- Access to the UAVs and support equipment on a "lease" basis so the user is spared the cost of ownership.
- Turnkey UAV operations, including payload integration, flight safety and logistics support.
- Low cost services using shared assets.

CIRPAS provides cost effective flight services, which benefits a broad spectrum of research.

CIRPAS operates out of two facilities. The primary site is located near the NPS campus at the Marina Municipal Airport. This facility includes a 30,000 sq ft hangar, maintenance and administrative spaces for CIRPAS staff. These include a fully outfitted machine shop, electronics room and a calibration lab for the upkeep of scientific instrumentation. The second site is at McMillan Airfield, Camp Roberts, California, 90 miles south of the Marina facility. The Camp Roberts site provides the Center with a base of operations for both manned and unmanned aerial vehicle (UAV) flight activities.

The California Institute of Technology supports CIRPAS as the prime contractor. It is also partners with NPS in providing the latest instrumentation for atmospheric research.

RESEARCH THRUSTS:

- Atmospheric and Oceanographic Research
- Fleet and USJFCOM Exercises
- Support for CONOPS Development
- Payload Test and Evaluation
- UAV Experimentation with Operational Forces supported by analysis provided by NPS Departments and Institutes

THE CIRPAS AIRCRAFT

UV-18A 'Twin Otter': The CIRPAS UV-18A 'Twin Otter' has two primary missions. The vehicle's large useful load makes it ideal for carrying instrumentation for atmospheric/oceanographic research. The twin

turboprop Short Takeoff and Landing (STOL) aircraft can cruise at very low speeds for long durations. The aircraft has a maximum takeoff weight of 13,500 pounds.

Characteristics of the CIRPAS Twin Otter include:
- Maximum endurance of 5 hrs. (extended further during ferry operations)
- Maximum altitude of 25kft
- 70-160 KIAS Operational Speed Range
- 200 amp of payload power (DC and AC combined)
- Wing span of 65 ft.
- GTOW of 13,500 lbs. (~6000 lbs. useful)

Pelican: The Pelican is a highly-modified Cessna 337 Skymaster originally developed by the Office of Naval Research for low-altitude, long-endurance atmospheric and oceanographic sampling. With additional support from NASA's ERAST Program, the air vehicle has been configured to operate as a UAV surrogate. In the UAV surrogate role, Pelican provides a low-risk, low-cost test and evaluation platform by avoiding the airspace restrictions and other complications associated with unmanned aircraft operations. CIRPAS' second Pelican air vehicle is a converted Cessna O2-A. It is operated without the Predator avionics equipment and is available for use in support of a variety of generic payload demonstrations.

Characteristics of Pelican include:
- Maximum endurance of 15 hrs.
- Maximum altitude of 15kft
- Cruise speed of 90 KIAS
- Nose payload bay capacity of 330 lbs.
- Wing hardpoints and cabin space for additional payloads
- 1.2 kW of payload power
- Wing span of 42 ft.
- GTOW of 4600 lbs.

Altus ST UAV: The Altus Single Turbo (ST) UAV was developed by General Atomics ASI to support high-altitude atmospheric monitoring requirements of NASA's Environmental Research Aircraft and Sensor Technology Program. The Altus™ UAV is based on the proven Predator® and GNAT™ line of unmanned aircraft. The Department of Energy's Sandia National Labs funded the fabrication of a single-stage turbocharged Altus™ UAV to support the Atmospheric Radiation Measurement (ARM) Science Campaign. As a result of a cooperative agreement with DOE, CIRPAS provides the vehicle's services during the remainder of the year to other users.

Characteristics of Altus ST include:
- Maximum endurance of 30 hrs.
- Maximum altitude of 45kft
- Cruise speed of 70 KIAS
- Nose payload bay capacity of 330 lbs.
- 1.2 kW of payload power
- Wing span of 55 ft.
- GTOW of 2100 lbs.

Predator UAV: CIRPAS maintains and operates the U.S. Navy's only two Predator UAVs. One air vehicle is configured with the EO/IR, SAR and Ku-band SATCOM payloads; the other aircraft has the EO/IR payload only. The Predators and payloads were provided to CIRPAS as a result of the Center's Tactical Control System (TCS) developmental and operational test support. The air vehicles and payloads are available for other RDT&E or CONOPS development activities on a not-to-interfere basis with the TCS Program Office objectives.

Characteristics of the Predator UAV include:
- Maximum endurance of 36 hrs.
- Maximum altitude of 25kft

- Cruise speed of 70 KIAS
- Nose payload bay capacity of 450 lbs., wing hardpoints
- 1.8 kW of payload power
- Wing span of 48 ft.
- GTOW of 2250 lbs.

GNAT-750 UAV: The GNAT-750 UAV was developed by General Atomics ASI to support unmanned, medium altitude, endurance surveillance and other sampling requirements. The GNAT-750 is the predecessor to the Predator UAV.

Characteristics of the GNAT-750 UAV include:
- Maximum endurance of 30 hrs.
- Maximum altitude of 18kft
- Cruise speed of 70 KIAS
- Nose payload bay capacity of 125 lbs.
- 1.2 kW of payload power
- Wing span of 35 ft.
- GTOW of 1450 lbs.

Ground Control Station: The General Atomics ASI Ground Control Station (GCS) provides aircraft control functions for the CIRPAS-operated UAVs. The GCS has redundant Pilot/Payload Operating Stations and is housed in a rugged, 18-ft long wheeled container. CIRPAS currently owns two GCSs and associated Ground Data Terminals capable of operating Predator/Altus/GNAT-750/Pelican air vehicles. GCS #1 includes a UHF and dual VHF radios for communication to other aircraft, range or ATC personnel. Additional radios provide direct communication between flight crew and other personnel if requirement exists. GCS #1 also has a video closed-captioning system to overlay aircraft and target position data on imagery before transmission to user.

Atmospheric/Oceanographic Aircraft Payloads: CIRPAS can provide use of a wide variety of atmospheric and oceanographic sensors to the research community. The CIRPAS sensor suite includes off-the-shelf instrumentation as well as one-of-a-kind, custom-built packages.

CIRPAS possesses a variety of scientific instruments and instrument suits. The basic meteorological and GPS suite consists of a Rosemount temperature probe, a Edgetech chilled mirror dew point sensor, a Rosemount flow angle probe with static ports, Vaisala temperature and dew point sensors, a Novatel GPS receiver with a ground survey station for differential correction, a TANS Vector GPS attitude system, a C-Midget-II INS-GPS system, an IRGA humidity and carbon-dioxide sensor, and an Aerodyne fast absolute humidity sensor. The CIRPAS aerosol instrumentation suite consists of a TSI 3-color nephelometer, a Radiance soot photometer, a TSI Ultrafine particle counter, and a TSI condensation nuclei counter. The CIRPAS cloud and particle instrumentation suite consists of an FSSP–100, a PCASP-100X, both with upgraded electronics, a CAPS scatter and occultation probes, and DMT 2D-P and 2D-PP probes, a TSI aerodynamic particle spectrometer.

RESEARCH FACILITIES:

- Marina Facility
  - 30,000 sq ft maintenance hangar
  - 3000 ft runway – manned operations only
  - Naval Reserve Unit
  - Office space, flight operations
  - Maintenance facility
  - Payload development and integration
  - Logistics planning and support to research and test projects
- Camp Roberts Facility
  - Friendly airspace for testing and training (R2503)
  - Military ground maneuvers (equipment, personnel)

- o   3500 x 60 ft runway
- o   2000 sq ft hangar
- o   Shared utilization of NRL
- o   Temporary office space

RESEARCH PROGRAM (Research and Academic)-FY2003:

The Naval Postgraduate School's sponsored program exceeded $71 million in FY2003. Sponsored programs included both research and educational activities funded from an external source. A profile of the sponsored program for the Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) is provided below:

Size of Program: $5,116K
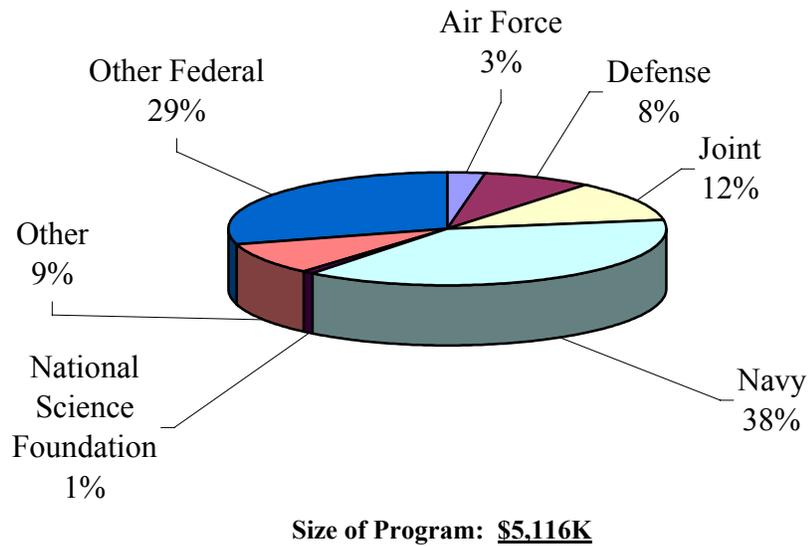
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AERIAL SURVEY OF THE OCEAN/ATMOSPHERE
Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Office of Naval Research

SUMMARY: There were several objectives related to this research: 1) obtain a regular (approximately bi-weekly) synoptic time series of the meso- and sub-mesoscale structure of the coastal ocean and atmosphere off central California, which is essential to understanding the local air/sea interaction problem; 2) use these data to develop improved numerical forecast models of both ocean and atmosphere, with particular emphasis on the Navy's Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) model. The time series of flights over the greater Monterey Bay area provides observations of the mesoscale and sub-mesoscale structure of the atmospheric boundary layer and facilitates a study of the coastal ocean's response to forcing at these scales. All flights sampled at a minimum air temperature, relative humidity, wind speed, ocean sea surface temperature, and sea surface visual imagery.

KEYWORDS: Oceanography, Sea Surface Temperature, Near Surface Winds

ALASKA PREDATOR UAV DEMO
Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: U.S. Coast Guard Research and Development Center

SUMMARY: Mission window in Alaska was five days with Predator UAVs 30 and 35 with the electro-optic/infrared (EO/IR) payload only. Forty-two flight hours were proposed, forty hours for mission flights and two hours for functional check flight. Assumed flight time per sorties at less than eight hours (consecutive) per each 24-hour day; 48 hours per each seven-day period. Flight crew must be away from OP site 12 hours each 24-hour day. All flight activity was conducted from the Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) Ground Control Station (GCS) and line of site. Assumed flight activity per CIRPAS-approved test plan. Assumed no facilities use fees (range, hangar, office space, toilet, land phone, forklift, etc.). Assumed flights to occur in airspace where a chase aircraft is not required.

KEYWORDS: UAV, Predator, CONOPS, USCG

ARM TWIN OTTER MEASUREMENT SUPPORT
Haflidi H. Jonsson, Research Associate Professor
Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Pacific Northwest National Lab

SUMMARY: The experimental objective of the ARM Program is to characterize empirically the radiative processes in the earth's atmosphere with improved resolution and accuracy. A key to this characterization is the effective treatment of cloud formation and cloud properties in global climate models (GCMs). Through this characterization of radiative properties, it will be possible to understand both the forcing and feedback effects. GCM modelers will then be able to better identify the best approaches to improved parameterizations of radiative transfer effects. This is expected to greatly improve the accuracy of long-term, GCM predictions and the efficacy of those predictions at the important regional scale, as the research community and Department of Energy (DOE) attempt to understand the effects of greenhouse gas emissions on the earth's climate.

KEYWORDS: Meteorology, Aerosol, Optical Depth, Visibility

AURA ENGINEERING FLIGHT TEST SUPPORT
Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: U.S. Department of Energy

SUMMARY: Provided Altus UAV flight support for AURA project. Funds provided by the Department of Energy primarily supported the Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) administrative functions and CIRPAS scheduled and unscheduled maintenance. More than fifty percent of the funds required to support Prairie Dog II were sent to a contractor. The contractor was required to provide mission and flight support for this project.

KEYWORDS: Meteorology, Aerosol, Optical Depth, Visibility

CENTER FOR INTERDISCIPLINARY REMOTELY PILOTED AIRCRAFT STUDIES (CIRPAS)
FLIGHT TIME
Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Office of Naval Research

SUMMARY: Researchers conducted a time series of flights over the greater Monterey Bay to observe the mesoscale and sub-mesoscale structure of the atmospheric boundary layer and the coastal ocean's response to forcing at these scales. All flights sampled at a minimum air temperature, relative humidity, wind speed, ocean sea surface temperature, and sea surface visual imagery. Some flights also observed atmospheric aerosols, turbulent fluxes, sea surface backscatter, and the spectral distribution of ocean-leaving radiance. A few selected flights coordinated with research cruises and other ground-based activities.

KEYWORDS: Oceanography, Sea Surface Temperature, Near Surface Winds

CENTER FOR INTERDISCIPLINARY REMOTELY PILOTED AIRCRAFT STUDIES (CIRPAS)
PREDATOR FLIGHT SUPPORT FOR EDU-2 LEVEL IV T&E
Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Naval Air Systems Command

SUMMARY: Supported Naval Air Systems Command (NAVAIR) PM-263 test objectives with Predator MAE UAV flight operations at El Mirage, California. Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) provided flight support over a two-week mission window with Predator P030 and P035 air vehicles for 20 flight and 15 ground test hours, weekdays. Predator payload included electro-optic/infrared (EO/IR) skyball. All flight active were line of sight. Each sortie was approximately ten hours per each 24-hour day. Assumed FCFs, launch, and recovery activity occurred from CIRPAS Ground Control Station (GCS)/GDT. Flight crew must be away from operations site twelve hours each twenty-four hours.

KEYWORDS: UAV, Predator, CONOPS, JFC

CENTER FOR INTERDISCIPLINARY REMOTELY PILOTED AIRCRAFT STUDIES (CIRPAS)
SUPPORT OF OFFICE OF NAVAL RESEARCH (ONR) RESEARCH OBJECTIVES
Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Office of Naval Research

SUMMARY: The objective of this study was to describe the mesoscale variability and air/sea interaction processes during the Office of Naval Research Autonomous Ocean Sampling Network (AOSN)-II

experiment in the Monterey Bay in August 2003. The overall goal of the AOSN-II program was to quantify the gain in predictive skill for principal circulation trajectories, transport at critical points, and near-shore bioluminescence potential in the Monterey Bay as a function of model-guided, remote adaptive sampling using a network of autonomous underwater vehicles. The role of the Twin Otter was to map ocean surface temperature and wave state, as well as measure the turbulent flux rates of momentum, heat, and water vapor in the atmosphere/ocean exchange process, quantifying the meteorological conditions in the boundary layer, and characterizing the physical properties of the marine boundary layer aerosol. The Twin Otter flew 70 hours in 20 flights out of Marina, California, in support of this experiment.

KEYWORDS: Oceanography, Sea Surface Temperature, Near Surface Winds

CHARACTERIZATION OF THE EVOLUTION OF TROPOSPHERIC ASIAN AEROSOLS
Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Naval Research Laboratory

SUMMARY: The primary objective of this 6.1 project is the characterization--through direct measurements--of the radiative, microphysical, and morphological properties of the natural and anthropogenic Asian aerosols that are transported to the west coast of the United States in the springtime. These Asian aerosols affect the dynamics of the atmosphere, with important implications for numerical weather prediction. They also affect satellite remote sensing of the surface and atmosphere. For example, the retrieval of ocean color from satellites requires accurate knowledge of the radiative effects of the aerosols in the intervening atmosphere. Quantitative measurements of the properties and effects of these Asian aerosols are sparse. Particularly lacking is knowledge of how the aerosols evolve with time. This project took the first direct measurements of the radiative properties and effects of the Asian aerosols along the west coast of the U.S. As a secondary objective, these measurements of aerosol properties were used, combined with hyperspectral imaging of the coastal ocean, in satellite validation studies of ocean color and aerosol. Flights occurred throughout April 2003, when conditions were favorable.

KEYWORDS: Meteorology, Aerosol, Optical Depth, Visibility

DEFENSE INTELLIGENCE AGENCY (DIA) UAV OPERATIONS SUPPORT
Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Defense Intelligence Agency

SUMMARY: Assisted the Defense Intelligence Agency (DIA) in the integration and testing of a classified UAV payload. Transported Predators P030, P035, Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) Ground Control Station (GCS), and associated payload to General Atomics El Mirage facility. CIRPAS provided oversight and technical guidance for the integration of the DIA payload and GCS modifications. Assumed no facilities use fees. Also assumed test activity per CIRPAS-approved test plan.

KEYWORDS: UAV, Predator, CONOPS, DIA

INSTALLATION SUPPORT OF TAMDAR
Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: National Aeronautics and Space Administration Langley Research Center

SUMMARY: Integrated the tropospheric airborne meteorological data reporting (TAMDAR) sensor onto the Twin Otter. Conducted five flight hours of dedicated TAMDAR testing. Sent TAMDAR data to the National Aeronautics and Space Administration (NASA) for evaluation.

KEYWORDS: Meteorology, Aerosol, Optical Depth, Visibility

INTEGRATION OF AEROSOL AND WIND LIDAR ONTO CIRPAS TWIN OTTER
Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: U.S. Department of Commerce

SUMMARY: Tested laser radar (LIDAR) installation and performance on the Center for Interdisciplinary Remotely Piloted Aircraft Studies Twin Otter.

KEYWORDS: Aerosol, Wind LIDAR

JOINT FORCES COMMAND JOINT OPERATIONAL TEST BED SYSTEM (JOTBS) PROGRAM
Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: U.S. Joint Forces Command

SUMMARY: Supported Joint Forces Command, Joint Operational Test Bed System (JOTBS) MAE UAV test objectives with four Predator MAE UAV flight operations with Predator P030 and P035 air vehicles and one Ground Control Station (GCS)/GDT.

KEYWORDS: UAV, Predator, CONOPS, JFC

LIDAR TWIN OTTER MEASUREMENTS SUPPORT
Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: National Oceanic and Atmospheric Administration

SUMMARY: Assisted the National Polar-Orbiting Operational Environmental Satellite System (NPOESS) to understand ocean surface and Las Doppler LIDAR returns from a space-based perspective and developed better model parameterization of air-sea. Configured and operated Twin Otter Doppler Wind LIDAR during collaborative LIDAR studies at Langley Research Center and Goddard Space Flight Center (GSFC).

KEYWORDS: Meteorology, Aerosol, Optical Depth, Visibility

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)/ARMY ROTORCRAFT SUPPORT AT CAMP ROBERTS
Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: National Aeronautics and Space Administration Ames Research Center

SUMMARY: Provided NASA Ames access to Camp Roberts for UAV flight activity between 21 and 25 April 2003. Assumed flight activity per Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) approved test plan and no Federal Aviation Administration control of airspace (CoA). All coordination meetings involving CIRPAS were conducted at Camp Roberts.

KEYWORDS: UAV, Camp Roberts, NASA

NAVAL POSTGRADUATE SCHOOL (NPS) / CENTER FOR INTERDISCIPLINARY REMOTELY PILOTED AIRCRAFT STUDIES (CIRPAS) PREDATOR FLIGHT SUPPORT FOR FISCAL YEAR 2004
Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: U.S. Joint Forces Command

SUMMARY: Supported Joint Forces Command, Joint Operational Test Bed System (JOTBS) medium-altitude endurance (MAE) UAV test objectives with four Predator MAE UAV flight operations with Predator P030 and P035 air vehicles and one Ground Control Station (GCS) /GDT.   Estimates and limitations were as follows: 50 flight hours per deployment, Predator payload will include only the electro-optic/infrared (EO/IR) skyball and/or already integrated communications packages. All deployments were to CONOS. All flight active was line of sight; downlink to Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) GCS at all times. Each sortie was approximately eight hours per each 24-hour day, less than 48 hours per each seven-day period. Flight crew must be away from ops site 12 hours of each 24 hours. Assumed flight activity per CIRPAS-approved test plan. Assumed no facilities use fees. Assumed chase plane was not required. Assumed FCFs, launch, and recovery activity occurs from CIRPAS GCS/GDT. Assumed maintenance/compatibility issues of the EDU2/JFC GDT covered separately. Assumed Level II-IV operations with EDU-2 / JFCOM GDT; specific level dependent on EDU2 status.

KEYWORDS: UAV, Predator, CONOPS, JFC

NAVAL POSTGRADUATE SCHOOL (NPS) / CENTER FOR INTERDISCIPLINARY REMOTELY PILOTED AIRCRAFT STUDIES (CIRPAS) SUPPORT OF OFFICE OF NAVAL RESEARCH (ONR) AIRBORNE RESEARCH OBJECTIVES
Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Office of Naval Research

OBJECTIVE: To determine how the abundance and physical and chemical characteristics of aerosol particles affect their efficiency as cloud condensation nuclei and how clouds' radiative properties, such as reflectance, are affected by the character of the aerosol they grow upon.

SUMMARY: To do this, condensation-nuclei and cloud-condensation-nuclei concentration needs be measured as well as the size distribution of the aerosol particles and their composition. Inside the clouds, the cloud droplet size spectra need to be measured, as well as the liquid water content and droplet composition. Above the clouds, radiometry is of essence. The Twin Otter payload for this study consisted of particle counters, size spectrometers, a CCN spectrometer, an aerosol mass spectrometer, the MOUDI particle samplers, a cloud water probe, a counter-flow virtual impactor, a stabilized radiometer platform, nephelometer, soot photometer, and if available in time for the project, a carbon vaporization spectrometer currently under development for the Center for Interdisciplinary Remotely Piloted Aircraft Studies. The mission was carried out in Marina, California, during the month of July 2003 at the height of the stratus season. The Twin Otter will fly 65 flight hours for the project in about 17 flights.

KEYWORDS: Meteorology, Aerosol, Optical Depth, Visibility

NAVAL POSTGRADUATE SCHOOL (NPS) / CENTER FOR INTERDISCIPLINARY REMOTELY PILOTED AIRCRAFT STUDIES (CIRPAS) SUPPORT OF OFFICE OF NAVAL RESEARCH (ONR) AIRBORNE RESEARCH OBJECTIVES
Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Office of Naval Research

SUMMARY: A time series of flights south of Martha's Vineyard were conducted in support of C-Blast, with 80 flight hours over a 5-week period. All flights measured turbulence fluxes of heat momentum and humidity, as well as sea surface temperature, broadband radiation, and both upwelling and downwelling spectral irradiance. C-Blast was coordinated with another, higher flying aircraft carrying high resolution infrared (IR) imagers, with instruments ship, instrumented tower in the water two miles south of Martha's Vineyard, instrumented tower on Nantucket Island, and a number of both anchored and drifting instrumented buoys.

KEYWORDS: Oceanography, Sea Surface Temperature, Near Surface Winds

NAVAL POSTGRADUATE SCHOOL (NPS) / CENTER FOR INTERDISCIPLINARY REMOTELY PILOTED AIRCRAFT STUDIES (CIRPAS) SUPPORT OF OFFICE OF NAVAL RESEARCH (ONR) OBJECTIVES
Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Office of Naval Research

SUMMARY: Project was carried out using the Center for Remotely Piloted Aircraft Studies (CIRPAS) Twin Otter and various scientific instruments from CIRPAS' airborne and calibration suites. Operations were supported by CIRPAS' scientific and flight operations personnel. CIRPAS provided meteorological and navigational data to all the projects, and also measurements from other facility instruments as requested by the Principal Investigators (PI) for each project. CIRPAS provided a data system consisting of several computers, networked and synchronized to GPS time. The data system not only serviced the facility equipment, but also the special research instruments maintained and operated by the PIs themselves, their co-PIs, and students, as needed. A satellite communications link provided the PIs and their collaborators with real-time access on the ground to the aircraft measurements.

KEYWORDS: Meteorology, Aerosol, Optical Depth, Visibility

NAVAL POSTGRADUATE SCHOOL (NPS) SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM
Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Office of Naval Research

SUMMARY: Supported Office of Naval Research Small Business Innovation Research (SBIR) program in the development and management of SBIR contracts.

KEYWORDS: SBIR, Environmental Instruments, Contract Management

REMOTE SENSING TECHNOLOGIES AND TECHNIQUES
Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: U.S. Department of Energy-National Nuclear Security Administration (NNSA)

KEYWORDS: Meteorology, Aerosol, Optical Depth, Visibility

SKYLINK EXPERIMENT
Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: U.S. Department of Energy-Lawrence Livermore National Laboratory

SUMMARY: Assumed payload compatible with existing interface (i.e., no new payload frame or fairing). Assumed limited effort for mechanical and electrical integration/ground-based compatibility testing. Pelican was flown in manned-only mode. Two flight hours for round-trip ferry. Configured with C-Migits II and data acquisition system. Flight crew must be away from OP site 12 hours each 24-hour day. Assumed flight activity per Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS)-approved test plan. Assumed all technical interchange meetings occurring at the facilities in Marina, California.

KEYWORDS: UAV, Pelican, Laser Communications

SPEC SMALL BUSINESS INNOVATION RESEARCH (SBIR) PHASE III SUPPORT DEVELOP A NEW INSTRUMENTATION TO MEASURE THE OPTICAL PROPERTIES OF CLOUDS
Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Air Force Flight Test Center

SUMMARY: Under on existing Office of Naval Research Phase II Small Business Innovation Research (SBIR) contract, SPEC Incorporated performed research to develop new instrumentation to measure the optical properties of clouds, including sub-visible cirrus clouds that have been observed in the upper troposphere and lower stratosphere. Because these clouds scatter light, they can adversely affect the direction finding ability (i.e., targeting) of long-range lasers used to identify and lock onto enemy missiles. Personnel at Edwards Air Force Base (Edwards) are currently developing a laser-based system to target enemy missiles as they enter the upper troposphere/lower stratosphere and provide information in real time to a second laser-based system capable of taking protective counter measures. Edwards has contacted SPEC to provide a (Phase III) prototype system capable of characterizing the laser beam used for targeting. The additional research utilized and customized existing software algorithms and hardware. Existing laser-based CCD camera imaging technology used to process images of cloud particles in real time will be adapted to capture and process pulses from the Edwards targeting laser.

KEYWORDS: Meteorology, Aerosol, Optical Depth, Visibility

TWIN OTTER DOPPLER WIND LIDAR DATA ANALYSIS
Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: U.S. Department of Commerce

SUMMARY: Assisted the National Polar-Orbiting Operational Environmental Satellite System (NPOESS) to understand ocean surface and Las Doppler LIDAR returns from a space-based perspective and to develop better model parameterization of air-sea. Configured and operated Twin Otter Doppler Wind LIDAR during collaborative LIDAR studies at LaRC and Goddard Space Flight Center (GSFC).

KEYWORDS: Meteorology, Aerosol, Optical Depth, Visibility

WINDS LIDAR UPGRADES, EXPERIMENTAL OBSERVATIONS, AND DATA ANALYSIS
Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: National Oceanic and Atmospheric Administration

SUMMARY: Measurement of the global tropospheric winds, clouds, and aerosols with a space-based LIDAR system is one of the thrust area focuses of the National Polar Orbiting Operational Environmental Satellite System (NPOESS). This research supported this NPOESS effort using a similar Doppler wind LIDAR integrated onto a research aircraft operated by the Center for Remotely Piloted Aircraft Studies (CIRPAS) at the Naval Postgraduate School (NPS). The ultimate goal in obtaining the measurements and conducting analyses was to understand coherent Doppler wind measurements in preparation for satellite-based global wind profiling in the future.

KEYWORDS: Meteorology, Aerosol, Optical Depth, Visibility

FORMATION AND PERPETUATION OF RIFTS AND GRADIENTS IN OPTICAL AND MICROPHYSICAL PROPERTIES OF MARITIME STRATUS
Haflidi H. Jonsson, Research Associate Professor
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: National Science Foundation

SUMMARY: Measurement of the physical characteristics of in cloud-free areas (rifts) embedded in stratus and stratocumulus using the Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) Twin Otter.

KEYWORDS: Meteorology, Aerosol, Optical Depth, Visibility

CENTER FOR INTERDISCIPLINARY REMOTELY PILOTED AIRCRAFT STUDIES (CIRPAS)

2003
Faculty Publications
and Presentations

PUBLICATIONS

Hegg, D.A., Covert, D.S., Crahan, K., and Jonsson, H., "The Dependence of Aerosol Light-Scattering on RH Over the Pacific Ocean, *Geophysical Research Letters,* 29(8)*,* 60-1 – 60-4, 2002.

Lu, M., Wang, J., Freedman, A., Jonsson, H.H., Flagan, R.C., McClatchey, R.A., et al., "Analysis of Humidity Halos Around Trade Wind Cumulus Clouds," *Journal of Atmospheric Science,* 60, 1041-1059, 2003.

Reid, J.S., Westphal, D.L., Livingston, J.M., Savoie, D.L., Maring, H.B., Jonsson, H.H., et al., "Dust Vertical Distribution in the Caribbean During the Puerto Rico Dust Experiment, *Geophysical Research Letters*, 29(7), 55-1 – 55-4, 2002.

Wang, J., Flagan, R.C., Seinfeld, J.H., Jonsson, H.H., Collins, D.R., Russell, P.B., et al., "Clearcolumn Radiative Closure During ACE-Asia: Comparison of Multiwavelength Extinction Derived from Particle Size and Composition with Results from Sunphotometry," *Journal of Geophysical Research,* 107 (D23), 4688, doi: 10.1029/2002JD002465, 2002.

SCHOOL OF
AVIATION SAFETY

CAPT KENNETH P. NEUBAUER, USN
DIRECTOR

SCHOOL OF AVIATION SAFETY

OVERVIEW:

The School of Aviation Safety's mission is to educate aviation officers at all levels to identify and eliminate hazards, to manage safety information, to investigate and report mishaps, and to develop and administer command safety programs. The School of Aviation Safety conducts safety related research and provides assistance in support of the Naval Aviation Safety Program. The combined teaching, research, and service are dedicated to enhancing combat readiness through preservation of assets, both human and material.

CURRICULA SERVED:

- Aviation Safety Officer (ASO) Course: A 21-day course designed to prepare Aviation Safety Officers to assist commanders and commanding officers in administering unit safety and mishap prevention programs.
- Aviation Safety Command (ASC) Course: A six-day course designed to indoctrinate aviation squadron commanding officers, officers screened for command, and major aviation staff officers in the policies, philosophy, and techniques of an effective command safety program.

RESEARCH THRUSTS:

- Human Factors of Air Safety: An area of research dealing with the underlying causes of human error in aviation mishaps, including individual, team and organizational factors that may contribute to the chain of events leading to an aircraft mishap. Researchers at the School of Aviation Safety are engaged in the study of human error as an underlying cause in aviation mishaps due to aircrew, supervisory and maintenance factors. This line of research was recently expanded to include a comprehensive root cause analysis of U.S. Navy aircraft mishaps, and to conduct extensive statistical trend analysis of the Navy's online safety climate survey database.

- Command Climate Assessment Surveys: The School of Aviation Safety has been a leader in the development and application of web-based surveys used to assess Command Climate. Two survey applications have been developed, and are in use today by U.S. Navy and U.S. Marine Corps units. The Command Safety Assessment (CSA) survey system is used to assess command climate, the perceived effectiveness of a commands safety program, and other factors related to the safety of flight operations. The Maintenance Climate Assessment Survey (MCAS) was developed to address similar command issues in the maintenance community. MCAS also measures command climate and other factors, but with respect to maintenance operations. CSA/MCAS are designed specifically for the aviation application. Additional research is being conducted to quantify results of the CSA/MCAS as a predictive tool for mishap prevention. A derivative of the on-line MCAS process focusing specifically on Naval Aviation Depot (NADEP) issues has also been developed and implemented. Recently, the School of Aviation researchers have begun to develop and apply the same command climate assessment methods to USMC Ground Forces. An advanced version of the USMC Ground Force Command Climate Survey system is currently undergoing Test and Evaluation and will become operational in FY 04.

- Afloat Safety Climate Assessment Survey: The School of Aviation Safety, a pioneer in the development and application of web-based surveys to assess organizational safety climate, expanded its aviation-oriented domain to include other naval activities. An extension of the aviation safety climate assessment process, the on-line afloat safety climate assessment survey process was tailored to afford Navy surface and subsurface commanders the ability to examine the perceived safety climates aboard their vessels. Under sponsorship of the Naval Safety Center, this program focused on key issues to better understand the influences that a Naval command may have on the chain of events leading to a mishap. The process is grounded in theory relating key attributes of organizations that were successful in reducing risks associated with hazardous operations.

- ▪ <u>Organizational Risk Factors:</u> An area of research dealing with the potential influence of leadership, organizational structure, safety climate, and safety culture, on mishap causation. Researchers at the School of Aviation Safety are working in collaboration with social scientists from Haas Business School, UC Berkeley, Stanford University, Carnegie-Mellon, University of Arizona, and NASA-Ames Research Center to develop and validate Organizational Risk Models. This research is closely allied to the ongoing development and application of the U.S. Navy Surface and U.S. Marine Corps Ground Force Command Climate Assessment Surveys. The phase I organizational risk factors research effort was completed in December 2002, and included a comprehensive review of literature, and the development of a conceptual framework for measuring safety climate and safety culture. A second phase is planned for FY 04 to develop and validate web-based organizational risk assessment models and measurement methods.

RESEARCH PROGRAM (Research and Academic)-FY2003:

The Naval Postgraduate School's sponsored program exceeded $71 million in FY2003. Sponsored programs included both research and educational activities funded from an external source. A profile of the sponsored program for the School of Aviation Safety is provided below:
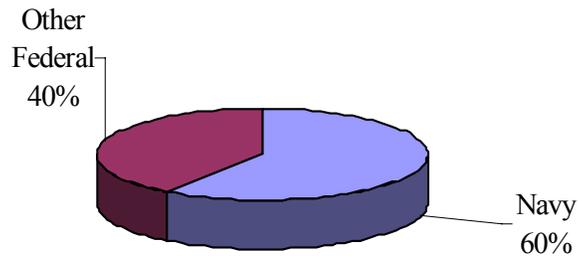
Size of Program: <u>$288K</u>

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SCHOOL OF AVIATION SAFETY

JOINT FORCE SAFETY RESEARCH ANALYSIS OF COMMAND SAFETY CLIMATE AND HUMAN FACTORS ACCIDENT DATA
Anthony P. Ciavarelli, Professor
School of Aviation Safety
Sponsor: Secretary of the Navy for Safety and Survivability

SUMMARY: Dr. Ciavarelli is leading a multidisciplinary research team at the School of Aviation to perform comprehensive analysis of Command Safety Climate and U.S. Naval Aviation Safety data. This research is conducted in collaboration with other organizational scientists located at the University of California-Berkeley and Stanford University. This study represents and initial effort to establish a comprehensive joint service safety research and intervention program for U.S. military aviation. The planned research is aimed at developing and applying new and improved methods for analyzing tri-service safety center databases and command climate survey data in order to identify common underlying causes of aircraft mishaps. Such analyses are intended to form the basis for safety improvements and performance enhancement across services.

All three services operate safety centers that routinely collect, analyze, and disseminate safety data with the intention of informing their military aviation professionals about significant statistical trends and hazards. However, there is no substantive effort designed to systematically compare and cross-correlate mishap statistical trends, or to explore possible common underlying mishap causes across services. Yet, there are many missions flown across services in which there are common hazards, similar risks, and sometimes, unfortunately, identical mishap outcomes (e.g., controlled flight into terrain and midair collisions).

A major premise of this research is that there is much to be gained by a careful study of the service mishap databases, and the analysis of potential mishap cause commonalities. In addition, there are some new, advanced analysis methods (root cause models), and emerging technologies (intelligent agent-based data mining software programs) that have not been applied in an attempt to identify trends in both mishap statistical data and in analyzing large samples of safety climate survey data (such as the comprehensive climate survey data now routinely collected across all Naval Aviation units). The Navy now has in its safety climate database tens of thousands of completed safety climate surveys taken across nearly two-thirds of the U.S. Navy and U.S. Marine Corps aviation squadrons.

The ongoing analyses will build upon data and analyses already available at the service safety centers and at the Naval Postgraduate School. Initial data analysis (Phase I Study Effort) will focus on the U.S. Navy data, and will eventually (over a period of 2-3 years) expand to consider data from U.S. Air Force and U.S. Army safety centers.

Data analysis methods will include, but not be limited to the following:

- *Root-Cause Analysis* -- In root cause analysis, much care is taken to distinguish "symptoms from causes." The symptoms of the mishap are typically the most apparent and immediate event leading to the accident. Whereas the root cause reflects the underlying condition, precursors, or key events earlier in the accident chain, the presence of which precipitated the mishap. Root cause analysis aims to identify underlying "causes" of mishaps, typically by constructing fault tree models that map out, (1) the sequence of events contributing to the mishap, (2) events within the sequence that represent active errors, and (3) points in the sequence that represent latent systemic failures or flaws (as possible root causes). This mishap event data analysis will initially focus on the Navy's database, with special consideration to analyzing root causes of the Navy's "skill-based" aircrew error accidents.
- *Data mining* – the Navy has purchased a License to use Battelle Laboratory's Starlight data visualization system as an aid to identify common causal factors across Navy and sister service aircraft mishaps. This analysis will use the U.S. Safety Center Human Factors Analysis Classification System (HFACS), which provides a narrative summary of all Naval Aviation accidents, and a list of causal factors classified in terms of specific categories of human error.

PRESENTATION:

Ciavarelli, A.P. and Figlock, R., "Report of Technical Progress and Preliminary Findings," Navy Human Factors Quality Management Board (HFQMB), December 2003.

KEYWORDS: Organizational Climate, Survey Questionnaire, Statistics, Data Mining, Accident Analysis

ORGANIZATIONAL RISK MODEL DEVELOPMENT
Anthony P. Ciavarelli, Professor
School of Aviation Safety
Sponsor: National Aeronautics and Space Administration Ames Research Center

OBJECTIVE: To develop and validate an Organizational Risk Assessment Model for use by the National Aeronautics and Space Administration (NASA).

SUMMARY: A program of research was initiated to develop and validate an Organizational Risk Model for use in the NASA space exploration program. Dr. Ciavarelli worked with a research team consisting of research psychologists at the NASA-Ames Research Center, Carnegie-Mellon University, Stanford University, and the Jet Propulsion Laboratory (JPL). Dr. Ciavarelli drew from his existing work related to organizational factors in aviation accidents (Ciavarelli, Figlock, Sengupta, and Roberts, 2001; Ciavarelli and Figlock, 1997), the works of Roberts (1990) and Libuser (1994), Gaba, Singer, Sinaiko, and Ciavarelli, (2003). He recently completed a comprehensive review of the literature on measuring organizational climate and safety culture. A preliminary technical report was published for NASA (Ciavarelli, 2003) and served as a key input for construction of an Organizational Risk Assessment Model by NASA scientists. The organizational risk model considered measures and metrics related to organizational climate and culture in assessing the potential contribution of organizational factors to a variety of risk areas, such as accident risk, mission failure, program slippage, financial loss, and other loss potentials. Dr. Ciavarelli led the construction of a web-based survey technology, using an adapted version of the U.S. Marine Corps web-survey system. The web-survey technology will provide a means to rapidly construct questionnaire surveys, and to receive immediate feedback of results, and will enable normative data comparisons among survey samples and populations.

The U.S. Marine Corps Ground Force Command Assessment system, currently under development, will serve as the methodological and software system baseline for the NASA survey system. The USMC survey system is considered a third generation, advanced online survey technology, complete with a powerful authoring capability for rapid design, development, and testing of new online survey applications.

The new survey system may be used by the NASA research team as a means for exchanging views and for reaching a decision consensus during risk model development. Later, the resulting online web-survey method may serve as one means of providing a risk-decision support system for mitigating design, development, and operational risk for the International Space Station. The Organizational Risk Model will result from a team effort that requires a final integration of related collaborative efforts at the National Aeronautics and Space Administration (NASA), Jet Propulsion Laboratory (JPL), the Naval Postgraduate School (NPS), and other academic institutions.

Once developed and validated, the resulting Organizational Risk Model will be applicable to both civilian and military agencies. Outputs from this study are expected to greatly enhance the ongoing efforts to measure and assess operational risks in U.S. Naval Aviation and U.S. Marine Corps ground forces.

PUBLICATION:

Gaba, D., Singer, S., Sinaiko, A., and Ciavarelli, A.P., "Differences in Safety Climate Between Hospital Personnel and Naval Aviations," *Human Factors*, 45, (2) 173-185, Summer 2003.

PRESENTATION:

Ciavarelli, A.P., Roberts, K.H., and Gaba, D.M., "Culture and Climate of Safety," Conference on High-Reliability Theory and Practice in Medicine, Loma Linda University, August 2003.

SCHOOL OF AVIATION SAFETY

FINAL REPORT:

Ciavarelli, A.P., "Organizational Risk Assessment: The Role of Safety Culture," National Aeronautics and Space Administration-Ames Final Report, Naval Postgraduate School, February 2003.

KEYWORDS: Organizational Behavior Models, Risk Assessment, Safety Culture, Survey Methods

ORGANIZATIONAL SAFETY RISK ASSESSMENT SYSTEM U.S. MARINE CORPS GROUND FORCES COMMAND SAFETY ASSESSMENT SURVEY
Anthony P. Ciavarelli, Professor
School of Aviation Safety
Sponsor: Marine Corps Headquarters Safety Division

OBJECTIVE: To develop, implement, and test a web-based command climate assessment system for U.S. Marine Corps ground forces.

SUMMARY: A prototype *Aviation Command Safety Assessment* questionnaire was developed and administered to U.S. Navy and Marine Corps units in August 1996. The questionnaire was designed to measure the extent to which a particular Naval squadron met criteria of a so-called *High Reliability Organization.* Construction of the questionnaire was based primarily on the work of Karlene Roberts (1990), from the Haas Business School, University of California-Berkeley, and her colleague Carolyn Libuser (1994) from the University of California at Los Angeles. It was Roberts who coined the term high-reliability organization (HRO). Roberts and Libuser studied organizations in terms of their ability to effectively manage risks associated with possible accidents and material or financial losses. Results of the 1996 survey were presented to the Navy's ongoing human factors Quality Management Board (QMB) study of Naval mishaps. Findings from the study were used by the U.S. Navy to initiate a series of planned safety interventions, including a provision for continuous measurement of organizational safety effectiveness. Over the past few years, the survey questionnaire has been refined based upon statistical validation data, and an Internet-based version was developed. The current U.S. Naval Aviation Command Climate Survey questionnaire is now available at: http://www.safetyclimatesurveys.org/index1.asp.

The web-based survey provides aviation commanders with a means to administer the survey and to receive immediate feedback concerning key issues related to command climate, safety culture, workload, resource availability, estimated success of certain safety intervention programs, and other factors related to safely managing fleet flying operations. A key goal of the survey method, and Internet technology application, is to identify and correct any latent organizational conditions that may lead to increased accident risk. In April 2001, Dr. Ciavarelli initiated an additional application of this methodology to U.S. Marine Corps ground forces, with research and development funding from the Headquarters, U.S. Marine Corps. The new system will be fully operational by October 2003. The U.S. Marine Corps web site is at: https://miras.dbidb.com/usmc/login.html.

Dr. Ciavarelli participates with a Stanford University/VA Hospital research team headed by Stanford University professor (Dr. David Gaba). The Stanford University research team uses an adapted version of the survey to examine organizational culture in medical delivery agencies.

PUBLICATION:

Gaba, D., Singer, S., Sinaiko, A., and Ciavarelli, A.P., "Differences in Safety Climate Between Hospital Personnel and Naval Aviators," *Human Factors and Ergonomics*, 45, (2), 173-185, Summer 2003.

KEYWORDS: Organizational Effectiveness, Safety Culture, Risk Management, Survey Method

SCHOOL OF AVIATION SAFETY

ANALYSIS OF AGGREGATE COMMAND CLIMATE SURVEY DATA

Robert C. Figlock, Assistant Professor
Anthony P. Ciavarelli, Professor
School of Aviation Safety
Sponsor: Marine Corps Headquarters Safety Division

OBJECTIVE: To perform statistical analysis of the Command Safety Assessment and Maintenance Climate Assessment database in order to identify possible trends, and to validate climate survey instruments.

SUMMARY: An *Aviation Command Safety Assessment (CSA) survey* questionnaire was first developed and administered to Navy and Marine Corps units in August 1996. The questionnaire was designed to measure the extent to which a particular Naval squadron met criteria of a so-called *High Reliability Organization.* The results of the 1996 survey were presented to the Navy's ongoing human factor's Quality Management Board (QMB) study of Naval mishaps. Findings from the study were used by the U.S. Navy to initiate a series of planned safety interventions, including a provision for continuous measurement of organizational safety effectiveness. Over the past few years, the survey questionnaire has been refined based upon statistical validation data, and an Internet-based version was developed. In addition, a comparable questionnaire survey was developed specifically for maintenance operations. This companion survey questionnaire is referred to as the Maintenance Climate Assessment Survey (MCAS). Both questionnaires (CSA/MCAS) are now available to U.S. Navy and Marine Corps units via a secure Internet web site. The web-based surveys provide aviation commanders with a means to administer the surveys simultaneously to both aircrews and maintainers. Following survey administration, commanders receive immediate feedback concerning key issues related to command climate, safety culture, workload, resource availability, estimated success of certain safety intervention programs, and other factors related to safely managing fleet flying operations. An adapted form of this web-based organizational safety risk assessment method is currently under development for U.S. Marine Corps ground forces. A key goal of the survey method, and Internet technology application, is to identify and correct any latent organizational conditions that may lead to increased accident risk. At this time, CSA/MCAS only provide "snapshot" statistical summaries for each squadron that has taken the survey. A squadron commander can view the results of his/her own squadron and then make statistical comparisons to other like squadrons and to fleet averages. There is presently no capability for the system to generate analyses of longitudinal "aggregate" cross-sectional statistical comparisons. Such analysis would provide useful trend information for Naval Aviation managers to better manage aviation risks.

Research tasks and analyses undertaken on this research program are focused on completing extensive analyses of the "aggregate" CSA/MCAS database as outlined below.

1. Generate descriptive statistical summaries of CSA/MCAS database, comparing results by community, aircraft type, and other specific demographic variables.

2. Create statistical summary "graphic and tabular" profiles based on selected critical safety questionnaire items and demographics, and generate statistical profiles based upon the high-reliability organizational model or survey subscales.

3. Conduct comprehensive multivariate statistical tests to validate survey instruments. A wide range of statistical tests is planned to establish the measurement reliability and validity of the CSA and MCAS survey instruments. Planned statistical tests include principal components Factor Analysis (exploratory and confirmatory), Analysis of Variance and Cronbach-Alpha reliability tests, Discriminate Analysis, Correlation, and Multiple Regression. One very important validation strategy will be to determine whether or not survey item scores, or derived scoring metrics, can predict mishap or incident frequency. When completed, such analyses will provide evidence that measures taken during surveys can be correlated or associated with accident probability or occurrences.

4. Coordinate research activities with ongoing parallel development and validation efforts at Embry-Riddle Aeronautical University, NASA/Ames, and Stanford University Patient Safety Center to provide essential cross-validation of measurement scales, and to collaborate on lessons learned.

5. Publish periodic reports and articles for use by the Department of Defense and other government and private sectors to inform and educate aviation community and safety professionals.

PRESENTATION:

Ciavarelli, A.P., "Command Safety Assessment Summary of Selected Statistics," Human Factors Quality Management Board, June 2003.

KEYWORDS: Organizational Climate, Survey Questionnaire, Statistics

APPLIED RESEARCH USING THE COMMAND SAFETY ASSESSMENT SURVEY SYSTEM
Robert C. Figlock, Assistant Professor
School of Aviation Safety
Sponsor: Commander, Naval Air Forces

OBJECTIVE: To provide for continued refinements of the Command Safety Assessment Survey process and the detailed analysis of Commander, Naval Air Forces (CNAF) survey data.

SUMMARY: CNAF established the requirement for his operating forces to conduct periodic surveys using the on-line Command Safety Assessment Survey system. This web-based survey system provides aviation commanders with a means to administer surveys to both aircrews and maintainers. A key goal of this survey method is to identify and correct latent organizational conditions that may lead to increased mishap risk. Following survey administration, commanders receive immediate survey results feedback concerning key issues related to command climate, safety culture, workload, resource availability, estimated success of certain safety intervention programs, and other factors related to safely managing fleet flying operations. The Command Safety Assessment Survey process was designed to measure the extent to which a Naval Aviation organization met the criteria of a so-called "High Reliability Organization." Over the past few years, the survey process has been refined based upon statistical validation data, user input from the fleet, and researcher experience gained through the development and employment of the system. However, in-depth analysis of the survey data has not been completed due to resource constraints. This research effort provided for continued refinements of the Command Safety Assessment Survey process and the detailed analysis of CNAF survey data.

PRESENTATION:

Ciavarelli, A. and Figlock, R., "Aviation Safety Study: A Quantitative and Qualitative Analysis," Human Factors Quality Management Board (HFQMB) Video Teleconference, Naval Postgraduate School, 11 December 2003.

KEYWORDS: Safety Climate Assessment, Hazard Analysis, Risk Assessment, Risk Management, Aviation Accident Prevention

DEVELOP A WEB-BASED AFLOAT SAFETY CLIMATE ASSESSMENT SURVEY
Robert C. Figlock, Assistant Professor
School of Aviation Safety
Sponsor: Naval Safety Center

OBJECTIVE: To develop a web-based Afloat Safety Climate Assessment Survey

SUMMARY: The Naval Postgraduate School (NPS) School of Aviation Safety, working in concert with the Naval Safety Center, developed a web-based Climate Safety Assessment Survey (CSAS) to proactively assess aircrew perceptions of factors enhancing flight safety. The CSAS was based on a model of High Reliability Organizations (HRO), which was derived in part from studies involving Navy carrier-based flight operations as well as Navy nuclear submarine operations. The HRO model encompasses command and control, process auditing, quality assurance, reward systems, and risk management. The instrument's success, coupled with the fact that 80% of all maritime accidents are tied to human error, has led the Naval Safety Center to develop a similar system to proactively identify factors that contribute to afloat safety.

This effort entailed developing a notional Afloat Safety Climate Assessment Survey (ASCAS) based upon the current CSAS on-line assessment system, and then generating a web-based prototype for fleet testing and comment.

KEYWORDS: Human Error, Maritime Error, Maritime Accidents, Maritime Mishaps, Maritime Accident Investigation, Maritime Mishap Investigation, Maritime Accident Prevention, Maritime Mishap Prevention, Maritime Safety Climate Assessment, Afloat Safety Climate Assessment

HUMAN FACTORS TOOLS AND INTERVENTIONS FOR IMPROVING MAINTENANCE ERROR MANAGEMENT
Robert C. Figlock, Assistant Professor
John K. Schmidt, Assistant Professor
School of Aviation Safety
Sponsor: National Aeronautics and Space Administration Ames Research Center

OBJECTIVE: This effort encompasses the continued systematic implementation of the Human Factors Analysis and Factor Classifications System (HFACS-ME), a maintenance-based incident investigation, analysis, and reporting tool, as well as the on-line Maintenance Climate Assessment Survey (MCAS) in both operational units and rework facilities. Data derived will be used to tailor maintenance resource management (MRM) training and intervention efforts. Individual pre/post training evaluations were administered, work areas metrics were developed to assess intervention effectiveness, and a process for estimating Return on Investment (ROI) was developed.

SUMMARY: This project developed a standard process to identify, assess, and control maintenance errors. It attempted to validate interventions related to specific errors. Intervention strategies developed through this task were ear-marked for integration into standard maintenance and inspection systems for military aviation, commercial airlines, repair stations, and rotary-wing operations. This effort will lead to more effective assessment of the propensity for future errors within maintenance organizations, implementation of appropriate intervention strategies, and allocation of organizational resources toward their prevention.

PRESENTATION:

Figlock, R., "Integrated Safety and Training Approaches to Manage Risks in Naval Aviation Depot Maintenance," 12th International Symposium on Aviation Psychology, Dayton, OH, 14-17 April 2003.

KEYWORDS: Human Error, Maintenance Error, Flight Mishaps, Aviation Mishaps, Aviation Accidents, Flight Mishap Investigation, Aviation Mishap Investigation, Aviation Accident Investigation, Flight Mishap Prevention, Aviation Mishap Prevention, Aviation Accident Prevention, Design for Maintainability

HUMAN FACTORS TOOL AND INTERVENTIONS FOR MAINTENANCE RISK MANAGEMENT
Robert C. Figlock, Assistant Professor
John K. Schmidt, Assistant Professor
School of Aviation Safety
Sponsor: National Aeronautics and Space Administration Ames Research Center

OBJECTIVE: This effort is a multi-year project that encompasses the systematic development of human factors tools and interventions for maintenance risk management.

SUMMARY: The Maintenance Climate Assessment Survey (MCAS), originally developed to evaluate the safety posture of operational units, was effectively used to identify emerging hazards as potential targets for intervention. Its scope was modified for use with a mainly civilian workforce engaged in depot level overhaul and repair. The MCAS proved useful in confirming the presence of hazards determined in

incident analysis, as well as identifying other potential areas for intervention. The MCAS findings, taken together with those from incident investigations, were effectively used to tailor training and develop controls. This effort was to transition the MCAS as a risk management tool to fit commercial aviation applications, as well as Space Shuttle Program overhaul and repair. The present web-based MCAS was adapted in conjunction with industry partners to fit with their specific work force, job setting, and requirements. Aside from the on-line surveys, requisite training materials were developed to support survey administration and subsequent interpretation and action planning. A stand-alone version of the MCAS was developed for remote location use. Additionally, the ASRS database that was classified using the maintenance extension of the Naval Aviation Human Factors Analysis and Factor Classifications System (HFACS-ME) was updated and entered into the commercial variant of the Maintenance Error Information Management System (MEIMS). The updated database will be analyzed to discern potential patterns and trends, construct related risk analyses, and identify potential interventions based on the historical National Aeronautics and Space Administration (NASA) / Federal Aviation Administration (FAA) human factors in aviation maintenance and inspection research (HFAMI).

PRESENTATION:

Figlock, R., "Assessment of Naval Aviation Maintenance Safety Climate," 2003 Department of Defense (DoD) Maintenance Symposium and Exhibition, King of Prussia, PA, 27-30 October 2003.

KEYWORDS: Safety Climate Assessment, Hazard Analysis, Risk Assessment, Risk Management, Maintenance Error, Aviation Accidents, Accident Investigation, Aviation Accident Prevention

UPGRADE OF THE COMMAND SAFETY ASSESSMENT SURVEY SYSTEM
Robert C. Figlock, Assistant Professor
School of Aviation Safety
Sponsor: Safety Division, Headquarters

OBJECTIVE: To enhance the quality of the on-line Command Safety Assessment Survey system as part of an on-going research effort in support of the Secretary of the Navy's human factors research project.

SUMMARY: The on-line Command Safety Assessment Survey system provides aviation commanders with a means to administer surveys to both aircrews and maintainers. A key goal of this survey method is to identify and correct latent organizational conditions that may lead to increased mishap risk. Following survey administration, commanders receive immediate survey feedback concerning key issues related to command climate, safety culture, workload, resource availability, estimated success of certain safety intervention programs, and other factors related to safely managing fleet flying operations. Over the past few years, the survey process has been refined based upon statistical validation data and researcher experience gained through the development and employment of the system. Additionally, potential system improvements have been solicited from survey respondents and fleet commanders using the system. These upgrades will enhance both commanders' and researchers' abilities to examine and analyze safety survey data.

PRESENTATION:

Figlock, R., "Command Safety Assessment Surveys Presentation for HQMC Safety Division," Director, HQMC Safety Division, 11 December 2003.

KEYWORDS: Safety Climate Assessment, Hazard Analysis, Risk Assessment, Risk Management, Aviation Accident Prevention

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2003
Faculty Publications
and Presentations

PUBLICATION

Gaba, D., Singer, S., Sinaiko, A., and Ciavarelli, A.P., "Differences in Safety Climate Between Hospital Personnel and Naval Aviators," *Human Factors and Ergonomics*, 45, (2), 173-185, Summer 2003.

CONFERENCE PUBLICATION

Ciavarelli, A.P., Figlock, R., Sengupta, K., and Roberts, K.H., "Assessing Organizational Risk Using Survey Questionnaire Methods," *11th Annual International Symposium on Aviation Psychology*, Columbus, OH, 2001.

PRESENTATIONS

Ciavarelli, A.P., "Command Safety Assessment Summary of Selected Statistics," Human Factors Quality Management Board, June 2003.

Ciavarelli, A. and Figlock, R., "Aviation Safety Study: A Quantitative and Qualitative Analysis," Human Factors Quality Management Board (HFQMB) Video Teleconference, Naval Postgraduate School, 11 December 2003.

Ciavarelli, A.P. and Figlock, R., "Report of Technical Progress and Preliminary Findings," Navy Human Factors Quality Management Board (HFQMB), December 2003.

Ciavarelli, A.P., Roberts, K.H., and Gaba, D.M., "Culture and Climate of Safety," Conference on High-Reliability Theory and Practice in Medicine, Loma Linda University, August 2003.

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Figlock, R., "Command Safety Assessment Surveys Presentation for HQMC Safety Division," Director, Headquarters Marine Corps (HQMC) Safety Division, 11 December 2003.

Figlock, R., "Integrated Safety and Training Approaches to Manage Risks in Naval Aviation Depot Maintenance," 12th International Symposium on Aviation Psychology, Dayton, OH, 14-17 April 2003.

FINAL REPORT

Ciavarelli, A.P., "Organizational Risk Assessment: The Role of Safety Culture," National Aeronautics and Space Administration-Ames Final Report, Naval Postgraduate School, February 2003.