NAVAL POSTGRADUATE SCHOOL
Monterey, California

RADM PATRICK W. DUNNE, USN
Superintendent

RICHARD ELSTER
Provost

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**Abstract**

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 E. Meyer Institute of Systems Engineering (formerly the Institute for Defense Systems Engineering and Analysis, IDSEA), The Modeling, Virtual Environments, and Simulation (MOVES) Institute, and Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS).
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 2004. 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 2004, the level of research effort overall at the Naval Postgraduate School was 208 faculty work years and exceeded $92 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 FY2004, over 91% of the research program was externally supported. A profile of the sponsorship of the Naval Postgraduate School Research Program in FY2006 is provided in Figure 1.
The Chief of Naval Operations 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 FY2006 is provided in Figure 2.

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  
December 2006
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(MODELING, VIRTUAL ENVIRONMENTS, AND SIMULATION)

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Established in 1965, the Defense Resources Management Institute (DRMI) conducts professional education programs in resources management for senior military officers from all services and senior civilian officials from the United States and allied nations. The goal of the Institute's programs is to improve decision-making skills related to the allocation and use of scarce resources in modern defense organizations. The DRMI programs are sponsored by the Office of the Secretary of Defense and use NPS faculty to teach its programs, which are conducted at NPS and other locations worldwide. Since 1965, over 14,000 U.S. and 16,000 international officials from 162 countries have participated in DRMI programs.

MISSION:

The DRMI research program is sponsored by the Office of the Secretary of Defense and is designed to support the multidisciplinary nature of the curriculum. The program exceeded $550,000 in 2006.

RESIDENT COURSES OFFERED:

- Defense-resources management
- International defense-resources management
- Senior international defense-resources management
- Multiple-criteria decision making
- Budget preparation, execution, and accountability
- Financial integrity, accountability, and transparency
- Streamlining government through outsourcing, privatization, and public-private partnerships
- Base realignment and closure and economic redevelopment

FACULTY EXPERTISE:

DRMI’s multidisciplinary faculty is drawn from the fields of management, economics, operations research, and systems engineering. The faculty is composed of both civilians and U.S. military officers representing all services.

RESEARCH PROGRAM (Research and Academic)-FY2006:

The Naval Postgraduate School’s sponsored program exceeded $81 million in FY2006. Sponsored programs included both research and educational activities funded from an external source. The Defense Resource Management Institute’s program exceeded $102K in 2005.
Size of Program: $XXXXK
LaCivita, Charles  
Professor and Executive Director  
656-2445  
clacivita@nps.edu

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Email</th>
<th>Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airola, James</td>
<td>Assistant Professor</td>
<td><a href="mailto:jsairola@nps.edu">jsairola@nps.edu</a></td>
<td>656-2457</td>
</tr>
<tr>
<td>Frederiksen, Peter C.</td>
<td>Professor</td>
<td><a href="mailto:pcfreder@nps.edu">pcfreder@nps.edu</a></td>
<td>656-2661</td>
</tr>
<tr>
<td>Page, Chris, LTC, USMC</td>
<td>Lecturer</td>
<td><a href="mailto:elpage@nps.edu">elpage@nps.edu</a></td>
<td>656-2376</td>
</tr>
<tr>
<td>Amara, Jomana</td>
<td>Assistant Professor</td>
<td><a href="mailto:jhamara@nps.edu">jhamara@nps.edu</a></td>
<td>656-3591</td>
</tr>
<tr>
<td>Hladky, Mark, LTC, USA</td>
<td>Lecturer</td>
<td><a href="mailto:mhhladky@nps.edu">mhhladky@nps.edu</a></td>
<td>656-2569</td>
</tr>
<tr>
<td>Polley, Allan C.</td>
<td>Lecturer</td>
<td><a href="mailto:acpolley@nps.edu">acpolley@nps.edu</a></td>
<td>656-2017</td>
</tr>
<tr>
<td>Angelis, Diana</td>
<td>Associate Professor</td>
<td><a href="mailto:diangeli@nps.edu">diangeli@nps.edu</a></td>
<td>656-2051</td>
</tr>
<tr>
<td>Hurst, Stephen</td>
<td>Senior Lecturer</td>
<td><a href="mailto:sfhurst@nps.edu">sfhurst@nps.edu</a></td>
<td>656-3480</td>
</tr>
<tr>
<td>Regnier, Eva</td>
<td>Assistant Professor</td>
<td><a href="mailto:eregnier@nps.edu">eregnier@nps.edu</a></td>
<td>656-2912</td>
</tr>
<tr>
<td>Bellamy, Fred, Lt Col, USAF</td>
<td>Lecturer</td>
<td><a href="mailto:flbellam@nps.edu">flbellam@nps.edu</a></td>
<td>656-2310</td>
</tr>
<tr>
<td>McNab, Robert M.</td>
<td>Associate Professor</td>
<td><a href="mailto:rmmcnab@nps.edu">rmmcnab@nps.edu</a></td>
<td>656-3132</td>
</tr>
<tr>
<td>Richter, Anke</td>
<td>Associate Professor</td>
<td><a href="mailto:arichter@nps.edu">arichter@nps.edu</a></td>
<td>656-2468</td>
</tr>
<tr>
<td>Blandin, James S.</td>
<td>Professor</td>
<td><a href="mailto:jiblandin@nps.edu">jiblandin@nps.edu</a></td>
<td>656-2318</td>
</tr>
<tr>
<td>Melese, Francois</td>
<td>Associate Professor</td>
<td><a href="mailto:fmelese@nps.edu">fmelese@nps.edu</a></td>
<td>656-2009</td>
</tr>
<tr>
<td>Vaughan, Larry E.</td>
<td>Senior Lecturer</td>
<td><a href="mailto:jvaughan@nps.edu">jvaughan@nps.edu</a></td>
<td>656-2791</td>
</tr>
<tr>
<td>Bonspier, Donald E.</td>
<td>Senior Lecturer</td>
<td><a href="mailto:dbonspier@nps.edu">dbonspier@nps.edu</a></td>
<td>656-2224</td>
</tr>
<tr>
<td>Modisette, Joel, CDR, USN</td>
<td>Lecturer</td>
<td><a href="mailto:jdomodise@nps.edu">jdomodise@nps.edu</a></td>
<td></td>
</tr>
<tr>
<td>Wall, Kent D.</td>
<td>Professor</td>
<td><a href="mailto:kdwall@nps.edu">kdwall@nps.edu</a></td>
<td>656-2158</td>
</tr>
<tr>
<td>Costain, Phillip A.</td>
<td>Senior Lecturer</td>
<td><a href="mailto:pacostai@nps.edu">pacostai@nps.edu</a></td>
<td>656-2909</td>
</tr>
<tr>
<td>Morales, Luis</td>
<td>Senior Lecturer</td>
<td><a href="mailto:lmmorales@nps.edu">lmmorales@nps.edu</a></td>
<td>656-3669</td>
</tr>
<tr>
<td>Webb, Natalie J.</td>
<td>Associate Professor</td>
<td><a href="mailto:njwebb@nps.edu">njwebb@nps.edu</a></td>
<td>656-2013</td>
</tr>
<tr>
<td>Enns, John</td>
<td>Senior Lecturer</td>
<td><a href="mailto:jhenns@nps.edu">jhenns@nps.edu</a></td>
<td>656-2306</td>
</tr>
<tr>
<td>Morris, James H.</td>
<td>Professor</td>
<td><a href="mailto:jhmorris@nps.edu">jhmorris@nps.edu</a></td>
<td>656-2992</td>
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EASTERN NORTH CAROLINA MARINE CORPS FORCES AND INSTALLATIONS HIGH-INTENSITY HURRICANE EVACUATION DECISION SUPPORT
Eva Regnier, Assistant Professor
Defense Resources Management Institute
Sponsor: Marine Corps Installations East

SUMMARY: Provided technical assistance on the problems associated with the decision to evacuate eastern North Carolina Marine Corps forces and installations in the face of an inbound major hurricane (mid Category III or higher). Reporting is scheduled for September 2007.

EVALUATING COMPETING MODELS FOR PRODUCTION INVESTMENT VALUATION
Eva Regnier, Assistant Professor
Defense Resources Management Institute
Sponsor: National Science Foundation

OBJECTIVE: To address two very important research questions: first, how much power do validation methods developed for financial investments retain when applied to real investment decisions? Second, what are the most important characteristics of the dynamics of input, output, and demand in determining firm profits and shareholder return?

FRAMEWORKS FOR INTEGRATION OF ATMOSPHERIC-OCEANIC SCIENCE AND FORECASTING WITH OPERATIONAL DECISION-MAKING
Eva Regnier, Assistant Professor
Defense Resources Management Institute
Sponsor: National Science Foundation

OBJECTIVE: To identify key resource, research, and development requirements for the integration of the relevant infrastructures.

THE OPTIMAL ALLOCATION OF HIV PREVENTION DOLLARS IN THE UNITED STATES
Anke Richter, Associate Professor
Defense Resources Management Institute
Sponsor: RTI International, Inc.

OBJECTIVE: The Naval Postgraduate School will provide the following services on RTI International, Inc.’s HIV projects:

- Review of existing models
- Suggestions for improvements in current models
- Background research for new models
- Analysis of existing data
DEFENSE RESOURCES
MANAGEMENT INSTITUTE

2006
Faculty Publications
and Presentations
DEFENSE RESOURCES MANAGEMENT INSTITUTE

PUBLICATIONS


CONFERENCE PUBLICATIONS


ONLINE PUBLICATIONS


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 proficiencies 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)-FY2006:

The Naval Postgraduate School’s sponsored program exceeded $81 million in FY2006. Sponsored programs included both research and educational activities funded from an external source.

Size of Program: $18M  ok for 06
NATIONAL SECURITY AFFAIRS

Wirtz, James
Professor and
Chairman
656-3483
jwirtz@nps.edu

Lavoy, Peter R
Assistant Professor and
Associate Chairman for Research
656-3167
plavoy@nps.edu

Abenheim, Donald
Associate Professor
656-2208
dabenheim@nps.edu

Garrett, Stephen
Visiting Professor
656-3191
sgarrett@nps.edu

Miller, Lyman
Associate Professor
656-2143
hmiille1@nps.edu

Baylouny, Anne Marie
Assistant Professor
656-2739
ambaylou@nps.edu

Hooper, Col. Charles, USA
Army Chair for Foreign Area
656-1039
cwhooper@nps.edu

Moran, Daniel J.
Associate Professor
656-2059
djmoran@nps.edu

Bruneau, Thomas C.
Professor
656-3760
Tbruneau@nps.edu

Knopf, Jeff
Visiting Associate Professor
656-5088
jwknofp@nps.edu

Nasr, Vali
Professor
656-3292
vnasr@nps.edu

Clary, Christopher
Research Associate
656-3587
coclary@nps.edu

Lawson, Letitia
Visiting Assistant Professor
656-2744
lllawson@nps.edu

Olsen, Edward A.
Professor
656-3163
eolsen@nps.edu

Clunan, Anne
Assistant Professor
656-2904
alclunan@nps.edu

Loeffler, RADM Steven, USN (ret.)
Senior Lecturer
619-440-5276
srloeffl@nps.edu

Piombo, Jessica Assistant Professor
656-2831
jripiombo@nps.edu

Croissant, Auriel
Assistant Professor
656-3680
asacroiss@nps.edu

Looney, Robert E.
Professor
656-3484
relooney@nps.edu

Porch, Douglas R.
Professor
656-1038
dporch@nps.edu

Eaton, Kent
Associate Professor
656-2511
kheaton@nps.edu

Malley, Michael
Assistant Professor
656-2409
msmalley@nps.edu

Rasmussen, Maria
Associate Professor
656-3673
mrasmussen@nps.edu
Roberts, David
Visiting Professor
656-3191
dcrobert@nps.edu

Stone, Elizabeth
Research Associate
656-7891
elstone@nps.edu

Tuong, Vu
Assistant Professor
656-3655
thvu@nps.edu

Roll, LT Raymond, USN
656-2067
rbroll@nps.edu

Swanland, Brian
Senior Lecturer
656-3952
beswanla@nps.edu

Twomey, Christopher
Assistant Professor
656-3543
ctwomey@nps.edu

Sakoda, Robin
Instructor
656-3168
rhsakoda@nps.edu

Trinkunas, Harold, A
Assistant Professor
656-2863
hatrinku@nps.edu

Yost, David S.
Professor
656-2579
dyost@nps.edu

Salmoni, Barak
Assistant Professor
656-2554
bsalmoni@nps.edu

Tsypkin, Mikhail
Associate Professor
656-2218
mtsypkin@nps.edu
LOCAL ORGANIZING AND CHARITY NETWORKS IN THE ARAB EAST
Anne Marie Baylouny, Assistant Professor
Department of National Security Affairs
Sponsor: Naval Postgraduate School

SUMMARY: Conducted research in the Middle East geared toward the writing and publication of book articles; formulation of new research initiative.

POLITICAL CHANGE, ECONOMIC REFORMS, AND POLITICAL VIOLENCE IN SOUTHEAST ASIA
Auriel Croissant, Assistant Professor
Department of National Security Affairs
Sponsor: Naval Postgraduate School

OBJECTIVE: To write, edit, and publish four books and four to six articles.

SUPPORT OF NAVAL INTELLIGENCE RESEARCH AND EDUCATION
CAPT Timothy J. Doorey, USN, Military Faculty
Department of National Security Affairs
Sponsor: Office of Naval Intelligence

OBJECTIVE: To provide resources for Navy 1630 (Intelligence Officer) research and education; to provide facility support to ensure Navy 1630 student education.

SUBNATIONAL DETERMINANTS OF SECURITY IN LATIN AMERICA
Kent Eaton, Associate Professor
Department of National Security Affairs
Sponsor: Naval Postgraduate School

SUMMARY: Researched and wrote three new articles on the sub-national determinants of security in Latin America, conducted field research in select countries, and developed relationships with future sponsors.

CHEMICAL, BIOLOGICAL, RADIOLOGICAL, AND NUCLEAR JOINT PROJECT MANAGER-INFORMATION SYSTEMS DATA SUPPORT
Thomas H. Johnson, Research Associate Professor
Department of National Security Affairs
Sponsor: SPAWAR Systems Center-San Diego

SUMMARY: Ensured continued support for implementation of the chemical, biological, radiological, and nuclear data model across the Joint Program Executive Office for Chemical Biological Defense in support of the Joint Project Manager-Information Systems, Software Support Activity.

HPAC DATA MODELING
Thomas H. Johnson, Research Associate Professor
Department of National Security Affairs
Sponsor: Defense Threat Reduction Agency

OBJECTIVE: To provide resources and personnel to serve as U.S. delegate to the NATO ATP 45 and Warning Reporting Panel. Tasks will include preparation and participation in formal and informal meetings OCONUS and CONUS.
NATIONAL SECURITY AFFAIRS

JPM-IS JOINT EFFECTS MODEL DATA ACCREDITATION SUPPORT
Thomas H. Johnson, Research Associate Professor
Department of National Security Affairs
Sponsor: Information Systems Joint Program Office

SUMMARY: Continued support of the joint effects model program.

JPM-IS AND SOFTWARE SUPPORT ACTIVITIES CHEMICAL, BIOLOGICAL, RADIOLOGICAL, AND NUCLEAR DATA SUPPORT AND MANAGEMENT
Thomas H. Johnson, Research Associate Professor
Department of National Security Affairs
Sponsor: SPAWAR Systems Center-San Diego

OBJECTIVE: To support the JPM-IS Program Manager and the Joint Program Executive Office for Chemical and Biological Defense Software Support Activities in the formulation and execution of their data program.

MODELING AND SIMULATION OF TERRORIST ACTIVITY
Thomas H. Johnson, Research Associate Professor
Department of National Security Affairs
Sponsor: Joint Warfare Analysis Center

SUMMARY: Conducted a graduate level course during the 2006 spring quarter at the Naval Postgraduate School. The course modeled terrorism, its participants, networks, and organization capabilities. Terrorism and the groups that foment it are at the forefront of concern for policymakers and defense analysis worldwide. This course aimed to contribute to existing scholastic literature.

NATO AND INTERNATIONAL COORDINATION OF CHEMICAL, BIOLOGICAL, RADIOLOGICAL, AND NUCLEAR DATA
Thomas H. Johnson, Research Associate Professor
Department of National Security Affairs
Sponsor: Defense Threat Reduction Agency

OBJECTIVE: The primary goal of the Chemical, Biological, Radiological, and Nuclear (CBRN) data model, which is founded on the NATO Joint Command, Control, and Communication Information Exchange Model, is to eliminate system interoperability failures by mapping legacy CBRN data to a common reference schema.

SHI'A POLITICS AND RELIGIOSITY: LOOKING BACK TO LOOK AHEAD
Abbas Kadhim, Assistant Professor
Department of National Security Affairs
Sponsor: Naval Postgraduate School

OBJECTIVE: Over the next two years, to conduct research to complete and publish one edited volume on the study of Shi'a resurgence, one book manuscript on the formation of the Shi'a school of theology and its current role in the political life in the Middle East, four articles/book chapters, and to develop a new research program on the relationship between Islamic traditional education/schools and social/political activism in post-Saddam Iraq.
COMPARATIVE STRATEGIC CULTURE
Peter R. Lavoy, Assistant Professor
Department of National Security Affairs
Sponsor: Defense Threat Reduction Agency

OBJECTIVE: To review the state of the field of comparative strategic culture by commissioning several experts to produce literature review essays and annotated bibliographies and to conduct a small workshop in Monterey, California.

IDENTIFYING AND ATTRIBUTING RESPONSIBILITY FOR BIOLOGICAL WEAPONS USE
Peter R. Lavoy, Assistant Professor
Department of National Security Affairs
Sponsor: Defense Threat Reduction Agency

OBJECTIVE: To assess the challenges that policymakers and military commanders face in correctly identifying and attributing responsibility for the use of Biological Warfare Agents (BW). Looking at past cases from World War II to the present, four categories of BW use will be examined: actual use of biological weapons, suspected use of biological weapons, claimed use of biological weapons, and natural occurrences of biological outbreaks.

NUCLEAR WEAPONS PROLIFERATION: 2016
Peter R. Lavoy, Assistant Professor
Department of National Security Affairs
Sponsor: National Intelligence Center

SUMMARY: The Principal Investigator and invited subject matter experts examined the conditions, drivers, and warning indicators associated with future cases of nuclear weapons proliferation. This examination took place during a conference at the Naval Postgraduate School in July 2006 and in follow-on activities in support of the sponsoring agency.

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

SUMMARY: The Center for Contemporary Conflict at the Naval Postgraduate School is continuing a multi-year project drawing on civilian and military officials and non-governmental experts from India, Pakistan, and the United States. The goal of the project is to identify practical policy measures the United States and other governments might consider to help reduce the threat from nuclear arsenals and potential Indo-Pakistani hostilities.

STRATEGIC STABILITY IN SOUTH ASIA: U.S. POLICY OPTIONS
Peter R. Lavoy, Assistant Professor
Department of National Security Affairs
Sponsor: Department of Energy

OBJECTIVE: The Naval Postgraduate School Center for Contemporary Conflict (CCC) will conduct a two-year project that will draw on civilian and military officials and non-governmental experts from India, Pakistan, and the United States. The goal is to identify practical policy measures these countries might consider to reduce the threats from nuclear arsenals and potential Indo-Pakistani hostilities. Specifically, the CCC will conduct two workshops (one in New Delhi, India, and the other in Islamabad, Pakistan) and a
conference in Monterey, California, to analyze the key military elements that affect conventional and nuclear deterrence and strategic stability in south Asia.

U.S.-CHINA STRATEGIC DIALOGUE
Peter R. Lavoy, Assistant Professor
Department of National Security Affairs
Sponsor: Defense Threat Reduction Agency

OBJECTIVE: To bring together Chinese and American national security experts for a dialogue on nuclear strategy, arms control, missile defense, and nuclear proliferation in order to improve mutual understanding and reduce the possibility of political or military conflict between China and the United States.

THE U.S.-INDIA GLOBAL PARTNERSHIP: REGIONAL SECURITY IMPLICATIONS
Peter R. Lavoy, Assistant Professor
Department of National Security Affairs
Sponsor: Defense Threat Reduction Agency

OBJECTIVE: To examine potential avenues of cooperation between the United States and India for the global partnership outlined by President George W. Bush and Prime Minister Manmohan Singh on 18 July 2005. This study will explore potential areas of cooperation with India, outline likely implications of such cooperation for other regional actors, assess the broader costs and benefits for U.S. interests, and identify possible policy responses for the United States, both to enhance the global partnership and to minimize potential negative consequences throughout Asia.

WEAPONS OF MASS DESTRUCTION SEMINAR SERIES
Peter R. Lavoy, Assistant Professor
Department of National Security Affairs
Sponsor: Federal Bureau of Investigation

OBJECTIVE: To conduct a series of academic seminars for regional concentrations of Federal Bureau of Investigation agents and associated U.S. government professionals (assistant district attorneys, customs officers, etc.). The topic of the seminars will be related to proliferation of weapons of mass destruction.

DOMESTIC POLITICS AND REGIONAL SECURITY IN SOUTHEAST ASIA
Michael Malley, Assistant Professor
Department of National Security Affairs
Sponsor: Naval Postgraduate School

OBJECTIVE: To write and publish a book and articles; to formulate new research initiatives.

BALANCING STABILITY AND CHANGE: POLITICAL REFORM, ISLAMIC ACTIVISM, AND DEVELOPMENT SCENARIOS FOR PAKISTAN
Vali Nasr, Professor
Peter R. Lavoy, Assistant Professor
Department of National Security Affairs
Sponsor: Naval Engineering Logistics Office

SUMMARY: Examined the key factors that will decide how the Pakistani state and its key actors (military services, civilian parties, Islamic parties, and social forces) will react to the challenge of maintaining
domestic and regional stability while addressing the county's agenda of socioeconomic modernization and political reform.

IRAN: DOMESTIC CHANGE AND REGIONAL CHALLENGES
Vali Nasr, Professor
Department of National Security Affairs
Sponsor: Naval Engineering Logistics Office

SUMMARY: This project examined changes in the Iranian state since 1997, and also the key factors that will decide how the Iranian state and its key actors (military services, senior clerics, social groups, and other decision-makers) will react to regional changes since 2001 and the current confrontation over Iran's nuclear program.

REGIONAL SECURITY EDUCATION PROGRAM
LT Raymond Roll, USN, Military Faculty
Department of National Security Affairs
Sponsor: Naval Postgraduate School

AQ KHAN RELATIONAL DATABASE
James Russell, Senior Lecturer
Department of National Security Affairs
Sponsor: Defense Intelligence Agency

OBJECTIVE: To focus on compiling a relational database on known figures and entities involved in the procurement network of the Pakistani scientist Aq Khan. This network was responsible for spreading technology related to weapons of mass destruction to a variety of different countries over the last decade. Much of the activity went undetected by the intelligence community. All the data from this project will be compiled from open sources.

WEAPONS OF MASS DESTRUCTION PROLIFERATION NETWORKS: MINIMIZING SUPPLY AND DISRUPTING TRANSFER
James Russell, Senior Lecturer
Department of National Security Affairs
Sponsor: Defense Threat Reduction Agency

SUMMARY: Assessed the motivations and techniques employed by supplier and consumer states and non-state actors to buy, sell, and trade weapons of mass destruction information, technology, and components. Examined the organization, techniques, processes, and deception and denial practices of past and current networks involved in the procurement of Weapons of Mass Destruction (WMD) and/or their related technology, expertise, or materials; explored commonalities and differences among networks; assessed whether there have been evolutionary or revolutionary trends over time; and estimated the likely near- and mid-term landscape that policymakers will have to navigate as they cope with combating WMD proliferation.
WEAPONS OF MASS DESTRUCTION PROLIFERATION NETWORKS: THE ROLE OF EUROPEAN SUPPLIERS
James Russell, Senior Lecturer
Department of National Security Affairs
Sponsor: Defense Intelligence Agency

SUMMARY: Assessed the involvement of European industrial suppliers in the proliferation of weapons of mass destruction by both state-and non-state actors; produced a report and briefing for the sponsor on this issue to inform their efforts in targeting proliferation problems; this project involved travel to Europe by the Principal Investigator for field research and liaison with European government officials involved in export controls and weapons of mass destruction counter-proliferation policies.

RUSSIAN-AMERICAN STUDY GROUP ON STRATEGIC CRISIS MANAGEMENT
Mikhail Tsypkin, Associate Professor
Department of National Security Affairs
Sponsor: Defense Threat Reduction Agency

SUMMARY: During fiscal year 2006, this bilateral research effort expanded its previous scope of work to explore the core aspects of the U.S.-Russian strategic relationship, with the primary focus of moving away from mutual assured destruction and cooperation in countering international terrorism.

U.S.-RUSSIAN COOPERATION IN STRATEGIC CRISIS MANAGEMENT
Mikhail Tsypkin, Associate Professor
Department of National Security Affairs
Sponsor: Defense Threat Reduction Agency

OBJECTIVE: To enhance U.S.-Russian cooperation in strategic crisis management.

CASE STUDIES ON MILITARY DOCTRINE AND MISPERCEPTION
Christopher Twomey, Assistant Professor
Department of National Security Affairs
Sponsor: Naval Postgraduate School

SUMMARY: Began revisions and additional cases for a book manuscript, submitted a book proposal, wrote an article-length version of the same, and developed relationships with future sponsors.

U.S.-CHINA STRATEGIC DIALOGUE, PHASE II
Christopher Twomey, Assistant Professor
Department of National Security Affairs
Sponsor: Defense Threat Reduction Agency

OBJECTIVE: To continue a track two dialogue on Sino-American strategic nuclear issues in order to improve mutual understanding and reduce the possibility of political or military conflict between China and the United States.
STATE AND CIVIL SOCIETY IN SOUTHEAST ASIA
Tuong Vu, Assistant Professor
Department of National Security Affairs
Sponsor: Naval Postgraduate School

OBJECTIVE: To complete and publish one edited volume on the study of Southeast Asian politics, one book manuscript on state formation and post-colonial transformation in Pacific Asia, four articles/book chapters on economic reform and political instability in Indonesia and Vietnam, and to develop a new research program on the relationship between Islamic education/schools and political activism in Southeast Asia.

ARMS CONTROL FUTURE ISSUES
James J. Wirtz, Professor
Department of National Security Affairs
Sponsor: Strategic Systems Programs

SUMMARY: To continue a track two dialogue on Sino-American strategic nuclear issues in order to improve mutual understanding and reduce the possibility of political or military conflict between China and the United States.

REMOTE SENSING TECHNOLOGIES AND TECHNIQUES
James J. Wirtz, Professor
Department of National Security Affairs
Sponsor: Department of Energy, NNSA Service Center

STRATEGY IN THE CONTEMPORARY WORLD
James J. Wirtz, Professor
Department of National Security Affairs
Sponsor: Defense Threat Reduction Agency

OBJECTIVE: To host a workshop to explore issues of current strategic, academic, and policy interest (the original study was undertaken in fiscal year 2000); and to hold a small workshop attended by an international team of scholars and selected policymakers to address issues of strategy in the contemporary world.

SENIOR RESEARCH FELLOW, NATO DEFENSE COLLEGE
David S. Yost, Professor
Department of National Security Affairs
Sponsor: Office of the Secretary of Defense

SUMMARY: Naval Postgraduate School Professor David S. Yost will be detailed to the NATO Defense College in Rome as a Senior Research Fellow from 1 October 2004 through 30 September 2007. This arrangement may be extended for an additional period of time upon mutual agreement from both parties.
DEPARTMENT OF NATIONAL SECURITY AFFAIRS

2006 Faculty Publications and Presentations
PUBLICATIONS


BOOKS


BOOK CHAPTERS


GRADUATE SCHOOL OF OPERATIONAL AND INFORMATION SCIENCES

PAUL STOCKTON
DEAN
DEPARTMENT OF
COMPUTER SCIENCE

PETER J. DENNING
CHAIRMAN
OVERVIEW:

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, doctor of philosophy, or master of computing technology. The requirements to complete either program are rigorous and comparable to those of other major universities.

CURRICULA SERVED:

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

DEGREES GRANTED:

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

RESEARCH THRUSTS AND FACULTY EXPERTISE:

Software Engineering:
Professor Valdis Berzins, Professor Ted Lewis, Professor Luqi, Associate Professor Mikhail Auguston, Associate Professor Doron Drusinsky, Associate Professor J. Bret Michael, Associate Professor Man-Tak Shing, Senior Lecturer Loren Peitso, and Visiting Professor Richard Riehle

Databases:
Associate Professor C.T. Otani and Research Associate Arijit Das

Information Security:
Professor Cynthia E. Irvine, Associate Professor George Dinolt, Research Associate Professor Karen Burke, Research Associate Professor William Murray, Research Associate Paul Clark, Lecturer Scott Cote, Senior Lecturer Chris Eagle, Lecturer J.D. Fulp, and Senior Lecturer Daniel Warren, Research Associate Thuy Nguyen, Research Associate Tim Vidas, Research Associate Charles Prince

Autonomous Systems:
Professor Neil Rowe, Associate Professor Chris Darken, Associate Professor Craig Martell, Assistant Professor Mathias Kolsch, and Assistant Professor Kevin Squire, Research Associate Tad Masek

MOVES Institute (Modeling, Virtual Environments, and Simulation):
Associate Professor Rudy Darken, Assistant Professor Amelia Sadagic, Lecturer Eric Bachmann, Senior Lecturer John Falby, Lecturer Perry McDowell, Military Faculty CDR Joseph Sullivan, and Research Professor John Hiles

Networks:
Professor Gurminder Singh, Associate Professor G. M. Lundy, Associate Professor Geoffrey Xie, and Research Associate John Gibson
**Programming Languages:**
Associate Professor Dennis Volpano

**RESEARCH FACILITIES:**
Computer Science Learning Resource Center; Introductory Computer Security Laboratory; Computer Information Security Laboratory; Public Key Infrastructure Laboratory; Introductory PC Network Laboratory; Intermediate Local Area Network Laboratory; Wireless and Mobile Computing Laboratory; Autonomous Robotics Coordination Laboratory; Software Engineering Laboratory; Modeling, Virtual Environments, and Simulation (MOVES) Institute

**RESEARCH CENTERS:**
Center for Information Security (INFOSEC) Studies and Research (CISR) Software Engineering Center

**RESEARCH PROGRAM (Research and Academic)-FY2006:**
The Naval Postgraduate School's sponsored program exceeded $81 million in FY2006. Sponsored programs include 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:

Size of Program: $3.7M
<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Office</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auguston, Mikhail</td>
<td>Associate Professor</td>
<td>831-656-2607</td>
<td><a href="mailto:maugusto@nps.edu">maugusto@nps.edu</a></td>
</tr>
<tr>
<td>Dinolt, George</td>
<td>Associate Professor</td>
<td>656-3889</td>
<td><a href="mailto:gwdinolt@nps.edu">gwdinolt@nps.edu</a></td>
</tr>
<tr>
<td>Irvine, Cynthia</td>
<td>Professor</td>
<td></td>
<td><a href="mailto:irvine@nps.edu">irvine@nps.edu</a></td>
</tr>
<tr>
<td>Bachmann, Eric</td>
<td>Research Assistant Professor</td>
<td>656-2168</td>
<td><a href="mailto:ddrusins@nps.edu">ddrusins@nps.edu</a></td>
</tr>
<tr>
<td>Berzins, Valdis</td>
<td>Professor</td>
<td>656-2601</td>
<td><a href="mailto:eceagle@nps.edu">eceagle@nps.edu</a></td>
</tr>
<tr>
<td>Blackman, Eric</td>
<td>Research Assistant Professor</td>
<td>656-3922</td>
<td><a href="mailto:kfblackman@nps.edu">kfblackman@nps.edu</a></td>
</tr>
<tr>
<td>Dinolt, George</td>
<td>Associate Professor</td>
<td>656-3889</td>
<td><a href="mailto:gwdinolt@nps.edu">gwdinolt@nps.edu</a></td>
</tr>
<tr>
<td>Irvine, Cynthia</td>
<td>Professor</td>
<td>656-2603</td>
<td><a href="mailto:pjd@nps.edu">pjd@nps.edu</a></td>
</tr>
<tr>
<td>Berzins, Valdis</td>
<td>Professor</td>
<td>656-2601</td>
<td><a href="mailto:eceagle@nps.edu">eceagle@nps.edu</a></td>
</tr>
<tr>
<td>Falby, John</td>
<td>Senior Lecturer</td>
<td>656-3390</td>
<td><a href="mailto:falby@nps.edu">falby@nps.edu</a></td>
</tr>
<tr>
<td>Falby, John</td>
<td>Senior Lecturer</td>
<td>656-3390</td>
<td><a href="mailto:falby@nps.edu">falby@nps.edu</a></td>
</tr>
<tr>
<td>New, John</td>
<td>Senior Lecturer</td>
<td>656-3390</td>
<td><a href="mailto:falby@nps.edu">falby@nps.edu</a></td>
</tr>
<tr>
<td>Clark, Paul</td>
<td>Research Associate</td>
<td>656-2395</td>
<td><a href="mailto:jdfulp@nps.edu">jdfulp@nps.edu</a></td>
</tr>
<tr>
<td>Clark, Paul</td>
<td>Research Associate</td>
<td>656-2395</td>
<td><a href="mailto:jdfulp@nps.edu">jdfulp@nps.edu</a></td>
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<td>656-2395</td>
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<td>Research Associate</td>
<td>656-2395</td>
<td><a href="mailto:jdfulp@nps.edu">jdfulp@nps.edu</a></td>
</tr>
<tr>
<td>Cote, Richard</td>
<td>Lecturer</td>
<td>656-2519</td>
<td><a href="mailto:rscote@nps.edu">rscote@nps.edu</a></td>
</tr>
<tr>
<td>Cote, Richard</td>
<td>Lecturer</td>
<td>656-2519</td>
<td><a href="mailto:rscote@nps.edu">rscote@nps.edu</a></td>
</tr>
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<td>Lecturer</td>
<td>656-2519</td>
<td><a href="mailto:rscote@nps.edu">rscote@nps.edu</a></td>
</tr>
<tr>
<td>Darken, Christian</td>
<td>Research Associate</td>
<td>656-2095</td>
<td><a href="mailto:cjdarken@nps.edu">cjdarken@nps.edu</a></td>
</tr>
<tr>
<td>Darken, Christian</td>
<td>Research Associate</td>
<td>656-2095</td>
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<td>656-2095</td>
<td><a href="mailto:cjdarken@nps.edu">cjdarken@nps.edu</a></td>
</tr>
<tr>
<td>Darken, Rudolph</td>
<td>Associate Professor</td>
<td>656-7588</td>
<td><a href="mailto:jhgarfin@nps.edu">jhgarfin@nps.edu</a></td>
</tr>
<tr>
<td>Darken, Rudolph</td>
<td>Associate Professor</td>
<td>656-7588</td>
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<td><a href="mailto:jhgarfin@nps.edu">jhgarfin@nps.edu</a></td>
</tr>
<tr>
<td>Das, Arjit</td>
<td>Research Associate</td>
<td>656-3970</td>
<td><a href="mailto:adas@nps.edu">adas@nps.edu</a></td>
</tr>
<tr>
<td>Das, Arjit</td>
<td>Research Associate</td>
<td>656-3970</td>
<td><a href="mailto:adas@nps.edu">adas@nps.edu</a></td>
</tr>
<tr>
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<tr>
<td>Michael, James Bret</td>
<td>Associate Professor</td>
<td>656-2655</td>
<td><a href="mailto:bmichael@nps.edu">bmichael@nps.edu</a></td>
</tr>
<tr>
<td>Prince, Charles</td>
<td>Research Associate</td>
<td>656-2073</td>
<td><a href="mailto:cdprince@nps.edu">cdprince@nps.edu</a></td>
</tr>
<tr>
<td>Squire, Kevin</td>
<td>Assistant Professor</td>
<td>656-2509</td>
<td><a href="mailto:kmsquire@nps.edu">kmsquire@nps.edu</a></td>
</tr>
<tr>
<td>Miller, Donna</td>
<td>Research Associate</td>
<td>656-2476</td>
<td><a href="mailto:dmliller@nps.edu">dmliller@nps.edu</a></td>
</tr>
<tr>
<td>Riehle, Richard</td>
<td>Visiting Professor</td>
<td>656-3316</td>
<td><a href="mailto:rdriehle@nps.edu">rdriehle@nps.edu</a></td>
</tr>
<tr>
<td>Vidas, Timothy</td>
<td>Research Associate</td>
<td>656-2025</td>
<td><a href="mailto:tmvidas@nps.edu">tmvidas@nps.edu</a></td>
</tr>
<tr>
<td>Murray, William</td>
<td>Research Associate Professor</td>
<td>656-2830</td>
<td><a href="mailto:whmurray@nps.edu">whmurray@nps.edu</a></td>
</tr>
<tr>
<td>Rowe, Neil</td>
<td>Professor and Associate Chairman for Research</td>
<td>656-2462</td>
<td><a href="mailto:ncrowe@nps.edu">ncrowe@nps.edu</a></td>
</tr>
<tr>
<td>Volpano, Dennis</td>
<td>Assistant Professor</td>
<td>656-3091</td>
<td><a href="mailto:volpano@nps.edu">volpano@nps.edu</a></td>
</tr>
<tr>
<td>Nguyen, Thuy</td>
<td>Research Associate</td>
<td>656-3989</td>
<td><a href="mailto:tdnguyen@nps.edu">tdnguyen@nps.edu</a></td>
</tr>
<tr>
<td>Shiflett, Dave</td>
<td>Research Associate</td>
<td>656-407</td>
<td><a href="mailto:shifflett@nps.edu">shifflett@nps.edu</a></td>
</tr>
<tr>
<td>Warren, Daniel</td>
<td>Senior Lecturer</td>
<td>656-2353</td>
<td><a href="mailto:warren@nps.edu">warren@nps.edu</a></td>
</tr>
<tr>
<td>Otani, C. Thomas</td>
<td>Associate Professor and Associate Chairman for Academic Affairs</td>
<td>656-3391</td>
<td><a href="mailto:ctwu@nps.edu">ctwu@nps.edu</a></td>
</tr>
<tr>
<td>Shing, Man-Tak</td>
<td>Associate Professor</td>
<td>656-2634</td>
<td><a href="mailto:mantak@nps.edu">mantak@nps.edu</a></td>
</tr>
<tr>
<td>Xie, Geoffrey</td>
<td>Assistant Professor</td>
<td>656-2693</td>
<td><a href="mailto:xie@nps.edu">xie@nps.edu</a></td>
</tr>
<tr>
<td>Peitso, Loren</td>
<td>Senior Lecturer and Associate Chair for Admin</td>
<td>656-3009</td>
<td><a href="mailto:lepeitso@nps.edu">lepeitso@nps.edu</a></td>
</tr>
<tr>
<td>Singh, Gurminder</td>
<td>Professor</td>
<td>656-3041</td>
<td><a href="mailto:gsingh@nps.edu">gsingh@nps.edu</a></td>
</tr>
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AUTOMATIC GENERATION OF SOFTWARE WRAPPERS
Valdis Berzins, Professor
Department of Computer Science
Sponsor: Tank Automotive Research, Development, and Engineering Center

OBJECTIVE: To develop and demonstrate a methodology for automatic generation of software wrappers to simplify development of distributed, embedded, and real-time system software modules. In order to improve the software development picture, places where the process can be automated must be identified. Automatically generated wrappers will allow insertion of modules into a prototyping environment. Automatic generation of the wrappers will enhance the development environment by reducing rote work and producing consistently-behaving module interfaces.

COMMON SOFTWARE ARCHITECTURES FOR GROUND-BASED MILITARY VEHICLE SYSTEMS
Valdis Berzins, Professor
Department of Computer Science
Sponsor: U.S. Army Tank-Automotive and Armaments Command

OBJECTIVE: To define a common software architecture/product line for ground-based military vehicle systems. To improve development, the right technology mix is needed in the areas of common software (embedded with common architecture), vehicle electronics (vetronics), and data-bus capability. The principal investigator will focus on the establishment of real-time requirements for SOS COE, operating system and hardware, investigation into best hardware solution for real-time control and the appropriate protocol for real-time control, and estimates of key OS and SOS COE timing in the proposal.

DEPENDABLE SOFTWARE ARCHITECTURE BASED ON QUANTIFIABLE COMPOSITIONAL MODEL
Valdis Berzins, Professor
Department of Computer Science
Sponsor: Air Force Office of Scientific Research

OBJECTIVE: To create new architecting methods to enable quantifiable architectural synthesis for dependable systems of systems. With the aim of improving software flexibility and ensuring dependability of the resultant systems, quantifiable architecture is the crucial abstraction stratum that bridges the great gap between software requirements and system implementation. An effective and practical quantifiable compositional model will be deeply studied. The Quantifiable Compositional Model defines compositional patterns associated with quantifiable constraints. This creates a formal foundation for establishing and binding precise metrics to computational activities and compositional interconnections, so that quantitative assessment can be automatically done at the architectural level.

ESTABLISH/MAINTAIN SOFTWARE ENGINEERING TEST LABORATORY
Valdis Berzins, Professor
Department of Computer Science
Sponsor: Joint Information Operations Center

SUMMARY: Established a lab for the purpose of stress testing real Department of Defense 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 ISP to enable the testing of different access configurations and to allow for outside entities to red term the systems. This lab was used to evaluate multiple different DoD systems over the years.
COMPUTER SCIENCE

NAVY CERTIFIER PROGRAM-PHASE IV
Karen Burke, Research Associate Professor
Department of Computer Science
Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: To increase the capability of the Navy's information assurance program in the area of systems certification. This program is subdivided into three tasks: 1) update and publish the course materials prior to instructing the course, 2) organize the attendees and arrange facilities for each class offering, and 3) teach the course at Fleet Concentration Centers, one on the east coast, one on the west coast, two overseas, and in Stafford, Virginia. This phase furthers the Navy Certifier Education Program.

ARTIFICIAL INTELLIGENCE FOR INDIVIDUAL COMBATANT SIMULATION
Christian Darken, Assistant Professor
Department of Computer Science
Sponsor: TRADOC Analysis Center-Monterey

OBJECTIVE: To investigate solutions to limitations in the current capability to develop Artificial Intelligence for simulated individual combatants.

GAMING THE SEGWAY CENTAUR
Christian Darken, Assistant Professor
Department of Computer Science
Sponsor: U.S. Army Rapid Equipping Force

OBJECTIVE: To model and simulate the Segway Centaur in the DELTA3D simulation/game engine in order to support analysis of how it could affect the operations of an infantry squad.

INTELLIGENT SOFTWARE AGENTS FOR MILITARY MODELING AND SIMULATION
Christian Darken, Assistant Professor
Department of Computer Science
Sponsor: Chief of Naval Operations

OBJECTIVE: To develop new intelligent software agent technologies in support of military modeling and simulation. Both entirely novel capabilities (such as learning) and novel adaptations of existing technologies to the military modeling and simulation domain will be developed.

MPESS: ANALYSIS OF ALTERNATIVE CONCEPTS FOR FUTURE ARMY MODELING AND SIMULATION STRATEGY
Christian Darken, Assistant Professor
Department of Computer Science
Sponsor: TRADOC Analysis Center-Monterey

OBJECTIVE: To support the Army's MPESS project by providing expert consultation, and developing alternative concepts for future Army modeling and simulation strategy and requirements for conceptual and data exchange models.
UNDERSTANDING OF REMOTE AUTHENTICATION AND IDENTIFICATION OF AUTHORIZED PARTIES ACROSS A NETWORK ENVIRONMENT
George Dinolt, Associate Professor
Department of Computer Science
Sponsor: National Security Agency

SUMMARY: Supported the National Security Agency (NSA) R22 to addresses “hard problems” in authentication. The principal investigator was on site at the NSA during fall 2006 to provide additional support as needed.

Z-EVES THESIS SUPPORT
George Dinolt, Associate Professor
Department of Computer Science
Sponsor: National Security Agency

OBJECTIVE: The Master’s thesis prepared by Annette Torrence (civilian) will follow-on to the work she did as part of her internship at the National Security Agency (NSA) R2. The NSA will fund travel for both the student and the principal investigator (PI), a small amount of the PI’s time, and some equipment in support of the project.

ANALYSIS OF MALICIOUS SOFTWARE COMPONENTS
Christopher Eagle, Senior Lecturer
Department of Computer Science
Sponsor: Naval Criminal Investigative Service

OBJECTIVE: To provide analysis of actual malicious software components discovered during the course of real world computer forensics investigations.

DEVELOPMENT OF WINDOWS RAM FORENSICS ANALYSIS TECHNIQUES
Christopher Eagle, Senior Lecturer
Department of Computer Science
Sponsor: Naval Criminal Investigative Service

OBJECTIVE: To advance the current state of the art in RAM forensics, specifically as applied to computers utilizing the Microsoft Windows NT family of operating systems.

INVESTIGATION OF SOFTWARE TAMPER PROTECTION MECHANISMS
Christopher Eagle, Senior Lecturer
George Dinolt, Associate Professor
Department of Computer Science
Sponsor: Air Force Research Laboratory

OBJECTIVE: To demonstrate techniques and develop tools for defeating anti-tamper mechanisms in sponsor-provided software programs. The measure of effectiveness of each anti-tamper protocol will be generated, summarizing the skills and experience level required to bypass each protection mechanism. The principal investigators will provide quarterly reports to the sponsor, which may include a training session to enhance the internal capabilities of the sponsor.
OBJECTIVE: The primary objective of sensor network research as part of COASTS is to undertake a system level test of Crossbow integrated sensor and IP cameras to assess the network capability to detect, classify and track anomalous events.

SUMMARY: The main focus of this project is to detect, classify and track vehicular traffic. However testing will be carried out to determine the feasibility to employ the network for water-borne and dismounted pedestrian applications. The principal research consists of a system-level test and evaluation of a prototyped sensor-camera network.

THESES DIRECTED:


ORGANIZATION AND CONDUCT OF RED AND WHITE TEAM SUPPORT FOR TWO CYBER DEFENSE EXERCISES

OBJECTIVE: To arrange for White (i.e., refereeing) and Red (i.e., computer/network attack) Team support for two inter-service academy cyber-defense exercises that will take place during calendar years 2005 and 2006. The principal investigators will utilize their own experience from participation in three previous exercises, along with contracted support from Cdxpers, Inc. and various Department of Defense vulnerability assessment organizations, to plan, organize, and execute the myriad White and Red Team activities that are necessary to conduct graded cyber-attack/defend exercises.

LINK 16 RULE SET VERIFICATION

OBJECTIVE: To assemble and direct a student research team to investigate the NCTSI requirement to evaluate the Link-16 interface-protocol rule-set (Ref. NCTSI RFP, November 2005). The project will identify resources available to test the implementation of the communications protocols, and develop a test methodology and strategy to accomplish testing of those protocols with minimal duplication of effort across Department of Defense activities.
ANALYSES FOR SECURE WIRELESS FEDERAL AVIATION ADMINISTRATION INFRASTRUCTURE  
Cynthia E. Irvine, Professor  
Timothy Levin, Research Associate Professor  
Department of Computer Science  
Sponsor: Federal Aviation Administration

ANALYSIS OF SEPARATION KERNEL-BASED SECURITY ARCHITECTURES  
Cynthia E. Irvine, Professor  
Department of Computer Science  
Sponsor: National Security Agency

OBJECTIVE: To analyze the security properties of various system architectures that utilize separation kernels. The analysis will examine the National Security Agency’s guideline for such architectures with respect to fundamental computer security principles, published system architectures, and similar guidelines and requirements produced by other organizations.

ANALYSIS OF XML SECURITY LABELS FOR CONTROL OF ACCESS TO SENSITIVE INFORMATION  
Cynthia E. Irvine, Professor  
Timothy Levin, Research Associate Professor  
Department of Computer Science  
Sponsor: North Atlantic Treaty Organization

OBJECTIVE: To analyze the use of XML meta-data for highly effective control of access to sensitive information. The analysis will examine a proposal for XMML-security label syntax and processing with respect to fundamental computer and communications security principles, as well as to similar activities recently undertaken by other organizations.

CT-T: COLLABORATIVE RESEARCH-ADAPTIVE SECURITY AND SEPARATION IN RECONFIGURABLE HARDWARE  
Cynthia E. Irvine, Professor  
Department of Computer Science  
Sponsor: National Science Foundation

OBJECTIVE: Embedded devices control everything from the cell-phones in our pockets to the anti-lock brakes in our cars. Many of these devices are implemented in reconfigurable hardware, which offers the high performance and deterministic timing of traditional asics, combined with the re-programmability of software. The goal of this research is to enhance the logistical structure and internal management of reconfigurable hardware to enforce a dynamic information protection policy with a high degree of assurance.

DEPARTMENT OF DEFENSE INFORMATION ASSURANCE SCHOLARS  
Cynthia E. Irvine, Professor  
Department of Computer Science  
Sponsor: National Security Agency

OBJECTIVE: To support student research and studies in information assurance. This work will be conducted as part of the information assurance scholarship program. Faculty and staff in the Center for Information Systems Security Studies and Research at the Naval Postgraduate School will provide student participants with guidance and material support relating to prerequisite studies and research leading to Master’s and Ph.D. degrees in computer science.
EXTENDED CYBERCIEGE-NCASSR PHASE III
Cynthia E. Irvine, Professor
Department of Computer Science
Sponsor: Office of Naval Research

SUMMARY: CyberCIEGE is an innovative computer-based tool used to teach network security concepts. CyberCIEGE enhances information assurance education and training through the use of computer gaming techniques. In the CyberCIEGE virtual world, users spend virtual money to operate and defend their networks, and can watch the consequences of their choices, while under attack. The purpose of this proposal is to address needed extensions to CyberCIEGE, drawing heavily upon the expertise at PNNL, the Naval Postgraduate School, and the student interns of the NSF Scholarship for Service Program.

GLOBAL INFORMATION GRID SECURITY SUPPORT
Cynthia E. Irvine, Professor
Department of Computer Science
Sponsor: National Security Agency

OBJECTIVE: To support the National Security Agency in its mission to provide information security and assurance guidance for the design, development, and rollout of the Global Information Grid.

HIGH ASSURANCE ARTIFACT DISTRIBUTION PROCEDURES AND APPLICATION OF SEPARATION KERNELS
Cynthia E. Irvine, Professor
Department of Computer Science
Sponsor: Space and Naval Warfare Systems Command

SUMMARY: The U.S. Navy has requirements to separate and manage information according to its sensitivity. To this end, several efforts are underway to develop components for composition into systems meeting requirements for environments that require high robustness. A problem faced by the developers of these components is the lack of a worked example for a high assurance development framework. The Trusted Computing Exemplar (TCX) project has developed such a framework. This research investigated the development of procedures for the near-term manual distribution of TCX artifacts. In addition, this research involved further investigation of multilevel applications, cross domain solutions, and technical exchange.

HIGH ASSURANCE PLATFORM SECURITY SUPPORT: PHASE II
Cynthia E. Irvine, Professor
Department of Computer Science
Sponsor: National Security Agency

OBJECTIVE: To support the National Security Agency in its mission to provide information security and assurance studies and guidance for the design, development, and rollout of high assurance components in support of its long-term vision for networked systems. For the purposes of this research, the work is divided into three tasks: 1) separation kernel protection profile support, 2) application platform protection support, and 3) studies of hardware support for establishing and maintaining secure state.
OBJECTIVE: To provide Masters-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: As of December 2006, the NPS CISR SFS program has graduated over 50 Federal Cyber Corps scholarship recipients. Graduates of the program have acquired positions in the Federal sector, with jobs at the National Security Agency (NSA), Space and Naval Warfare Systems Command (SPAWAR), Federal Deposit Insurance Corporation (FDIC), the Department of Housing and Urban Development (HUD), Defense Manpower Data Center (DMDC), Naval Research Lab (NRL), National Criminal Intelligence Service (NCIS), Central Intelligence Agency (CIA), and Sandia National Laboratory.

To date, the Center for Information Systems Security Studies and Research (CISR) at NPS has been successful in placing 100% of all its SFS graduates into OPM approved positions. Many students have also completed 3-6 month internships with approved agencies.

CONFERENCE PUBLICATIONS:


PRESENTATIONS:

Irvine, C.E., “What Might We Mean by 'Secure Code' and How Might We Teach What We Mean?” Workshop on Secure Software Engineering Education and Training, Oahu, Hawaii, April 2006.

THESES SUPPORTED:


LAB ENHANCEMENT AND MULTIPLAYER SCENARIO DEFINITION FOR CYBERCIEGE
Cynthia E. Irvine, Professor
Department of Computer Science
Sponsor: Office of the Secretary of Defense, National Security Agency – Executive Agent

OBJECTIVE: This effort was intended to begin work on a new version of an innovative information assurance teaching tool. In a novel approach to information assurance education, the Naval Postgraduate School and Rivermind, Inc. have developed CyberCIEGE, a resource management game focused on information security. The current version of CyberCIEGE reflects a wide range of information assurance topics; however, a multiplayer version of the tool would allow students to learn how adversaries test systems for vulnerabilities. This would make CyberCIEGE an even more effective tool for teaching information assurance concepts at both the undergraduate and graduate levels.

SUMMARY: The Draft Specification of the Multi-Player version of CyberCIEGE was completed. A user interface definition for the Multi-Player version was completed; and level of effort estimates for a Multi-Player version of CyberCIEGE were established. In conjunction with the specification effort, the existing version of CyberCIEGE was iteratively refined to make it more suitable for a multiplayer environment.

In January 2006, a hands-on CyberCIEGE workshop as part of the Seventh Workshop on Education In Computer Security (WECS) was conducted. Workshop attendees explored CyberCIEGE scenarios and utilized the Scenario Development Tool to construct their own scenarios. This exercise provided substantial feedback from first hand observation of interaction with the tool by a range of players. This lead to a number of interface enhancements including:

- Players can now get immediate refunds on physical security purchases, allowing player to test effects of different security settings without incurring costs.
- Double-click on user or computer in USER or COMPONENT screen transfers to OFFICE screen with the item selected entity. When placing computers, highlight invalid workspaces in red.
- Add zoom and height information to selectable camera positions so relative movement from those positions is smooth.
- Drag and drop components instead of scrap and repurchase.
- Simplified filters interface.
- Clicking on zone maps in the ZONE screen now selects the corresponding zone.
- In the NETWORK screen, when a component is selected, the network buttons of attached networks are depressed. Removed the confusing plug icon from the NETWORK screen.
- Add help tips for buttons and window panes, activated by hovering or right click.
- Add summary of current cash to the COMPONENT and ZONE screens.
- Make training purchase per selected user rather than for each user and restore pop up summary of what has just been purchased.

Research was conducted to demonstrate how CyberCIEGE could be used to meet requirements for user awareness of basic concepts in Information Assurance (IA). The Department of Defense (DOD) addressed the idea of user awareness in DOD Directive 8750.1. Two CyberCIEGE campaigns were created: one for basic user awareness, and a second that emphasizes skill application and problem solving, and is intended for technical users and addresses more advanced concepts and technical considerations.
An investigation of assessment strategies for educational games and, in particular, virtual world-based simulations was conducted. It was evident that analysis of the effectiveness of games is in its infancy; however, some work is beginning to show that games offer an effective alternative to or supplement for more traditional modes of education. For example, through the use of virtual worlds, games provide a concrete experience within which students can internalize domain-specific concepts. Student's critical thinking skills are honed. In addition, the game format appeals to students with short attention spans.

PUBLICATION:

THESIS DIRECTED:

SOFTWARE PRODUCTS:
CyberCIEGE: Information Assurance Training Tool, Version 1.7c.

**LIGHTWEIGHT FORMAL METHODS FOR SOFTWARE SECURITY TESTING AUTOMATION**

Cynthia E. Irvine, Professor
Department of Computer Science
Sponsor: Office of Naval Research

**SUMMARY:** Testing is a significant element in the production of high assurance systems. Yet current testing technologies are labor intensive and lack a formal basis, and comprehensive testing can seriously impede the time to market of new products. To address these problems, researchers propose to develop automated tools for software security testing.

**MODELING FEDERAL AVIATION ADMINISTRATION INFORMATION ASSURANCE USING CYBERCIEGE**

Cynthia E. Irvine, Professor
Department of Computer Science
Sponsor: Federal Aviation Administration

**OBJECTIVE:** To build a set of CyberCIEGE scenarios customized for exploring and demonstrating the effects of security choices within the Federal Aviation Administration (FAA) information technology (IT) infrastructure. Information assurance issues and characteristics particular to the FAA infrastructure and that remain suitable for representation in such a model will be identified.

**MULTILEVEL PRINT SERVER, PHASE II: REQUIREMENTS FOR COMMON CRITERIA V3.0**

Cynthia E. Irvine, Professor
Department of Computer Science
Sponsor: Space and Naval Warfare Systems Command

**SUMMARY:** The U.S. Navy has requirements to separate information according to its sensitivity. Currently, there is no high assurance facility to ensure that print jobs in a multilevel environment are appropriately separated and marked. To address this problem, a multilevel print server (MLPS) that will
mark documents through the use of separation pages is needed. A protection profile sketch intended to be an initial requirements document for the MLPS was completed in June 2005. It was based on Version 2.2 of the common criteria. This research will update the MLPS protection profile sketch to Version 3.0, Rev 2 of the common criteria and provide initial security target analysis.

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

OBJECTIVE: 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: As of December 2006, the NPS CISR SFS program has graduated over 50 Federal Cyber Corps scholarship recipients. Graduates of the program have acquired positions in the Federal sector, with jobs at the National Security Agency (NSA), Space and Naval Warfare Systems Command (SPAWAR), Federal Deposit Insurance Corporation (FDIC), the Department of Housing and Urban Development (HUD), Defense Manpower Data Center (DMDC), Naval Research Lab (NRL), National Criminal Intelligence Service (NCIS), Central Intelligence Agency (CIA), and Sandia National Laboratory.

To date, the Center for Information Systems Security Studies and Research (CISR) at NPS has been successful in placing 100% of all its SFS graduates into OPM approved positions. Many students have also completed 3-6 month internships with approved agencies.

CONFERENCE PUBLICATIONS:


PRESENTATIONS:


Irvine, C.E., “What Might We Mean by 'Secure Code' and How Might We Teach What We Mean?” Workshop on Secure Software Engineering Education and Training, Oahu, Hawaii, April 2006.

THESES SUPPORTED:


PHASE III: HIGH ASSURANCE TESTBED FOR MULTILEVEL INTEROPERABILITY

Cynthia E. Irvine, Professor
Department of Computer Science
Sponsor: National Reconnaissance Office

OBJECTIVE: To demonstrate how U.S. participants can use a single workstation for multilevel access to U.S. and coalition WANS at different classification levels. In 2004 and 2005, a testbed for a multilevel secure LAN/WAN architecture that combines protection against cyber attack with a hardened foundation for coalition operations was created. Currently, the testbed supports experimentation with access to multilevel as well as multiple single level networks. It supports commercial office productivity applications in the context of high assurance multilevel security. The effort in 2006 was to further design and develop prototype high assurance services. This work will include the evaluation and integration of low assurance multilevel components, as well as the development of additional high assurance components and mechanisms.

SUMMARY: The multilevel testbed has matured significantly during this reporting period. A full set of repeatable performance regression tests has been completed along with a set of preliminary performance tests. Testbed integration and configuration management processes are now being regularly followed. Integration included incorporation of the NRL Multilevel Chat application as well as VOIP via Skype and Breeze for preliminary examination of voice and other multimedia technologies. Work on the MYSEA server included development of a Remote Application Service, enhancements for more robust application support, and web-based access to server-located the file system via WebDAV.

The first stage of an effort to integrate Dynamic Security Services (DSS) into the testbed has been completed with the incorporation of Linux-based DSS gateways in the system-high segment of the network. In addition, the DSS policy editor was re-engineered for use in the testbed.

PUBLICATION:


CONFERENCE PUBLICATIONS:


PRESENTATION:


THESES DIRECTED:


SECURECORE FOR TRUSTWORTHY COMMODITY COMPUTING AND
COMMUNICATIONS
Cynthia E. Irvine, Professor
Department of Computer Science
Sponsor: National Science Foundation

OBJECTIVE: The Securecore project will investigate a minimal set of architectural and functional features required for trustworthy operation of mobile computing devices. It uses three target platforms to span a range of security requirements and design constraints: pocket devices (e.g., contact-less smart card), secure embedded systems (e.g., computer in a heart monitor), and mobile computing devices (e.g., handheld web-enabled computer). A clean-slate design will be used to achieve suitable levels of security, synergistically integrating the design of the three key components at the heart of modern, mobile-computing platforms: the processor hardware, the operating system kernel software, and the networking interface. The goal is to achieve security without compromising performance, size, cost, or energy consumption. A new, systematic analysis of integrated security requirements, design, and architecture for a secure core will be provided, and experiments and prototypes will be developed to demonstrate the types and levels of security achievable for commodity platforms using this secure core.

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

OBJECTIVE: To support development of high robustness common criteria protection profiles for two targets of evaluation (TOE): one will be a High Assurance Platform (HAP) and the other a High Assurance Separation Kernel (SK). Work will include analysis of the policies and requirements for these categories of TOE. The SKPP protection profile will be applicable to a category of separation kernels, including the trusted computing exemplar and real-time separation kernels. In addition, this work will provide insight into the development of medium robustness protection profiles for HAPs and SKs. The first phase of this research produced a preliminary draft protection profile. This effort will continue that work.

TRUSTED COMPUTING EXEMPLAR PHASE IV: FRAMEWORK FOR CONTROLLING
DYNAMICS OF DISTRIBUTED COMPUTATION
Cynthia E. Irvine, Professor
Department of Computer Science
Sponsor: Office of Naval Research

OBJECTIVE: To address the need for a high assurance secure system, as well as the absence of public domain worked examples of high assurance systems, the Naval Postgraduate School has embarked on a project to develop a trusted computing exemplar (TCE). Earlier work established requirements and an initial framework for rapid high assurance development. This work will explore a framework for controlling dynamics of distributed computation as might be supported by applications executing on the TCE kernel.

TRUSTED COMPUTING EXEMPLAR PHASE IV: TOOLS AND DEVELOPMENT
Cynthia E. Irvine, Professor
Department of Computer Science
Sponsor: Office of Naval Research

OBJECTIVE: To address the need for a high assurance secure system, as well as the absence of public domain-worked examples of high assurance systems, the Naval Postgraduate School has embarked on a project to develop a trusted computing exemplar (TCE). Earlier work established requirements and an initial framework for rapid high assurance development. The objective of the research defined here is to lay
the groundwork for the TCE project implementation through the analysis, design, and implementation of key project components.

FIELD-LEVEL COMPUTER EXPLOITATION PACKAGE
LCDR Vincent Janowiak, USN
LTJG Adrian Arvizo, USN
Department of Computer Science
Sponsor: SPAWAR Systems Center-San Diego

OBJECTIVE: To develop a portable, solid-state device capable of interrogating a computer system for intelligence gathering. The ideal implementation will be a bootable USB key, which will launch the developed exploitation package. The required technologies for this research project include open source Linux “live” distributions, as well as existing Windows and Linux-based forensic tools. Researchers also intend to include the capability to exploit running Windows-based systems with the same USB key. The desired end state is for personnel in the field to have the capability to quickly gather time-sensitive intelligence with minimal computer and forensic expertise.

COMPUTER VISION FOR INTERACTION, TRAINING, AND SURVEILLANCE
Matthias Kolsch, Assistant Professor
Department of Computer Science
Sponsor: Naval Postgraduate School

OBJECTIVE: To obtain funding for a research plan that strives to combine the strengths of Naval Postgraduate School departments and interests with principal investigator personal background and expertise. The goal is to establish a research thrust that is of international distinction and that leverages and furthers the students’ diverse career interests by type closely to teaching. Computer vision is at the core of this research effort, with particular focus on vision-based interfaces, distributed surveillance, and “smart cameras.”

DEPENDABLE SOFTWARE ARCHITECTURE BASED ON QUANTIFIABLE COMPOSITIONAL MODEL
Luqi, Professor
Department of Computer Science
Sponsor: Air Force Office of Scientific Research

OBJECTIVE: To create new architecting methods to enable quantifiable architectural synthesis for Dependable Systems of Systems. With the aim of improving software flexibility and ensuring dependability of the resultant systems, quantifiable architecture is the crucial abstraction stratum that bridges the great gap between software requirements and system implementation. An effective and practical quantifiable compositional model (QCM) will be deeply studied. The QCM defines compositional patterns with which quantifiable constraints are associated. This forms a formal foundation for establishing binding precise metrics to computational activities and compositional interconnections, so that quantitative assessment can be automatically done at the architectural level.

DOCUMENTATION DRIVEN SOFTWARE DEVELOPMENT
Luqi, Professor
Department of Computer Science
Sponsor: U.S. Army Research Office

OBJECTIVE: To develop an integrated, systematic, documentation-centric approach to software development, known as the documentation driven development (DDD) approach. The main issues for DDD are the creation and application of three key documenting technologies that will drive the development
process and a document driven management system that will support them. The DDD will actually provide an overall support infrastructure for use throughout the entire lifecycle of a software system—from conception to retirement. Moreover, it will reduce the time and cost of development, improve software quality and reliability, and support the maintenance and evolution of the system after release.

ESTABLISH/MAINTAIN SOFTWARE ENGINEERING TEST LAB

Luqi, Professor
Department of Computer Science
Sponsor: Joint Information Operations Center

OBJECTIVE: To establish a lab for the purpose of stress testing real DoD systems with an emphasis on a holistic approach. The systems will be made available through a separate Internet service provider (ISP) than the Naval Postgraduate School’s ISP to enable the testing of different access configurations and to allow for outside entities to red term the systems. This lab will be used to evaluate multiple different DoD systems over the years.

RISK ASSESSMENT IN SOFTWARE PROJECT

Luqi, Professor
Department of Computer Science
Sponsor: Naval Air Warfare Command-Weapons Division

OBJECTIVE: To develop a set of quantitative metrics for four indicators of risk in an evolutionary software project. These metrics can be automatically collected early in each cycle in the evolutionary development of a software project. They will be the basis for building a formal risk assessment model that will make different program managers derive the same projections on the same software project.

RESEARCH ON DISTRIBUTED COMPUTING, SYSTEM DEPENDABILITY, BATTLE MANAGEMENT, AND SENSOR AND WEAPONS MANAGEMENT/NETTING FOR BALLISTIC MISSILE DEFENSE

James Bret Michael, Associate Professor
Department of Computer Science
Sponsor: Missile Defense Agency

OBJECTIVE: To support the Missile Defense Agency in the development and assessment of the global integrated fire control system—a component of the C2BMC element of the ballistic missile defense system.

SYSTEMS-OF-SYSTEMS ARCHITECTURE FOR THE BALLISTIC MISSILE DEFENSE SYSTEM

James Bret Michael, Associate Professor
Department of Computer Science
Sponsor: Missile Defense Agency

OBJECTIVE: To support the Missile Defense Agency in architecting the Ballistic Missile Defense System.
DEFENSE FROM CYBER-ATTACK USING DECEPTION

Neil C. Rowe, Professor
Department of Computer Science
Sponsor: National Science Foundation

OBJECTIVE: To develop testable computational models of deception including the major sub-phenomena or trust, expectation, suspicion, surprise, deception plans, and manufactured patterns. Such a theory can be used to explain both offensive deceptions (to gain some advantage) and defensive deceptions (to foil someone else's plans). Researchers propose to develop testable computational models of deception including the major sub-phenomena or trust, expectation, suspicion, surprise, deception plans, and manufactured patterns. Such a theory can be used to explain both offensive deceptions (to gain some advantage) and defensive deceptions (to foil someone else's plans).

JOINT MOBILE NETWORK OPERATIONS JOINT TEST AND EVALUATION

Gurminder Singh, Professor
Geoffrey Xie, Assistant Professor
J.D. Fulp, Lecturer
Department of Computer Science
Sponsor: Joint Mobile Network Operations

OBJECTIVE: The JMNO JT&E project is chartered to employ multi-Service and other DoD support, personnel and equipment to investigate, evaluate and make recommendations to improve mobile network access and maintain current performance by identifying and developing joint doctrine and recommending DOTMLPF changes, enhance user-connectivity to their Service’s information resources while maneuvering through battlespace, enable interoperability and Information Assurance between different Service’s networks and maintain QoS across network boundaries. The objective is to participate in the Joint Warfighter Advisory Group (JWAG) and assist with Use Cases, TTPs and IA working groups.

SUMMARY: NPS participation in the JMNO effort has two strong components: technical leadership and student research. A summary of NPS contributions is as follows:

- Co-lead JWAG Working Groups on
  - Use Cases
  - Tactics, Techniques and Procedures (TTPs)
  - Information Assurance (IA)
- Technical leadership and assistance to the Control Plane working group
- Engage NPS students in the above areas of research and supervise theses
- Publish technical reports on the above topics
- Participate in JWAG meetings and teleconferences to report findings and provide technical guidance

SHARED TEXT INPUT

Gurminder Singh, Professor
Department of Computer Science
Sponsor: Naval Postgraduate School Foundation, Inc.

SUMMARY: IP networking is a spectacular success, catalyzing the diffusion of data networking across academic institutions, governments, businesses, and homes world-wide. This research addresses these challenges through a large-scale effort, bringing together a team that combines both theoretical and experimental expertise in data network design and operations. The team will explore a number of fundamental questions related to network control and management.
LEARNING AND AUTONOMOUS COORDINATION FOR ROBOTICS
Kevin Squire, Assistant Professor
Department of Computer Science
Sponsor: Naval Postgraduate School

SUMMARY: Developed representations and learning algorithms for natural human-robot communication and autonomous multiple robot coordination, as applicable to such military applications as terrain mapping, disaster and recovery, and unexploded ordinance removal.

IMPROVING FIRST ROUND ACCURACY OF LONG RANGE NAVAL GUNFIRE USING NUMERICAL WEATHER PREDICTION
LCDR Douglas Wahl, USN
Department of Computer Science
Sponsor: SPAWAR Systems Center-San Diego

OBJECTIVE: To develop an application that will improve the first round accuracy of long-range naval gunfire using numerical weather prediction.

COLLABORATIVE RESEARCH: NETS-NBD - A REVOLUTIONARY 4D APPROACH TO NETWORK-WIDE CONTROL AND MANAGEMENT
Geoffrey Xie, Assistant Professor
Department of Computer Science
Sponsor: National Science Foundation

OBJECTIVE: Investigation of the feasibility of a clean-slate design of the network control and management functionality following three key principles: network-level objectives, network-wide views, and direct control. The research is focused on the implementation and evaluation of an extreme network architecture called “4D,” after the architecture’s four functionality planes: decision that is logically centralized, dissemination, discovery, and data.

INVESTIGATION OF SELECTED INFORMATION ASSURANCE TOPICS
Geoffrey Xie, Assistant Professor
Department of Computer Science
Sponsor: National Security Agency

OBJECTIVE: Mr. Neal Ziring, the technical lead of the National Security Agency Systems and Network Attack Center, recently presented a list of information assurance (IA) research topics to the faculty of the Department of Computer Science, and requested proposals to incorporate some of the topics into master’s thesis or course projects. After careful evaluation of the topics, the principal investigator finds that his expertise in network security matches very well with four of the IA research topics. This proposal identifies these topics and describes the required budget for tackling these topics.

SOFTPHONE: OPEN SOURCE SOFTWARE VOICE OVER INTERNET PROTOCOL SOLUTION OVER EPLRS
Geoffrey Xie, Assistant Professor
John Gibson, Research Associate
Department of Computer Science
Sponsor: Marine Corps Systems Command

SUMMARY: Voice over IP may be the solution to deploy full-duplex telephone-communications services to bandwidth-deprived organizations via an existing wireless network infrastructure. The development of a software based “VoIPnet” would provide critical primary telephone services to highly-mobile maneuver
elements and redundant telephone networks for service-level organizations, with existing, digital-switched backbone access.
DEPARTMENT OF
COMPUTER SCIENCE

2006
Faculty Publications
and Presentations


Garfinkel, S., “Phone a Friend over Wi-Fi. A New Wi-Fi Phone from Vonage is Fun -- But It Doesn't Make Sense as a Replacement for the Cell Phone,” January 2006.


Garfinkel, S., “Searching for Mr. Wrong. Trying to Trace Internet Attacks Backward to Find the Perp is an Interesting Exercise - but Potentially Fruitless,” CSO Magazine, July 2006.


**REFEREED JOURNAL PUBLICATIONS**


**CONFERENCE PUBLICATIONS**


Irvine, C.E., “What Might We Mean by ‘Secure Code’ and How Might We Teach What We Mean?” Proceedings Workshop on Secure Software Engineering Education and Training, Oahu, Hawaii, April 2006.


**REFEREED CONFERENCE PUBLICATIONS**


**CONFERENCE PRESENTATIONS**


BOOK

COMPUTER SCIENCE

BOOK CHAPTERS


REFEREED BOOK CHAPTERS


TECHNICAL REPORTS


PATENT

DEPARTMENT OF DEFENSE
ANALYSIS

GORDON MCCORMICK
CHAIRMAN
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
- Irregular Warfare

RESEARCH CENTER:

- Center on Terrorism and Irregular Warfare

SPONSORED PROGRAM (Research and Academic)-FY2006:

The Naval Postgraduate School’s sponsored program exceeded $81 million in FY2006. Sponsored programs include both research and educational activities funded from an external source.

Size of Program: $978K
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<tr>
<td>McCormick, Gordon</td>
<td>Associate Professor and Chairman</td>
<td>656-2933</td>
<td><a href="mailto:GmCormick@nps.edu">GmCormick@nps.edu</a></td>
</tr>
<tr>
<td>Tucker, David</td>
<td>Associate Professor and Associate Chairman for Research</td>
<td>656-3754</td>
<td><a href="mailto:dctucker@nps.edu">dctucker@nps.edu</a></td>
</tr>
<tr>
<td>Arquilla, John</td>
<td>Associate Professor</td>
<td>656-3450</td>
<td><a href="mailto:jarquilla@nps.edu">jarquilla@nps.edu</a></td>
</tr>
<tr>
<td>Gustaitis, Pete</td>
<td>Senior Lecturer and Associate Chairman for Operations</td>
<td>656-3799</td>
<td><a href="mailto:pjgustai@nps.edu">pjgustai@nps.edu</a></td>
</tr>
<tr>
<td>Borer, Douglas</td>
<td>Associate Professor</td>
<td>656-2117</td>
<td><a href="mailto:daborer@nps.edu">daborer@nps.edu</a></td>
</tr>
<tr>
<td>Lober, George</td>
<td>Senior Lecturer</td>
<td>656-1019</td>
<td><a href="mailto:gwlober@nps.edu">gwlober@nps.edu</a></td>
</tr>
<tr>
<td>Denning, Dorothy</td>
<td>Professor</td>
<td>656-3105</td>
<td><a href="mailto:dedenning@nps.edu">dedenning@nps.edu</a></td>
</tr>
<tr>
<td>Roberts, Nancy</td>
<td>Professor</td>
<td>656-2742</td>
<td><a href="mailto:nroberts@nps.edu">nroberts@nps.edu</a></td>
</tr>
<tr>
<td>Duncan, Jennifer J.</td>
<td>Research Associate</td>
<td>656-3584</td>
<td><a href="mailto:jduan@nps.edu">jduan@nps.edu</a></td>
</tr>
<tr>
<td>Robinson, Glenn E.</td>
<td>Associate Professor</td>
<td>656-2710</td>
<td><a href="mailto:grobinson@nps.edu">grobinson@nps.edu</a></td>
</tr>
<tr>
<td>Freeman, Michael</td>
<td>Assistant Professor</td>
<td>656-3731</td>
<td><a href="mailto:mefreema@nps.edu">mefreema@nps.edu</a></td>
</tr>
<tr>
<td>Rothstein, Hy S.</td>
<td>Senior Lecturer</td>
<td>656-2203</td>
<td><a href="mailto:hrothst@nps.edu">hrothst@nps.edu</a></td>
</tr>
<tr>
<td>Giordano, Frank</td>
<td>Professor</td>
<td>656-7500</td>
<td><a href="mailto:frgiorda@nps.edu">frgiorda@nps.edu</a></td>
</tr>
<tr>
<td>Sepp, Kalev</td>
<td>Assistant Professor</td>
<td>656-2116</td>
<td><a href="mailto:kisepp@nps.edu">kisepp@nps.edu</a></td>
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DEFENSE ANALYSIS

JOINT THREAT WARNING SYSTEM
John Arquilla, Associate Professor
Department of Defense Analysis
Sponsor: U.S. Special Operations Command

OBJECTIVE: To conduct research regarding specific areas where Special Operations Forces (SOF) will most likely operate and the specific organizations that SOF will most likely encounter between 2008 and 2016.

JOINT THREAT WARNING SYSTEM: PHASE 2
John Arquilla, Associate Professor
Department of Defense Analysis
Sponsor: U.S. Special Operations Command

OBJECTIVE: To conduct research regarding specific areas where Special Operations Forces (SOF) will most likely operate and the specific organizations that SOF will most likely encounter between 2008 and 2016.

TERRORISM AND POLITICAL LEGITIMACY
Douglas Borer, Associate Professor
Department of Defense Analysis
Sponsor: Naval Postgraduate School

OBJECTIVE: To understand how small groups that use terror have historically become legitimate mass-based social movements.

SUSTAINED DECAPITATION OF TERRORIST GROUPS
Michael Freeman, Assistant Professor
Department of Defense Analysis
Sponsor: Naval Postgraduate School

OBJECTIVE: To study the potential value of attacking terrorist organizations with a strategy of sustained decapitations, by which the state would repeatedly and continuously decapitate the leader of a terrorist group even as he/she is replaced. The study will assess the necessity, value, and scarcity of leadership within organizations in conjunction with the likely reactions to this strategy among active terrorists, sympathizers, adversaries, and observers. This study will analyze the expected benefits of such a strategy against different terrorist groups and against Al-Qaeda in particular.

GAME THEORETIC APPROACHES TO TERRORIST AND INSURGENT NETWORKS
Gordon McCormick, Associate Professor
Guillermo Owen, Distinguished Professor
Department of Defense Analysis
Department of Applied Mathematics
Sponsor: Air Force Office of Scientific Research

OBJECTIVE: To provide analytical support for targeting terrorist networks.
DEFENSE ANALYSIS

THE STRUCTURE AND DYNAMICS OF INSURGENCY
Gordon McCormick, Associate Professor
Frank Giordano, Professor
Department of Defense Analysis
Sponsor: Counter Terrorism Technology Task Force

SUMMARY: Built a dynamic model of insurgency that clearly defines the variables, parameters, and relationships that shape the outcome of insurgent competitions.

LONG TERM STRATEGY PROJECT
Anna Simons, Associate Professor
Department of Defense Analysis
Sponsor: Office of the Secretary of Defense

OBJECTIVE: There are three goals for this 2006 pilot seminar: 1) to bring military officers with operational experience together with policy-oriented academics (along the lines of the Newport Summer Study but for an extended period of time) in the course of their degree work at the Naval Postgraduate School; 2) to produce a briefing and final report of the same high caliber as the Newport Summer Study briefings and reports, thereby demonstrating to the Office of the Secretary of Defense, the Navy, and NPS the “think tank” potential lying dormant within the uniformed services; and 3) to offer a select group of NPS officers a unique graduate school experience.

ANALYTICAL SUPPORT FOR THE JOINT COMMAND AND CONTROL REACHBACK STUDY
David Tucker, Associate Professor
Department of Defense Analysis
Sponsor: U.S. Joint Forces Command

OBJECTIVE: To support Joint Forces Command/J9 in the development of a white paper on reachback.

ASHBROOK CENTER ASSESSMENT
David Tucker, Associate Professor
Department of Defense Analysis
Sponsor: Ashbrook Center

OBJECTIVE: To assist the Ashbrook Center, Ashbrook University, Ashbrook, Ohio, in the establishment and assessment of a Master's degree program in American history and government.

CREDIBILITY ASSESSMENT TOOLS INITIATIVE
David Tucker, Associate Professor
Department of Defense Analysis
Sponsor: Counterintelligence Field Activity

OBJECTIVE: Credibility assessment tools for use in the field can be severely limited by a strong reliance on the subject’s report of critical data and the ability on the part of the examiner to objectively identify erroneous or deceptive data or statements. This effort is intended to assist in appraising the pragmatic potential of a broad array of psychological methods, and will provide a practical software demonstration of relevant methodological technique.
DEPARTMENT OF DEFENSE ANALYSIS

2006
Faculty Publications and Presentations

**CONFERENCE PUBLICATIONS**


**JOURNAL ARTICLE**


DEPARTMENT OF
INFORMATION SCIENCES

DANIEL C. BOGER
CHAIRMAN
OVERVIEW:

The Department of Information Science (IS) 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’s 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 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.

NPS’s systems technology laboratories contain (or have distributed access to) actual command-and-control systems for exercises and experiments. The prime example 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 and 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, speeding the acceptance of new approaches to decision-making and training.

**RESEARCH PROGRAM (Research and Academic)-FY2006:**

The Naval Postgraduate School’s sponsored program exceeded $81 million in FY2006. Sponsored programs include both research and educational activities funded from an external source. A profile of the sponsored program for the Department of Information Sciences is provided below.

![Pie chart showing the distribution of funding sources for FY2006.]

**Size of Program: $6.97M**
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<td>Boger, Dan C.</td>
<td>Professor and Chairman</td>
<td>656-3671</td>
<td><a href="mailto:dboger@nps.edu">dboger@nps.edu</a></td>
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<tr>
<td>Bordetsky, Alexander</td>
<td>Associate Professor and</td>
<td>656-2287</td>
<td><a href="mailto:abordets@nps.edu">abordets@nps.edu</a></td>
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<td>Baer, Wolfgang</td>
<td>Research Associate Professor</td>
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<td>Bergman, Mark</td>
<td>Assistant Professor</td>
<td>656-3562</td>
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<td>Bourakov, Eugene</td>
<td>Research Associate</td>
<td>656-1120</td>
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<td>Brutzman, Donald P.</td>
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<td>656-2149</td>
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<td>Buddenberg, Rex A.</td>
<td>Senior Lecturer</td>
<td>656-3576</td>
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<td>LCDR, USN</td>
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<td>Lecturer</td>
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<td><a href="mailto:dcourtney@nps.edu">dcourtney@nps.edu</a></td>
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<td>Professor</td>
<td>656-2260</td>
<td><a href="mailto:drdolk@nps.edu">drdolk@nps.edu</a></td>
</tr>
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<td>Elliott, Ray, Maj, USN</td>
<td>Military Faculty</td>
<td>656-2433</td>
<td><a href="mailto:raelliott@nps.edu">raelliott@nps.edu</a></td>
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<td>656-3000</td>
<td><a href="mailto:elfisher@nps.edu">elfisher@nps.edu</a></td>
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<td>Gallup, Shelley</td>
<td>Research Associate Professor</td>
<td>656-1040</td>
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<td>656-3983</td>
<td><a href="mailto:fahayesr@nps.edu">fahayesr@nps.edu</a></td>
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<td>Haitz, Michael A.,</td>
<td>Military Faculty, Lecturer</td>
<td>656-3027</td>
<td><a href="mailto:mahaitz@nps.edu">mahaitz@nps.edu</a></td>
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<td>Higgins, Susan</td>
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<td>56-3596</td>
<td><a href="mailto:slhiggins@nps.edu">slhiggins@nps.edu</a></td>
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<tr>
<td>Horner, Douglas</td>
<td>Research Associate Professor</td>
<td>656-0829</td>
<td><a href="mailto:dphorner@nps.edu">dphorner@nps.edu</a></td>
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<td>Housel, Thomas J.</td>
<td>Professor</td>
<td>656-4476</td>
<td><a href="mailto:tihousel@nps.edu">tihousel@nps.edu</a></td>
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<td>Hutchins, Susan G.</td>
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<td><a href="mailto:shutchins@nps.edu">shutchins@nps.edu</a></td>
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<td>Iatrou, Steven</td>
<td>Lecturer</td>
<td>656-3770</td>
<td><a href="mailto:sjiatrou@nps.edu">sjiatrou@nps.edu</a></td>
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<tr>
<td>Irvine, Nelson</td>
<td>Research Assistant Professor</td>
<td>656-1007</td>
<td><a href="mailto:njirvine@nps.edu">njirvine@nps.edu</a></td>
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<td>Jansen, Erik</td>
<td>Senior Lecturer</td>
<td>656-2623</td>
<td><a href="mailto:ejansen@nps.edu">ejansen@nps.edu</a></td>
</tr>
<tr>
<td>Mun, Johnathan C.</td>
<td>Research Professor</td>
<td>656-4438</td>
<td><a href="mailto:jcmun@nps.edu">jcmun@nps.edu</a></td>
</tr>
<tr>
<td>Sengupta, Kishore</td>
<td>Associate Professor</td>
<td>656-3212</td>
<td><a href="mailto:kishore@nps.edu">kishore@nps.edu</a></td>
</tr>
<tr>
<td>Kamel, Magdi N.</td>
<td>Associate Professor</td>
<td>656-2494</td>
<td><a href="mailto:mkamel@nps.edu">mkamel@nps.edu</a></td>
</tr>
<tr>
<td>Oros, Carl, Maj. USMC</td>
<td>Lecturer</td>
<td>656-2995</td>
<td><a href="mailto:cloros@nps.edu">cloros@nps.edu</a></td>
</tr>
<tr>
<td>Steckler, Brian D.</td>
<td>Lecturer</td>
<td>656-3837</td>
<td><a href="mailto:steckler@nps.edu">steckler@nps.edu</a></td>
</tr>
<tr>
<td>Kemple, William G.</td>
<td>Associate Professor</td>
<td>656-2191</td>
<td><a href="mailto:kemple@nps.edu">kemple@nps.edu</a></td>
</tr>
<tr>
<td>Osmundson, John S.</td>
<td>Associate Professor</td>
<td>656-3775</td>
<td><a href="mailto:josmund@nps.edu">josmund@nps.edu</a></td>
</tr>
<tr>
<td>Van Hise, John W., Jr.</td>
<td>Research Associate Professor</td>
<td>656-3069</td>
<td><a href="mailto:jwvanhis@nps.edu">jwvanhis@nps.edu</a></td>
</tr>
<tr>
<td>Kendall, Anthony</td>
<td>Lecturer</td>
<td>656-3146</td>
<td><a href="mailto:wakendal@nps.edu">wakendal@nps.edu</a></td>
</tr>
<tr>
<td>Pfeiffer, Karl, Lt Col, USAF</td>
<td>Assistant Professor</td>
<td>656-3635</td>
<td><a href="mailto:kdpfeiff@nps.edu">kdpfeiff@nps.edu</a></td>
</tr>
<tr>
<td>Welch, William</td>
<td>Lecturer</td>
<td>656-3212</td>
<td><a href="mailto:wwelch@nps.edu">wwelch@nps.edu</a></td>
</tr>
<tr>
<td>Kleinman, David L.</td>
<td>Professor</td>
<td>656-4148</td>
<td><a href="mailto:dkleinm@nps.edu">dkleinm@nps.edu</a></td>
</tr>
<tr>
<td>Rhoades, Mark</td>
<td>Lecturer</td>
<td>277-3153</td>
<td><a href="mailto:mmrhoad@nps.edu">mmrhoad@nps.edu</a></td>
</tr>
<tr>
<td>Zolla, George</td>
<td>Lecturer</td>
<td>656-3397</td>
<td><a href="mailto:gazolla@nps.edu">gazolla@nps.edu</a></td>
</tr>
<tr>
<td>Marvel, Orin E.</td>
<td>Visiting Associate Professor</td>
<td>656-3446</td>
<td><a href="mailto:omarvel@nps.edu">omarvel@nps.edu</a></td>
</tr>
<tr>
<td>Schleher, D. Curtis</td>
<td>Professor</td>
<td>656-3767</td>
<td><a href="mailto:dschleher@nps.edu">dschleher@nps.edu</a></td>
</tr>
<tr>
<td>Maule, William</td>
<td>Research Assistant Professor</td>
<td>56-3376</td>
<td><a href="mailto:rwmaule@nps.edu">rwmaule@nps.edu</a></td>
</tr>
<tr>
<td>Schneidewind, N.F.</td>
<td>Professor</td>
<td>656-2719</td>
<td><a href="mailto:nschneid@nps.edu">nschneid@nps.edu</a></td>
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ONETESS SYNTHETIC ENVIRONMENT DESIGN REVIEW
Wolfgang Baer, Research Associate Professor
Department of Information Sciences
Sponsor: TRADOC Analysis Center-Monterey

OBJECTIVE: To review and support the “One-Tactical-Engagement Family of Simulation Systems” (ONETESS) synthetic environment database and algorithm design being developed by AT&T for TRADOC Analysis Center, Monterey and Operational Test Command, Ft. Hood.

PROTOTYPE MICRO-TERRAIN DATABASE GENERATION SYSTEM
Wolfgang Baer, Research Associate Professor
Department of Information Sciences
Sponsor: TRADOC Analysis Center-Monterey

OBJECTIVE: To generate and utilize high-resolution terrain information. This includes tasks required to upgrade, document, and transition the Perspective View Nascent Technologies system from a research tool to an operational capability for generating and using terrain for operational test and tactical applications.

U.S. SPECIAL OPERATIONS COMMAND-NAVAL POSTGRADUATE SCHOOL
COOPERATIVE FIELD EXPERIMENTATION PROGRAM
Wolfgang Baer, Research Associate Professor
Department of Information Sciences
Sponsor: Naval Postgraduate School

OBJECTIVE: This proposal requests funding for the preparation, integration, and participation of a system capable of refining the location of an Unmanned Aerial Vehicle (UAV)-identified target specifying the location of potential targets in a UAV video data stream. The goal is to track moving targets and provide coordinate approaching one-meter accuracies in ten-second intervals. The effort includes the modification of Nascent Technologies software to include input of digital-video frames, global positioning system (GPS), and attitude coordinates, and interactive tracking and output of located target coordinates.

EXPLORING THE PROCEDURAL ROLE OF SENSEMAKING DURING THE SYSTEMS DEVELOPMENT LIFECYCLE
Mark Bergman, Assistant Professor
Department of Information Sciences
Sponsor: Naval Postgraduate School

OBJECTIVE: To better understand the role of sense-making during the systems-development lifecycle; specifically, to examine problem-requirements-determination and system-formation processes during various stages of system development, so as to understand the relationship between these processes from a sense-making point of view.

COMMUNICATION SYSTEMS ANALYSES OF ALTERNATIVES OF PRESENT SYSTEMS IN THE JOINT MISSION BATTLESPACE PHASE I
Daniel C. Boger, Professor
Department of Information Sciences
Sponsor: Northrup Grumman

OBJECTIVE: To perform an analysis of alternatives for currently-funded C4I systems and make comparisons of alternatives that vary the number/class of platforms in a Battlegroup and Expeditionary Strike Group changes in the capability of C4I systems associated with the difference in platform's cost. The
analysis should provide evaluation of the relevant differences in the execution of both Naval and joint missions.

**CYBER WARFARE INTEGRATION NETWORK**  
Daniel C. Boger, Professor  
Department of Information Sciences  
Sponsor: Northrop Grumman Systems

**OBJECTIVE:** To exchange information between Northrop Grumman Systems Corporation and the Naval Postgraduate School concerning their respective capabilities and research findings as pertains to Sea Power 21/FORCEnet.

**INTELLIGENCE VISUALIZATION AND ACTIVITY DATABASE SOFTWARE**  
Daniel C. Boger, Professor  
Department of Information Sciences  
Sponsor: Lockheed Martin Orincon Defense

**OBJECTIVE:** To participate in naval, Marine Corps, and joint/coalition sea trials such as limited-objective exercises, fleet-battle exercises to collect, process, display, evaluate, and potentially disseminate ISR to tactical contacts/tracks in a multi-source/multi-INT environment.

**NAVAL POSTGRADUATE SCHOOL SOFTWARE TESTED FOR MARITIME DOMAIN AWARENESS**  
Daniel C. Boger, Professor  
Department of Information Sciences  
Sponsor: Naval Postgraduate School

**OPERATIONAL TEST AND EVALUATION SUPPORT FOR INFORMATION OPERATIONS AND INFORMATION ASSURANCE**  
Daniel C. Boger, Professor  
Department of Information Sciences  
Sponsor: Director, Operational Test and Evaluation

**OBJECTIVE:** To provide investigative research support to the Deputy Director for Naval and Netcentric Warfare Systems. The investigative research will focus on several different exploratory efforts, including a class research project and several faculty research topics. Each Investigator will examine a different topic and will provide their results to the Sponsor, including the anticipated benefit of continued research at the Naval Postgraduate School. The DOT&E sponsor desires introductory-type research and insights. Promising research efforts may lead to additional, more extensive research depending on initial investigative results.

**PROFESSORSHIP OF INFORMATION SCIENCES**  
Daniel C. Boger, Professor  
Department of Information Sciences  
Sponsor: Naval Postgraduate School Foundation, Inc.

**OBJECTIVE:** To establish and fund a professorship of information sciences in the Graduate School of Operational and Information Sciences at the Naval Postgraduate School.
CENETIX SUPPORT FOR HURT PROGRAM
Alexander Bordetsky, Associate Professor
Department of Information Sciences
Sponsor: Air Force Research Laboratory

SUMMARY: Networking and presentation support for the Air Force Research Laboratory’s Heterogeneous, Urban, RSTA (Reconnaissance Surveillance and Target Acquisition) Team (HURT) program.

COMMAND AND CONTROL ARCHITECTURE FOR THE NEW JERSEY HEALTH EMERGENCY PREPAREDNESS AND RESPONSE NETWORK
Alexander Bordetsky, Associate Professor
Department of Information Sciences
Sponsor: State of New Jersey Department of Health and Senior Services

OBJECTIVE: To design and provide implementation guidance for a situational awareness, command and control network architecture for the State of New Jersey Department of Health and Senior Services (NJDHSS). This will provide the State Emergency Preparedness and Response System with a viable health Command, Control, and Communication (C3) system capable of responding to all public health emergencies, acts of terrorism, and mass casualty incidents.

SCOPE: Faculty and students of the Naval Postgraduate School will address New Jersey’s command, control, and communication network design through the following research activities:

- Analysis of current NJDHSS C3 systems for responding to a public health emergency and mass casualty incident, including recommendations for an integrated C3 health network,
- Design and prototype of a Health Command Center and satellite Medical Coordination Centers, and integration of Command Center communications and decision aides with legacy systems,
- Design and evaluation of networking solutions for Medical Mobile Response Team communication with the New Jersey Health Command and Control network,
- Use of the Naval Postgraduate School testbed as a prototype for designing the NJDHSS C3 centers,
- Design of database integration and emergency response simulation and training requirements, and
- Assist in implementing the final Health Emergency Response Network.

CONFERENCE PUBLICATION:

THESIS DIRECTED:
DECISION MAKING CONSTRUCTS FOR A DISTRIBUTED ENVIRONMENT
Alexander Bordetsky, Associate Professor
Department of Information Sciences
Sponsor: Aptima, Inc.

OBJECTIVE: To validate CART and assist with integrating new capabilities into e-wall.

GROOVE-BASED COLLABORATION AND RAPIDLY FORMED NETWORKS FOR EFFECTIVE COMMUNICATIONS, SURVEILLANCE, AND SITUATIONAL AWARENESS IN HUMANITARIAN ASSISTANCE/DISASTER RELIEF
Alexander Bordetsky, Associate Professor
Department of Information Sciences
Sponsor: Office of Force Transformation

OBJECTIVE: The U.S. Navy responded to the devastation wrought by Hurricane Katrina by designating a Joint Force Maritime Component Commander (JFMCC) to coordinate the maritime response. That response consisted of ships, helicopters, naval construction engineers (Seabees), logistics, and medical personnel just to name a few. Besides the unique command and control relationship between the Navy shore command infrastructure and the afloat maritime command, complicating matters for the JFMCC was the devastation to the shore communications infrastructure at the Naval facilities in the area affected by Katrina. Only a few days into the crisis response, former Naval Postgraduate School (NPS) students on senior Navy staffs contacted Professor Alexander Bordetsky of the NPS Department of Information Sciences. With their knowledge of the network and collaboration expertise resident at NPS, they asked if NPS could assist the relief effort by helping to establish a better C4I capability for the JFMCC. It was readily apparent that the NPS Center for Network Innovation and Experimentation (CENETIX) did have the capacity to assist.

The CENETIX-TNT team developed solutions for geographically-distributed global-collaborative work between homeland defense operators, remote experts, and higher level HQ that would be used to set up the Second Fleet Groove-based, relief-support, collaborative network.

The Groove-based network would allow ship-to-shore collaboration with global reach back to federal sources.

The main steps necessary to deploy the Groove-based, relief-support, collaborative network would include:

1. Providing relief operators with small laptops loaded by the Groove clients,
2. Establishing key shared workspaces in Groove by NPS NOC and Second Fleet afloat site,
3. Facilitating access management in designated workspaces,
4. Providing Second Fleet and higher HQ participants with rapid online training on Groove shared data operations (NPS crew),
5. Establishing VPN reach back from the Second Fleet ship to NPS, NORTHCOM, FEMA, CG HQ, and NBFC.

CONFERENCE PUBLICATION:


THESIS DIRECTED:

INFORMATION SCIENCES

TNT-BASED NETWORK CONNECTIVITY FOR WOLFPAC EXPERIMENTATION
Alexander Bordetsky, Associate Professor
Department of Information Sciences
Sponsor: Department of Defense, Washington Headquarters Services

OBJECTIVE: To provide adaptive, multi-path, wireless networks for interconnecting the Stiletto ship with geographically distributed, unmanned vehicles, divers, and collaborating command centers ashore.

TNT-BASED NETWORK CONNECTIVITY FOR WOLF-PACK STILETTO
Alexander Bordetsky, Associate Professor
Department of Information Sciences
Sponsor: U.S. Special Operations Command

SUMMARY: The TNT MIO 06-4 and 07-1 conducted experiment proved the feasibility of integrating Stiletto in a tactical MIO network and provided vital requirements for configuring networking and operations support capabilities onboard the Stiletto mobile NOC and command center. The ship-to-shore OFDM wireless network between Stiletto’s onboard NOC (configured by the Naval Postgraduate School) and the Navy site ashore operated well and allowed the MIO team in SF Bay to communicate with the Stiletto command post. Also, the CENETIX-developed, first self-aligning broadband wireless solution (SAOFDM), which will be deployed on Stiletto during future experiments, was successfully tested at SF Bay onboard the Alameda County Sheriff's boat, in a configuration similar to Stiletto. In TNT MIO 06-4, with only one SAOFDM node onboard the Alameda County boat and a fixed OFDM node ashore, it immediately provided sufficient bandwidth for collaborative tools and multiple video feeds (1.5-3Mbps level), even when subjected to additional sharp zigzag movement of the vessel, to as far as 4.5 miles off-shore. In addition, the members of the Stiletto TOC were able to communicate and observe video/radiation detection from the remote warning sites in Sweden, Austria, and Singapore.

CONFERENCE PUBLICATIONS:


TNT FIELD EXPERIMENTATION PROGRAM/SPECIAL OPERATIONS: TNT TESTBED AND NETWORKS
Alexander Bordetsky, Associate Professor
Department of Information Sciences
Sponsor: U.S. Special Operations Command

OBJECTIVE: Integration and operation of TNT Network and Special Operations Command (SOCOM) Tactical Applications for TNT fiscal year 2006 experiments.

SCOPE: The Center plays a key role in most of the networking and information technology tasks of TNT fiscal year 2006 experimentation:

- Twenty-four/seven operation and continuing improvement of TNT long-haul, wireless testbed, including the Naval Postgraduate School, Camp Roberts, and ground mobile and surface operation centers,
- Expending the TNT backbone to the globally distributed locations critical to SOCOM experimentation,
Enabling data sharing and geographically-distributed collaboration using collaborative technology and situational awareness systems with SOCOM MSC, Forrest Services, Biometrics Fusion Center, DTRA, OFT-TacSat, Coast Guard, and other selected expert teams,

- Bringing new agile-adaptive (self-organizing) networking solutions in UAV, ground vehicles, surface vehicles (manned and unmanned RIBs), and sensor TNT networking,
- Developing maritime interdiction operation extension for the TNT testbed, including joint research activities with LLNL, including the new sites in Alameda Island, Sweden, Austria, Singapore, and Australia,
- Integrating emergency relief, humanitarian operations, and homeland defense support in TNT experimentation,
- Providing data collection and TNT network modeling; integrating network performance and configuration modeling in unmanned aerial vehicle and light reconnaissance vehicle path-planning C2 packages,
- Exploring cognitive monitoring, situational understanding development, and data fusion solutions (jointly with MIT) in TNT experiments,
- Providing student research teams for TNT network/IT integration and operation, including IS 4926 Network Operations, IS 4188 Collaborative Technology, IS 4730 Large-Scale Systems Design and Experimentation classes, Master’s Thesis, and Ph.D. students.

CONFERENCE PUBLICATIONS:


THESES DIRECTED:


**LEGACY INTEGRATION OF TRANSFORMATIONAL COMMUNICATIONS SYSTEMS RESEARCH**
Rex A. Buddenberg, Senior Lecturer
Department of Information Sciences
Sponsor: National Reconnaissance Office

**SUMMARY:** Researched legacy integration aspects of Transformational Communications Systems (TCS) and recommended maintenance items for legacy applications to make them “TCS-ready.” Supported thesis research.

**RADIO-WAN RESEARCH AND TESTING**
Rex A. Buddenberg, Senior Lecturer
Department of Information Sciences
Sponsor: Marine Corps Systems Command

**SUMMARY:** Continued investigation and testing of commercial and adapted-from-commercial radio-WAN technology and products. This research is principally aimed at understanding the implications of using IEEE 802.16-based equipment for U.S. Marine Corps purposes.

**UTILITY OF COMMERCIAL WIRELESS STUDY IN SUPPORT OF UNITED STATES NORTHERN COMMAND**
Rex A. Buddenberg, Senior Lecturer
Brian D. Steckler, Lecturer
Department of Information Sciences
Sponsor: United States Northern Command

**SUMMARY:** Analyzed the state of commercial wireless networking environments to understand market trends and direction, as well as current and future technology.

**TEST AND EVALUATION OF AN INTEGRATED VIDEO/CAMERA SENSOR SUITE FOR PERSISTENT INTELLIGENCE, SURVEILLANCE, AND RECONNAISSANCE IN SUPPORT OF TACTICAL COALITIONS**
ENS Michael Chesnut, USN
Department of Information Sciences
Sponsor: SPAWAR Systems Center-San Diego

**SUMMARY:** This research focused on the test and evaluation of commercial, off-the-shelf technology in order to create an unattended, ground-based, integrated video/camera sensor suite for persistent intelligence, surveillance, and reconnaissance in a tactical coalition environment.
ENHANCED MISSION CAPABILITIES ENABLED THROUGH FUTURE BROADBAND INTERNET PROTOCOL AND CELLULAR UPGRADES

LT Thomas G. Conroe, USN
Department of Information Sciences
Sponsor: SPAWAR Systems Center-San Diego

SUMMARY: Researched the additional mission capabilities and enhanced current mission capabilities that broadband Internet protocol and cellular technologies would enable the E-6B to conduct.

APPLICATION OF 802.16 ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING POINT TO MULTI-POINT WIRELESS NETWORK TOPOLOGY IN CONJUNCTION WITH NETWORKED ULTRA-WIDEBAND SENSORS

ENS Scott Diamond, USN
Orin E. Marvel, Visiting Associate Professor
Department of Information Sciences
Sponsor: SPAWAR Systems Center-San Diego

OBJECTIVE: To evaluate the feasibility of integrating commercial, off-the-shelf technologies to create a coalition command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) for wireless network topologies that can be utilized to provide attack aircraft and Special Forces ground assets with a high level of situational awareness and knowledge-sharing capacity.

ITR SYNTHETIC ENVIRONMENT FOR CONTINUOUS EXPERIMENTATION

Daniel R. Dolk, Professor
Department of Information Sciences
Sponsor: Purdue University

SUMMARY: In support of the development of a synthetic environment for modeling the impact of bio-terror weapons, this project addressed a number of relevant issues in the area of model management and decision support.

SYNTHETIC ENVIRONMENT FOR COMPUTATIONAL EXPERIMENTATION BASE PROTECTION APPLICATION

Daniel R. Dolk, Professor
Department of Information Sciences
Sponsor: Purdue University

COALITION OPERATING AREA SURVEILLANCE AND TARGETING SYSTEM 2006 PROPOSAL

James F. Ehlert, National Security Agency Cryptologic Chair Professor
Department of Information Sciences
Sponsor: Office of the Secretary of Defense

SUMMARY: In a recent message, all of the numbered Fleet Commanders in the U.S. Navy highlighted their most important requirements respective to information technology and communications. The number one concern of all of these Commanders was coalition communications, specifically a communication solution that enables real-time interoperability without a single-point of crossover, or failure, in systems. In addition, the fleet requires a common operating picture (or common information environment), chat, file sharing, voice-over Internet protocol, and translation software applications at all levels of command and control.
INFORMATION SCIENCES

COALITION OPERATING AREA SURVEILLANCE AND TARGETING SYSTEM 2006 PROPOSAL
James F. Ehlert, National Security Agency Cryptologic Chair Professor
Department of Information Sciences
Gurminder Singh, Professor
Department of Computer Science
Sponsor: Marine Corps Systems Command

SUMMARY: The documents shaping the United States national military strategy call for the use of emerging information technologies as a force multiplier to produce a more agile, flexible, and effective military to respond to an increasingly asymmetric enemy. A Joint Vision 2020 recognizes the role of unattended sensor networks in full-spectrum dominance through increasing battle-space awareness and precision engagement.

COMMANDER, UNITED STATES PACIFIC FLEET LIAISON DESK RESEARCH PROPOSAL
James F. Ehlert, National Security Agency Cryptologic Chair Professor
Department of Information Sciences
Sponsor: U.S. Pacific Fleet

SUMMARY: Established the Naval Postgraduate School desk for the benefit of both commands.

COOPERATIVE OPERATIONS AND APPLIED SCIENCE AND TECHNOLOGY STUDIES
James F. Ehlert, National Security Agency Cryptologic Chair Professor
Edward Fisher, Lecturer
Department of Information Sciences
Sponsor: OSD

OBJECTIVE: Cooperative Operations and Applied Science and Technology Studies (COASTS) is an NPS-led research and development project focused on providing students with research opportunities with real-world needs and applications. It is multi-disciplinary, with contributions by students and faculty from several schools and departments at NPS, along with contributions by other nations.

COASTS is a combined Indonesian, Malaysian, Singaporean, Thai, and American research and development effort to investigate commercial, off-the-shelf command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) technologies to provide real-time situational awareness for multi-national, tactical, and remote decision makers in a cooperative environment. The capstone field experiment is conducted annually in May and June. COASTS-07 is the third iteration in the series and will build on the successes and lessons learned from the 2005 and 2006 field experiments. In 2007, COASTS also plans to employ some select technologies into two major multi-national Pacific Fleet exercises, specifically the U.S. Pacific Fleet exercise TALISMAN SABER 2007 (with COMSEVENTHFLT in Australia during June 2007) and COMLOG WESTPAC’s Southeast Asia Cooperation Against Terrorism (SEACAT) 2007 exercise (in Singapore from 14-22 August 2007).

CYBER DEFENSE UNMANNED AERIAL VEHICLE TRAINING AND COASTS FIELD EXPERIMENTATION PROGRAM
James F. Ehlert, National Security Agency Cryptologic Chair Professor
Department of Information Sciences
Sponsor: Naval Postgraduate School

OBJECTIVE: The COASTS program will research and test function solutions that directly support the key objectives in the June 2005 Department of Defense publication, “Strategy of Homeland Defense and Civil Support.”
IRAQI ENROLLMENT VIA VOICE AUTHENTICATION PROJECT
James F. Ehlert, National Security Agency Cryptologic Chair Professor
Department of Information Sciences
Sponsor: Department of Defense Finance and Accounting

SUMMARY: The Iraqi Enrollment via Voice Authentication Project is an Office of the Secretary of Defense-sponsored research project that explores the utility of voice authentication technologies that may potentially augment U.S. capabilities in Iraq, specifically at the Baghdad Correctional Facility.

IRAQI ENROLLMENT VIA VOICE AUTHENTICATION PROJECT PHASE 1C
James F. Ehlert, National Security Agency Cryptologic Chair Professor
Department of Information Sciences
Sponsor: Office of the Assistant Secretary of Defense

OBJECTIVE: To enhance operations at the Baghdad Correctional Facility (BCCF) by expediting and improving the visitation process, and thereby contributing to the security mission and the overall management of the detention facility and the detainees. To reduce the necessity for travel by visitors to schedule meetings with detainees at BCCF and to ease access to detainees on the day of visitation. To provide a method of generating a voice biometric database that will be of potential intelligence value in combating the insurgency in Iraq.

PACIFIC FLEET
James F. Ehlert, National Security Agency Cryptologic Chair Professor
Department of Information Sciences
Sponsor: Naval Postgraduate School

OBJECTIVE: To encourage collaboration between COMPACFLT and NPS faculty and students.

PROOF OF CONCEPT: DEMONSTRATION OF AUTOMATIC SPEECH RECOGNITION TECHNOLOGY IN SUPPORT OF VISITATION OPERATIONS AT THE BAGHDAD CENTRAL CORRECTION FACILITY
James F. Ehlert, National Security Agency Cryptologic Chair Professor
Department of Information Sciences
Sponsor: Office of the Assistant Secretary of Defense

OBJECTIVE: To create a pilot system using existing commercial, off-the-shelf (COTS) technologies in order to help manage detention visitation at the Baghdad Central Correctional Facility (BCCF), formerly known as the Abu Ghraib Detention Facility. This system will serve as a proof-of-concept system in the demonstration and pilot evaluation of an Arabic voice-activated menu-driven phone system using existing COTS automated speech recognition technology in order to expedite a visitor's entry to a controlled facility/secure space (Abu Ghraib).

INTEROPERABLE BY DESIGN: ENGINEERING FORCENET CHAT FOR INTEGRATION WITH EXISTING JOINT AND COALITION COLLABORATION ARCHITECTURES
Capt. Bryan Evito, USMC
Department of Information Sciences
Sponsor: SPAWAR Systems Center-San Diego

OBJECTIVE: To extend the Navy's FORCEnet maritime chat requirements (being defined in the Trident Warrior experiments) to include requirements allowing the integration of the FORCEnet chat architecture with joint, coalition, and other services' chat architectures, focusing primarily on those actually employed by the combatant commands.
IMPLEMENTATION OF FORCENET ATTRIBUTES AND MEASURES SCHEMA  
Shelley P. Gallup, Research Associate Professor
Department of Information Sciences  
Sponsor: Naval Network Warfare Command

SUMMARY: Provided knowledge management design and support for Naval Network Warfare Command experimentation and reporting.

NAVAL POSTGRADUATE SCHOOL SUPPORT TO OPNAV N71  
Shelley P. Gallup, Research Associate Professor
Edgar Bates, Research Associate
Department of Information Sciences  
Sponsor: Chief of Naval Operations, N71F

SUMMARY: Provided analysis support to the Chief of Naval Operations in the area of command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR).

SUPPORT FOR EXTENDED AWARENESS EXPERIMENTATION PROGRAM  
Shelley P. Gallup, Research Associate Professor
Steven E. Pilnick, Research Associate Professor
Department of Information Sciences  
Sponsor: Joint Forces Command

OBJECTIVE: Joint Forces Command experiments will be independently assessed to determine potential solutions to current and future unmanned aerial vehicle and ISR systems interoperability shortfalls; the expected outcome of the assessment process is appropriate documentation of material and non-material improvements that can be pursued through Department of Defense processes for implementation.

SUPPORT FOR FORCENET INNOVATION AND EXPERIMENTATION PROGRAM  
Shelley P. Gallup, Research Associate Professor
William G. Kemple, Associate Professor
William Maule, Research Assistant Professor
Department of Information Sciences  
Sponsor: Naval Network Warfare Command

OBJECTIVE: To complete Trident Warrior 05 and related support activities; to provide similar support for the NETWARCOM FORCEnet innovation and experimentation events in fiscal year 2006, including any spiral development of technology, process, and measures that are to be included in the series of events leading up to and including Trident Warrior fiscal year 2006.

SUPPORT FOR FORCENET INNOVATION AND EXPERIMENTATION PROGRAM  
Shelley P. Gallup, Research Associate Professor
William G. Kemple, Associate Professor
William Maule, Research Assistant Professor
Department of Information Sciences  
Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: To complete Trident Warrior 05 and related support activities; to provide similar support for the NETWARCOM FORCEnet innovation and experimentation events in fiscal year 2006, including any spiral development of technology, process, and measures that are to be included in the series of events leading up to and including Trident Warrior fiscal year 2006.
SUPPORT FOR FORCENET SEA TRIAL EXPERIMENTATION PROGRAM
Shelley P. Gallup, Research Associate Professor
Department of Information Sciences
Sponsor: Naval Network Warfare Command

SUMMARY: As the principal analysis agent for FORCEnet experimentation, provided support for the FORCEnet Sea Trial Initiative: common operational picture, long endurance unmanned aerial vehicles, and networks in Trident Warrior 06, including exercising oversight of event objectives, ensuring that the events were designed to meet NAVNETWARCOM and N71F FORCEnet program objectives. Continued development and employment of NPS FIRE KM technology to help manage experiment planning and execution, archive data and experimentation results, and integrate results and program details for use in collaboration with related efforts.

SUPPORT FOR JOINT RAPTOR 06
Shelley P. Gallup, Research Associate Professor
Department of Information Sciences
Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: The Naval Postgraduate School (NPS) will act as the principal analysis consultant agency for Joint Raptor (JRAE) 06 experimentation. NPS will provide support for JRAE 06 initiatives, including GCCS/JTT, TBMCS, C2PC/OMA, AFATDS, HSI, and networks. Specifically, NPS will facilitate, and collaborate with SPAWAR subject matter experts in defining event objectives, ensuring that objectives are designed to meet NAVNETWARCOM and N71F FORCEnet program objectives. The NPS (FORCEnet Innovation and Research Enterprise) KM enterprise will be adapted as required to manage experiment planning and execution, archive data and experimentation results, and integrate results and program details for use in collaboration with related efforts.

SUPPORT FOR THE KU BAND LIMITED OBJECTIVE EXPERIMENT
Shelley P. Gallup, Research Associate Professor
William G. Kemple, Associate Professor
Department of Information Sciences
Sponsor: Naval Network Warfare Command

OBJECTIVE: As the principal analysis agent for FORCEnet experimentation, this project includes support for a FORCEnet Sea Trial-limited objective experiment that will assess the Ku band concept of operations as it relates to the ability to surge between MILSATCOM connectivity to commercial SATCOM connectivity to ensure persistent SATCOM availability.

SUPPORT FOR U.S. JOINT FORCES COMMAND EXTENDED AWARENESS 2006 EXPERIMENTATION
Shelley P. Gallup, Research Associate Professor
Steven E. Pilnick, Research Associate Professor
Department of Information Sciences
Sponsor: U.S. Joint Forces Command

OBJECTIVE: To provide experimentation and other analytical support to the extended awareness series of experiments conducted by the Joint Forces Command Joint Operational Testbed System.
COMMUNITY MODELS, MODEL-BASED COMMUNICATIONS, AND VIRT
Richard Hayes-Roth, Professor
Department of Information Sciences
Sponsor: Naval Sea Systems Command

OBJECTIVE: To increase productivity of operators by implementing VIRT services that provide each operator valuable information at the right time. The research will look for outstanding opportunities to prototype, demonstrate, and evaluate these concepts and related methods through collaboration with the Cooperative Engagement Capability program. In particular, the principal investigators (PI) will attempt to enhance and improve their efforts related to horizontal fusion and other appropriate experiments and programs. The PIs will attempt to stimulate wider Naval Postgraduate School interest in these topics, especially through related working groups within the newly-formed Consortium for the Grid, hosted by the Naval Postgraduate School.

COMMUNITY MODELS, MODEL-BASED COMMUNICATIONS, AND VIRT
Richard Hayes-Roth, Professor
Department of Information Sciences
Sponsor: Program Executive Office, Integrated Warfare Systems

OBJECTIVE: To increase productivity of operators by implementing VIRT services that provide each operator with valuable information at the right time. The research will look for outstanding opportunities to prototype, demonstrate, and evaluate these concepts and related methods through collaboration with the Cooperative Engagement Capability program. In particular, the principal investigators (PI) will attempt to enhance and improve their efforts related to horizontal fusion and other appropriate experiments and programs. The PIs will attempt to stimulate wider Naval Postgraduate School interest in these topics, especially through related working groups within the newly-formed Consortium for the Grid, hosted by the Naval Postgraduate School.

NAVAL POSTGRADUATE SCHOOL SUPPORT FOR COOPERATIVE MARITIME AWARENESS JOINT CONCEPT TECHNOLOGY DEMONSTRATION
Richard Hayes-Roth, Professor
Department of Information Sciences
Sponsor: Naval Research Laboratory

OBJECTIVE: To provide technical support to the technical manager, architecture, and engineering teams of the Cooperative Maritime Awareness (CMA) Joint Concept Technology Demonstration being conducted in partnership with Singapore. Work will be divided into two phases, an initial phase lasting approximately 3 months, and a follow-on phase lasting approximately twenty-seven months. In the first phase, the Naval Postgraduate School (NPS) will contribute to the development of the technology management plan, which will determine overall technical objectives, roles, and responsibilities for the CMA technology effort. In the second phase, NPS will perform appropriate work identified in the assigned management plan.

NAVAL RESEARCH LABORATORY COMPREHENSIVE MARITIME AWARENESS JOINT CONCEPT TECHNOLOGY DEMONSTRATION
Richard Hayes-Roth, Professor
Department of Information Sciences
Sponsor: Naval Research Laboratory

SUMMARY: Supported the Comprehensive Maritime Awareness Joint Concept Technology Demonstration technical manager in the development and assessment of the technical architecture. The principal investigator worked closely with Naval Research Laboratory personnel and numerous stakeholders, including the Office of Naval Intelligence and the U.S. Coast Guard. The principal investigator was assisted by U.S. Coast Guard officers who are Naval Postgraduate School students,
including LCDR Rusty Dash and LT Bob Creigh. This work focused on the development of quality attributes, scenarios, and the maritime information exchange model.

**NAVSEA PROGRAM EXECUTIVE OFFICE, INTEGRATED WARFARE SYSTEMS 6**
**COOPERATIVE ENGAGEMENT CAPABILITY**

Richard Hayes-Roth, Professor  
Department of Information Sciences  
Sponsor: Naval Sea Systems Command

**SUMMARY:** Continued research into valuable information at the right time (VIRT) and a rich semantic model of tracks. The principal investigator was assisted by Research Associate and Ph.D. student Curtis L. Blais. They continued to develop the semantic model of tracks and to promote this approach in several communities, especially the Maritime Domain Awareness community.

**PUBLICATIONS:**


**CONFERENCE PUBLICATIONS:**


EXTENDING THE TACTICAL INTERNET TO UNITED STATES MARINE CORPS DISTRIBUTED OPERATIONS UNITS
Capt. Glen Henton, USMC
Department of Information Sciences
Sponsor: Marine Corps Tactical Systems Support Activity

SUMMARY: Supported thesis research and experimentation in extending the tactical Internet to U.S. Marine Corps distributed-operations users.

FACILITATING THE PERFORMANCE OUTCOMES
Thomas J. Housel, Professor
Department of Information Sciences
Sponsor: Spatial Integrated Systems, Inc.

OBJECTIVE: This cooperative research will focus on exploring the business process improvements enabled through the use of a “virtual” planning capability. It is theorized that introducing integrated scanning technology systems with collaborative software functionalities (i.e., knowledge management, data access, and re-use) will quickly enable process improvements to the Navy’s existing planning and engineering process. This study will seek to either validate or disprove this theory. Metrics for research will be identified and analyzed, and a report will be completed that will detail conclusions, validations, and lessons learned. The study will also recommend a strategy for integrating these technologies into the existing Navy planning and engineering process.

FACILITATING THE PERFORMANCE OUTCOMES AND ACCELERATING THE EFFECTIVE USE OF COLLABORATIVE TECHNOLOGIES IN NAVAL CORE PROCESSES
Thomas J. Housel, Professor
Department of Information Sciences
Sponsor: Spatial Integrated Systems, Inc.

SUMMARY: The Naval Postgraduate School was responsible for the following tasks: expanding the Collaborative Competence Survey Study to include several Navy organizations; exploring the potential return on investment for use of collaborative and 3D technologies in several additional core Department of Defense processes (primarily Navy); and examining the implications of the above for the acquisition of collaborative and 3D technologies (results to be presented at the 2007 Naval Postgraduate School Acquisition Conference.)

FACILITATING THE PERFORMANCE OUTCOMES AND ACCELERATING THE EFFECTIVE USE OF COLLABORATIVE TECHNOLOGIES IN NAVAL CORE PROCESSES
Thomas J. Housel, Professor
Department of Information Sciences
Sponsor: Spatial Integrated Systems, Inc.

SUMMARY: The Department of Information Sciences at the Naval Postgraduate School requires financial valuation expertise in Knowledge Valuation Analysis (KVA) for research being conducted regarding the acquisition process. Specifically, there is a need for research on the use of real options and KVA in the acquisition context.
IMPLEMENTING DECISION SUPPORT TOOLS FOR THE INTELLIGENCE COLLECTION
SYSTEMS BUDGETING PROCESS
Thomas J. Housel, Professor
Department of Information Sciences
Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: To implement a fleet-wide decision support methodology and software tool set to assist in monitoring the performance of intelligent systems.

IMPLEMENTING DECISION SUPPORT TOOLS FOR THE INTELLIGENCE COLLECTION
SYSTEMS PORTFOLIO MANAGEMENT PROCESS
Thomas J. Housel, Professor
Department of Information Sciences
Sponsor: Chief of Naval Operations – Space and Naval Warfare Systems Command

OBJECTIVE: To implement a fleet-wide decision support methodology and software tool set to assist in monitoring the performance of intelligence information systems. The results of this decision support activity will aid the Chief of Naval Operations N20 executives.

SYSTEM-DYNAMICS REAL-OPTIONS ANALYSIS
Thomas J. Housel, Professor
Department of Information Sciences
Sponsor: Boeing

OBJECTIVE: The purpose of this research is to support the efforts of the Boeing Phantom Works team in their use of Vensim modeling tolls to support the GEOS team’s modeling of Advanced NCO. The Naval Postgraduate School (NPS) team will review the GEOS team’s model for advanced network centric operations. The NPS team will create the software interface of Johnathan Mun’s real-options risks-analysis software to the Boeing team’s Vensim modeling tool. The NPS team will make a presentation for Phantom Works in Seattle on the results of this research GEOS project.

USING KNOWLEDGE VALUATION AND REAL OPTIONS TO QUANTIFY THE VALUE OF ACQUISITION OPTIONS IN THE NAVAL OPEN ARCHITECTURE PROGRAM
Thomas J. Housel, Professor
Department of Information Sciences
Sponsor: Program Executive Office, Integrated Warfare Systems

SUMMARY: This research focused on identifying the best approach for using collaborative technology to support OA acquisition-system lifecycle management. This research attempted to establish the required level of “collaborate competence” to ensure successful use of collaborative technologies among system design, development, testing, and deployment teams. Collaborative technology will only succeed if those OA system lifecycle team members can use it competently. Because of the increased management overhead required to make the OA approach successful, it is also critical to examine and monitor the value added by management at all levels. The knowledge value added approach provides a framework for measuring the value added by management, as well as all other productive assets, throughout the system lifecycle. Determining the value added by management is necessary to understand the interdependence of collaborative technologies capabilities and management’s contribution to the increased productivity promised by the OA approach.
VALUATION AND RISK ASSESSMENT OF RAPID EQUIPPING FORCE OPTIONS
Thomas J. Housel, Professor
Department of Information Sciences
Sponsor: TRAC Monterey

OBJECTIVE: To work with subject matter experts in a given war fighting process to identify Rapid Equipping Force (REF) technology insertion options of interest to senior stakeholders to generate a proof-of-concept methodology case example and research report. The methodology will be supported by productivity (ROI) analysis software. The case example will be used to teach decision makers, and those that support decision makers, how to use the methodology to quickly assess the value of given REF technology insertion options.

COLLABORATION AND KNOWLEDGE MANAGEMENT
Susan G. Hutchins, Research Assistant Professor
Department of Information Sciences
Sponsor: Office of Naval Research

OBJECTIVE: The Naval Postgraduate School is proposing a one-year effort, under the Collaboration and Knowledge Management program, to assist in critiquing the model of team collaboration. This model emphasizes cognitive aspects of the collaboration process and includes the major cognitive processes that underlie this type of communication.

THE DEVELOPMENT OF A PROTOTYPE KNOWLEDGE MANAGEMENT SYSTEM FOR MARITIME DOMAIN DATA SOURCES
Magdi N. Kamel, Associate Professor
Department of Information Sciences
Sponsor: Naval Postgraduate School

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

SUMMARY: A three-year research effort, under the Adaptive Architectures for Command and Control program, emphasizing the analysis and design of expeditionary strike group command-and-control architectures.

JOINT INTELLIGENCE INTEROPERABILITY BOARD (JIIB) SYSTEMS BASELINE ASSESSMENT-CM (JSBA-CM)
William G. Kemple, Associate Professor
Richard A. Kimmel, Research Associate
Department of Information Sciences
Sponsor: U.S. Joint Forces Command

SUMMARY: Provided modeling, simulation, and analysis support for the Joint Intelligence Operability Board fiscal year 2006 experiment, JSBA-CM.
OBJECTIVE: The Department of Information Sciences shall assess JSBA-related study requirements and methodologies; research and develop JSBA 06 architecture analyses; design, develop, organize, and maintain JSBA process model(s) and tools and the associated data; execute model run activities; and analyze results. The PI shall conduct analytical support to the JIIB team, including scenario development and verification, execution of model runs, and direct analyses for a variety of intelligence, surveillance, and reconnaissance assessments as part of JSBA 06. The PI shall develop reports that document the analytic products developed.

OBJECTIVE: To assess JSBA-related study requirements and methodologies; to research and develop JSBA 06 architecture analyses; to design, develop, organize, and maintain JSBA process model(s) and tools and the associated data.

OBJECTIVE: To validate the idea that the Network, Structure, Tasks, Activities, and Roles (NETSTAR) Process-A combination of advanced pattern recognition techniques and a quantitative theory of organizations allows decision makers to achieve more effective disruption of enemy activities by identifying the enemy command and control organization. This includes the roles of tracked individuals in the organization, control of resources, communications network(s), and responsibilities for tasks of both individuals and assets of the organization.

SUMMARY: Richard A. Kimmel, Research Associate, was selected for the Office of Naval Research (ONR) Science and Technology (S&T) Advisor program in fiscal year 2005 and remained detailed to Commander, Third Fleet, San Diego, California, through calendar year 2006. Under this program S&T Advisors remain attached to their home command and ONR funds this billet directly to the Advisor’s home command. Science and Technology Advisors are civilian scientists and engineers selected through a nationwide competition from the Naval technical community to participate in this career development tour. They serve as the representative of the Commander on interactions with S&T organizations in government,
academia, and industry. They assist and advise the host command in the identification of needs that have a critical impact on combat readiness. They also support the Department of Navy S&T and research and development communities to provide rapid technology insertion, long-term investment leverage, and surge capability in support of high priority fleet/force issues. The Science Advisors are concerned with programs relating to all aspects of naval warfare.

POSTURING U.S. INFORMATION OPERATIONS FOR THE GLOBAL WAR ON TERROR AND BEYOND

Maj. Tara Lewelling, USAF
Department of Information Sciences
Sponsor: SPAWAR Systems Center-San Diego

SUMMARY: When combined with other effects-based actions, it is postulated that Information Operations (IO) provide asymmetric advantage for U.S. military operations. In reality, however, there is a distinct difference between acquiring asymmetric capabilities for the battlefield and ensuring asymmetric advantage on the battlefield. In order to achieve its full promise, U.S. IO plans and programs must concentrate not only on the creation of capabilities that enable the potential of asymmetric action, but must also enable strategy, tactics, and theoretical underpinnings that translate this potential into asymmetric advantage relative to the types of conflicts U.S. forces will face for the next 10-25 years.

EFFECTIVENESS OF A COMMERCIAL, OFF-THE-SHELF 802.11 WIRELESS MESH NETWORK IN SUPPORT OF MULTI-MISSION OPERATIONS RELATIVE TO HASTILY FORMED SCALABLE DEPLOYMENTS

Lt. Rob Lounsbury, USAF
Department of Information Sciences
Sponsor: SPAWAR Systems Center-San Diego

OBJECTIVE: To evaluate the effectiveness of a commercial, off-the-shelf 802.11 wireless mesh network in supporting multi-mission operations relative to hastily formed scalable deployments.

EDISON VKR TXC WEB SERVICE INTEGRATION

William Maule, Research Assistant Professor
Shelley P. Gallup, Research Associate Professor
Department of Information Sciences
Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: To develop Edison as an independent resource to provide web services to TXC/VKR and receive web services from TXC/VKR, with appropriate security provisions. The Edison infrastructure will be linked to the fire system via grid technology and to TXC/VKR via web services. A major focus of the effort will be an integrated workflow process for future collaborative web services and grid computing development between SPAWAR and the Naval Postgraduate School.

CENTER FOR EDGE POWER

Mark E. Nissen, Professor
Department of Information Sciences and Graduate School of Business and Public Policy
Sponsor: Office of the Assistant Secretary of Defense – Networks and Information Integration

OBJECTIVE: To foster, coordinate, and promote multidisciplinary research on all elements of network-centric operations (e.g., including concepts, organization, command and control, management, doctrine, personnel, technology).
SUMMARY: In fiscal year 2004, the Department of Defense (DoD) Command and Control Research Program (CCRP) launched a set of related initiatives designed to explore innovative behaviors, organizations, and technologies, and their implications for command and control (C2). One of the established initiatives is the Virtual Edge Institute: a network of research centers located at colleges, universities, and research organizations, both within the DoD and in the private sector. The first of these Centers—the Center for Edge Power—was established, through funding from the Office of the Assistant Secretary of Defense for Networks and Information Integration, for innovative C2 research at the Naval Postgraduate School (NPS). Associate Professor Mark Nissen serves as the Director of this Center.

The Center for Edge Power fosters, coordinates, and promotes multidisciplinary research on all elements of network-centric operations (e.g., including concepts, organization, command and control, management, doctrine, personnel, technology). The term “edge” derives from the seminal book entitled Power to the Edge (Alberts and Hayes, 2003), which depicts new ways of organizing military forces and enabling more powerful warfare by leveraging shared awareness and dynamic knowledge. The central premise is that power (i.e., the capability to accomplish intended actions) needs to flow from the centers of military organizations to their edges. Using this metaphor, “center” refers principally to headquarters (e.g., where decision makers request information from the field), and “edge” refers principally to front lines (e.g., where combatants—at the pointy end of the metaphorical spear—fight wars). The concept clearly involves more than simply realigning organizational charts and realigning decision rights. People at the edges of organizations must be aware of command intent; know how to accomplish tasks, activities, and processes; and be able to self-organize and self-synchronize to achieve the desired effects.

Although the Center for Edge Power focuses on military organizations and problems, the edge concept also applies well to business, government, and other organizational domains. For instance, the edge of a business organization is where customer interactions take place. Approaches to work, organization, management, and technology other than the Edge will also be conceived, investigated, and refined, and a fluid flow of concepts and applications, both to and from public- and private-sector organizations, is envisioned.

PUBLICATIONS:


CONFERENCE PUBLICATIONS:


CONFERENCE PRESENTATIONS:


WORKING PAPERS:


KEYWORDS: Command and Control, Edge, Knowledge, Knowledge Flow, Knowledge Management, Knowledge Superiority, Modeling and Simulation, Organizational Design

NAVAL INFORMATION WARFARE ACTIVITY INFORMATION WARFARE/INFORMATION OPERATIONS RESEARCH AND CURRICULUM SUPPORT

Maj. Carl Oros, USMC, Lecturer
Department of Information Sciences
Sponsor: Naval Information Warfare Activity

SUMMARY: Earlier correspondence with the Naval Information Warfare Activity (NIWA) has indicated a plan to provide a total of $95,000 to the Naval Postgraduate School in fiscal year 2006. This is a decrease from the fiscal year 2005 amount of $130,000, and an overall historical down-trend from the originally programmed $200,000. Per precedent, expect NIWA to submit fiscal year allocated funds on a quarterly basis throughout fiscal year 2006.

UNITED STATES MARINE CORPS WARFIGHTING LAB SUPPORT COMPANY AND BELOW WIRELESS NETWORK INFRASTRUCTURE AND MANAGEMENT PROJECT

Maj. Carl Oros, USMC, Lecturer
Department of Information Sciences
Sponsor: Marine Corps Warfighting Laboratory

OBJECTIVE: To provide technical research, component recommendation, and testing in support of the Marine Corps Warfighting Lab's (MCWL) Company and Below Wireless Network Infrastructure and Management (WNIM) project. Additionally, the Naval Postgraduate School will assist MCWL in conducting testing during the WNIM limited technology assessments.
OBJECTIVE: Traditional authentication mechanisms are implemented by answering three questions: a) what you have, b) what you know, and c) who you are; traditional biometrics (fingerprints, hand geometry, and iris) subscribe to this model. However, there is recent interest in behavioral biometrics, which in addition to the three questions posed above addresses a fourth question as to how the biometrics were generated. Voice and dynamic signature are two well-known behavioral biometrics. While traditional biometrics become weaker as authentication tools with increased usage, the behavioral biometrics become stronger as authentication tools with increased usage.

In this context, researchers are studying a specific behavioral biometric called the Bio-Pen (manufactured by DynaSig) and evaluating the effectiveness of that tool as an authentication device.

SUMMARY: The Bio-Pen was successfully tested at COASTS Test II at Fort Hunter Legget in January 2007. Lt. Kenton Odgers will be completing and submitting his thesis on the use of behavioral biometrics for authentication by 31 March 2007.

IRAQI ARABIC VOICE AUTHENTICATION

OBJECTIVE: Random acts of violence due to terrorism in Iraq have highlighted the need for a secure authentication mechanism to protect the lives of U.S. and Iraqi citizens. In addition, an October 2006 report by the Special Inspector General for Iraq Reconstruction has identified other serious problems in terms of rampant corruption and the inability to manage funds in Iraq. It is believed that billions of dollars might have been stolen due to lack of proper, feasible, authentication mechanisms.

Though other biometrics, such as fingerprint, face, and iris, have been installed they do not seem to be effective given the lack of appropriate infrastructure to support such mechanisms. In this context, with the minimal availability of phones (land lines and cellular), voice authentication technology seems the most practical and potential scheme to protect the lives of U.S. and Iraqi citizens, as well as bring sanity to financial transaction processes in Iraq.

This project, in collaboration with Nuance, is developing an Iraqi Arabic Voice authentication tool. Major Jeff Withee and Captain Eddie Pena are graduate students developing a concept of operations for possible financial-transaction applications using Iraqi Arabic Voice authentication. They will also independently test the accuracy of the Iraqi Arabic authentication system.

SUMMARY: The Iraqi Arabic Voice Authentication project is on schedule and is expected to be completed by 31 May 2007. The Iraqi Arabic Grammar and Language Model have been completed. The Nuance Caller Authentication system in Iraqi Arabic will be completed by 15 March 2007.

A briefing on the use of Iraqi Arabic Authentication for financial applications was presented to Dr. Linton Wells, III, Principal Deputy Assistant Secretary of NII (OSD). Researchers are in the process of presenting a more complete briefing to other interested agencies at the Department of Defense.

LICENSE PLATE RECOGNITION

OBJECTIVE: One of the ways to secure access to government buildings such as foreign embassies is to install a license plate recognition (LPR) system at the entrance and exit gates of such facilities. The LPR
The system will have long-range digital cameras mounted at strategic locations to best capture the license plate image of an inbound or outbound vehicle.

The system will detect the license plate in real-time, match it against a watch list of authorized and unauthorized visitors, and alert local law enforcement authorities of possible unauthorized infringements.

The Naval Postgraduate School is working with Kestrel Corporation and has submitted a research proposal to CNTPO to develop and field a system for field testing in Thailand for an LPR system that will recognize Thai license plates.

**SUMMARY:** A research proposal for the recognition of license plates in Thailand has been submitted to CNTPO and is in the final stages of being funded.

**KEYWORDS:** Collaborative Information Environment, Military Transformation, Mobile Computing, Unattended Sensor Systems, Unmanned Aerial Vehicle, UAV, Unmanned Autonomous Systems, UAS, Wireless Networking, Biometrics, Reachback, Disadvantaged User, 802.11, 802.16

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**COASTS PROGRAM COLLABORATION AND TACTICAL/EMERGENCY RESPONSE SERVICES MONITORING, SURVEILLANCE, AND TARGETING SYSTEMS INTEGRATION**

Brian D. Steckler, Lecturer
James F. Ehlert, National Security Agency Cryptologic Chair Professor
Department of Information Sciences
Sponsor: Mercury Data Systems

**OBJECTIVE:** The Naval Postgraduate School and Mercury Data Systems will co-develop various solutions in support of homeland defense, border and port security, law enforcement, emergency response, telecommunications and data security, leveraging technologies suitable for surveillance, targeting, wireless communications, manned/unmanned sensors, and graphically-displayed GPS-enabled situational awareness systems.

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**HASTILY FORMED NETWORKS SUPPORT FOR HUMANITARIAN ASSISTANCE/DISASTER RELIEF RESEARCH AND DEVELOPMENT**

Brian D. Steckler, Lecturer
Rex A. Buddenberg, Senior Lecturer
Department of Information Sciences
Sponsor: Office of the Secretary of Defense

**SUMMARY:** The Naval Postgraduate School (NPS) is responding to Hurricane Katrina by providing rapidly-deployed wireless-communications capabilities to Joint Task Force Katrina in support of the Department of Defense’s requirements for command and control, as well as for ongoing NPS research in hastily formed networks for humanitarian assistance/disaster relief.

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**NAVAL POSTGRADUATE SCHOOL/COMMANDER, PACIFIC FLEET/USNS MERCY INMARSAT BGAN SERVICES PROPOSAL**

Brian D. Steckler, Lecturer
Department of Information Sciences
Sponsor: U.S. Pacific Fleet

**SUMMARY:** This project enabled Commander, Pacific Fleet to provide funding to the Naval Postgraduate School to cover service costs for the USNS Mercy’s use of the Naval Postgraduate School Hughes 9201 BGAN satellite Internet access device during the USNS Mercy’s 2006 Southeast Asian humanitarian operations outreach cruise.
NAVAL POSTGRADUATE SCHOOL/DEFENSE MANPOWER DATA CENTER HASTILY FORMED NETWORKS/NONCOMBATANT EVACUATION OPERATIONS TRACKING SYSTEMS COLLABORATION PROPOSAL
Brian D. Steckler, Lecturer
Department of Information Sciences
Sponsor: Office of the Secretary of Defense

SUMMARY: Enabled the Naval Postgraduate School (NPS) to collaborate with the Defense Manpower Data Center (DMDC) on integration of the NPS’ hastily formed networks flyway kits and disaster communications capabilities for humanitarian assistance/disaster relief with the DMDC Noncombatant Evacuation Operations Tracking System.

EXTENDING THE TACTICAL INTERNET TO U.S. MARINE CORPS DISTRIBUTED OPERATIONS UNITS
Capt. Justin R. Swick, USMC
Department of Information Sciences
Sponsor: MCTSSA

SUMMARY: Supported thesis research and experimentation in extending the tactical Internet to U.S. Marine Corps distributed operations users.

JOINT INTELLIGENCE VIRTUAL UNIVERSITY CULTURAL STUDIES DEVELOPMENT
John W. Van Hise, Jr., Research Associate Professor
Department of Information Sciences
Sponsor: Defense Intelligence Agency

SUMMARY: Managed, developed, and integrated a major cultural studies and language expansion of the Joint Intelligence Virtual University using synchronous, asynchronous, and blended courseware.

IP CENTER OF EXCELLENCE
LCDR Reese Zomar, USN
Department of Information Sciences
Sponsor: Naval Network Warfare Command

SUMMARY: Supported and enabled the IP Center of Excellence to continue class/lab standup, fulfilling community education requirements.
DEPARTMENT OF INFORMATION SCIENCES

2006
Faculty Publications and Presentations
INFORMATION SCIENCES

PUBLICATIONS


CONFERENCE PUBLICATIONS


INFORMATION SCIENCES


PRESENTATIONS


BOOKS


OVERVIEW:

The Naval Postgraduate School’s 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’s 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)-FY2006:

The Naval Postgraduate School’s sponsored program exceeded $81 million in FY2006. 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: $3.7M
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<tr>
<th>Name</th>
<th>Title</th>
<th>Office</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eagle, James D.</td>
<td>Professor and Chairman</td>
<td>656-2654</td>
<td><a href="mailto:jeagle@nps.edu">jeagle@nps.edu</a></td>
</tr>
<tr>
<td>Wood, R. Kevin</td>
<td>Professor and Associate Chairman for Research</td>
<td>656-2523</td>
<td><a href="mailto:kwood@nps.edu">kwood@nps.edu</a></td>
</tr>
<tr>
<td>Alderson, David</td>
<td>Assistant Professor</td>
<td>656-1814</td>
<td><a href="mailto:dlalders@nps.edu">dlalders@nps.edu</a></td>
</tr>
<tr>
<td>Dell, Robert</td>
<td>Associate Professor</td>
<td>656-2853</td>
<td><a href="mailto:dell@nps.edu">dell@nps.edu</a></td>
</tr>
<tr>
<td>Jacobs, Patricia A.</td>
<td>Professor</td>
<td>656-2258</td>
<td><a href="mailto:paja@nps.edu">paja@nps.edu</a></td>
</tr>
<tr>
<td>Annis, David</td>
<td>Assistant Professor</td>
<td>656-2530</td>
<td><a href="mailto:annis@nps.edu">annis@nps.edu</a></td>
</tr>
<tr>
<td>Ewing, Lee, MAJ, USA</td>
<td>Military Faculty</td>
<td><a href="mailto:plewing@nps.edu">plewing@nps.edu</a></td>
<td></td>
</tr>
<tr>
<td>Kline, Jeffrey</td>
<td>Senior Lecturer, Program Director, Center for Executive Education</td>
<td>656-7946</td>
<td><a href="mailto:jeke@nps.edu">jeke@nps.edu</a></td>
</tr>
<tr>
<td>Bradley, Gordon H.</td>
<td>Professor</td>
<td>656-2359</td>
<td><a href="mailto:gbradley@nps.edu">gbradley@nps.edu</a></td>
</tr>
<tr>
<td>Fricker, Ron</td>
<td>Associate Professor</td>
<td>656-3048</td>
<td><a href="mailto:rdfricker@nps.edu">rdfricker@nps.edu</a></td>
</tr>
<tr>
<td>Koyak, Robert A.</td>
<td>Associate Professor</td>
<td>656-2688</td>
<td><a href="mailto:rakoyak@nps.edu">rakoyak@nps.edu</a></td>
</tr>
<tr>
<td>Brown, Gerald G.</td>
<td>Distinguished Professor</td>
<td>656-2140</td>
<td><a href="mailto:gbrown@nps.edu">gbrown@nps.edu</a></td>
</tr>
<tr>
<td>Gaver, Donald</td>
<td>Distinguished Professor</td>
<td>656-2605</td>
<td><a href="mailto:dgaver@nps.edu">dgaver@nps.edu</a></td>
</tr>
<tr>
<td>Kress, Moshe</td>
<td>Professor</td>
<td>656-3647</td>
<td><a href="mailto:mkress@nps.edu">mkress@nps.edu</a></td>
</tr>
<tr>
<td>Buttrey, Samuel E.</td>
<td>Associate Professor</td>
<td>656-3035</td>
<td><a href="mailto:buttrey@nps.edu">buttrey@nps.edu</a></td>
</tr>
<tr>
<td>Hernandez, Andy, LTC, USA</td>
<td>Military Faculty</td>
<td>656-2663</td>
<td><a href="mailto:ahernandez@nps.edu">ahernandez@nps.edu</a></td>
</tr>
<tr>
<td>Lin, Kyle</td>
<td>Assistant Professor</td>
<td>656-2648</td>
<td><a href="mailto:klin@nps.edu">klin@nps.edu</a></td>
</tr>
<tr>
<td>Carlyle, Matthew</td>
<td>Associate Professor</td>
<td>656-2106</td>
<td><a href="mailto:mcarlyle@nps.edu">mcarlyle@nps.edu</a></td>
</tr>
<tr>
<td>Hoivik, Thomas H.</td>
<td>Senior Lecturer</td>
<td>656-2040</td>
<td><a href="mailto:thhoivik@nps.edu">thhoivik@nps.edu</a></td>
</tr>
<tr>
<td>Lucas, Thomas W.</td>
<td>Associate Professor</td>
<td>656-3039</td>
<td><a href="mailto:twlucas@nps.edu">twlucas@nps.edu</a></td>
</tr>
<tr>
<td>Crowson, Jeffrey</td>
<td>Assistant Professor</td>
<td>656-2618</td>
<td><a href="mailto:jcrowson@nps.edu">jcrowson@nps.edu</a></td>
</tr>
<tr>
<td>Hughes, Wayne</td>
<td>Professor</td>
<td>656-2484</td>
<td><a href="mailto:wphughes@nps.edu">wphughes@nps.edu</a></td>
</tr>
<tr>
<td>Maher, Kevin J., CDR, USN</td>
<td>Military Instructor</td>
<td>656-2691</td>
<td><a href="mailto:kjmaher@nps.edu">kjmaher@nps.edu</a></td>
</tr>
<tr>
<td>Name</td>
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<tr>
<td>McCauley, Michael</td>
<td>Research Professor</td>
<td>656-2191</td>
<td><a href="mailto:memcaaul@nps.edu">memcaaul@nps.edu</a></td>
</tr>
<tr>
<td>Posadas, Sergio, LtCol, USMC</td>
<td>Military Instructor</td>
<td>656-7626</td>
<td><a href="mailto:sposadal@nps.edu">sposadal@nps.edu</a></td>
</tr>
<tr>
<td>Schrady, David A.</td>
<td>Distinguished Professor Emeritus</td>
<td>656-2801</td>
<td><a href="mailto:dschrady@nps.navy">dschrady@nps.navy</a></td>
</tr>
<tr>
<td>Meyer, David, LCDR, USN</td>
<td>Military Faculty</td>
<td>656-3647</td>
<td><a href="mailto:dwmeyer@nps.edu">dwmeyer@nps.edu</a></td>
</tr>
<tr>
<td>Rosenthal, Richard E.</td>
<td>Professor</td>
<td>656-2795</td>
<td><a href="mailto:rosenthal@nps.edu">rosenthal@nps.edu</a></td>
</tr>
<tr>
<td>Shattuck, Lawrence</td>
<td>Senior Lecturer</td>
<td>656-2473</td>
<td><a href="mailto:lgshattu@nps.edu">lgshattu@nps.edu</a></td>
</tr>
<tr>
<td>Miller, Nita</td>
<td>Visiting Assistant Professor</td>
<td>656-2281</td>
<td><a href="mailto:nlmiller@nps.edu">nlmiller@nps.edu</a></td>
</tr>
<tr>
<td>Rowe, Anton</td>
<td>Research Assistant Professor</td>
<td>656-2385</td>
<td><a href="mailto:arowe@nps.edu">arowe@nps.edu</a></td>
</tr>
<tr>
<td>Szechtm, Roberto</td>
<td>Assistant Professor</td>
<td>656-3311</td>
<td><a href="mailto:rszechtm@nps.edu">rszechtm@nps.edu</a></td>
</tr>
<tr>
<td>Mislick, Gregory</td>
<td>Lecturer</td>
<td>656-3113</td>
<td><a href="mailto:gkmislic@nps.edu">gkmislic@nps.edu</a></td>
</tr>
<tr>
<td>Royset, Johannes</td>
<td>Research Assistant Professor</td>
<td>656-2578</td>
<td><a href="mailto:joroyset@nps.edu">joroyset@nps.edu</a></td>
</tr>
<tr>
<td>Taylor, James G.</td>
<td>Professor</td>
<td>656-2683</td>
<td><a href="mailto:jtaylor@nps.edu">jtaylor@nps.edu</a></td>
</tr>
<tr>
<td>Nussbaum, Daniel</td>
<td>Visiting Professor</td>
<td>656-2387</td>
<td><a href="mailto:dnussbaum@nps.edu">dnussbaum@nps.edu</a></td>
</tr>
<tr>
<td>Salmeron, Javier</td>
<td>Research Assistant Professor</td>
<td>656-2779</td>
<td><a href="mailto:jsalmero@nps.edu">jsalmero@nps.edu</a></td>
</tr>
<tr>
<td>Washburn, Alan R.</td>
<td>Distinguished Professor Emeritus</td>
<td>656-3127</td>
<td><a href="mailto:awashburn@nps.edu">awashburn@nps.edu</a></td>
</tr>
<tr>
<td>Olde, Brent, LT, USN</td>
<td>Assistant Professor</td>
<td>656-3807</td>
<td><a href="mailto:baolde@nps.edu">baolde@nps.edu</a></td>
</tr>
<tr>
<td>Sanchez, Paul</td>
<td>Senior Lecturer</td>
<td>656-3053</td>
<td><a href="mailto:pjsanche@nps.edu">pjsanche@nps.edu</a></td>
</tr>
<tr>
<td>Whitaker, Lyn R.</td>
<td>Associate Professor</td>
<td>656-3482</td>
<td><a href="mailto:lwhitaker@nps.edu">lwhitaker@nps.edu</a></td>
</tr>
<tr>
<td>Olwell, David</td>
<td>Senior Lecturer</td>
<td>656-2281</td>
<td><a href="mailto:dholwell@nps.edu">dholwell@nps.edu</a></td>
</tr>
<tr>
<td>Sanchez, Susan M.</td>
<td>Professor</td>
<td>656-2780</td>
<td><a href="mailto:smsanche@nps.edu">smsanche@nps.edu</a></td>
</tr>
<tr>
<td>Widdis, Daniel B., LCDR, USN</td>
<td>Military Instructor</td>
<td>656-3040</td>
<td><a href="mailto:dbwiddis@nps.edu">dbwiddis@nps.edu</a></td>
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INTERDISCIPLINARY APPLIED STATISTICAL RESEARCH
David H. Annis, Assistant Professor
Department of Operations Research
Sponsor: Naval Postgraduate School

OBJECTIVE: To complete a number of works-in-progress. These projects include 1) object ranking methods based on paired comparison data; 2) characterization and improvement of antibacterial susceptibility testing; 3) alternative methods for determining probability of detection of material anomalies; and 4) probabilistic modeling of fatigue life in the presence of a threshold.

COMPLEX SYSTEMS ASSESSMENT PILOT
Gordon H. Bradley, Distinguished Professor
Department of Operations Research
Sponsor: Joint Chiefs of Staff

OBJECTIVE: To provide data on U.S. forces (blue layer) to support complex system modeling for counter-improvised explosive devices in Iraq. To provide data for scenarios and models.

IMPROVED EXPLOSIVE DEVICES-RESEARCH AND EDUCATION
Gordon H. Bradley, Distinguished Professor
Department of Operations Research
Sponsor: Office of Naval Research

OBJECTIVE: To support research and education on countering improvised explosive devices. The research includes analysis of sensor effectiveness and construction of system models of the insurgent organizations.

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

SUMMARY: Provided continued support of research in large-scale optimization, including development and implementation of constraint shortest-path methods for routing manned and unmanned military aircraft, and a system to dynamically display and analyze incident data from Operation Iraqi Freedom, and to further develop and distribute the Networks and Graph Markup Language (NaGML).

RESPONDING TO THE THREAT OF IMPROVISED, EXPLOSIVE DEVICES: ANALYTICAL MODELS AND SYSTEMS MODELS
Gordon H. Bradley, Distinguished Professor
Department of Operations Research
Sponsor: Naval Postgraduate School

OBJECTIVE: To develop analytical and systems models for countering improvised, explosive devices (IEDs) in Iraq.
OBJECTIVE: To support research in large-scale optimization, including development and implementation of a stochastic, network-interdiction model to maximize the probability of mission success.

LARGE-SCALE NETWORK ALGORITHMS
W. Matthew Carlyle, Associate Professor
R. Kevin Wood, Professor
Department of Operations Research
Sponsor: National Security Agency

OBJECTIVE: To provide support for continuing research on attacker-defender modeling, and to provide travel funds for Naval Postgraduate School faculty to deliver presentations on current research and discuss future research topics.

NETWORK INTERDICTION FOR INFORMATION OPERATIONS
W. Matthew Carlyle, Associate Professor
Department of Operations Research
Sponsor: National Security Agency

OBJECTIVE: To provide support for faculty to conduct research on applications of network interdiction models to problems in information operations, and to provide funds for faculty and student travel to visit the NSA/CSS Threat Operations Center for collaboration, project meetings, and student experience tours.

STRATEGIC MOBILITY/COMBAT LOGISTICS ANALYSIS AND ASSESSMENTS
W. Matthew Carlyle, Associate Professor
Department of Operations Research
Sponsor: Chief of Naval Operations, N421

SUMMER PROGRAM IN OPERATIONS RESEARCH TECHNOLOGY PROGRAM DEVELOPMENT
W. Matthew Carlyle, Associate Professor
Department of Operations Research
Sponsor: National Security Agency

SUMMARY: Provided labor and travel support for the Principal Investigator to participate as the Distinguished Visiting Professor in the Operations Research, Modeling, and Simulation group's Summer Program in Operations Research Technology.

MODELING AND SIMULATION SUPPORT FOR TRADOC ANALYSIS COMMAND
Jeffrey Crowson, Assistant Professor
Department of Operations Research
Sponsor: TRADOC Analysis Center-Monterey

OBJECTIVE: To systematically assess a wide range of combat (and non-combat) stressors in the field. This would help answer three key questions regarding soldier stress reactions. To develop a model of the
relative contributions of these stressors and to determine at what point the cumulative effects of the stress lead to the point at which a soldier “snaps” and is unable to function.

AIR ROUTING TO MOVE PALLETs AND PEOPLE
Robert F. Dell, Associate Professor
Department of Operations Research
Sponsor: U.S. Central Command Deployment Distribution Operations

OBJECTIVE: To provide continuing research, support, and development of optimization models for the United States Central Command Deployment Distribution Operations Center. In the short term, the proposed research focuses on development of an optimal channel (also called a milk run) for each aircraft to fly daily for the next month. (U)

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

OBJECTIVE: To provide continuing research, support, and development of optimization models for the Army Assistant Chief of Staff for Installation Management.

ANALYTICAL SUPPORT TO THE JHSV PROGRAM OFFICE FOR PREPARATION OF CAPABILITY DEVELOPMENT DOCUMENT
LCDR Pamela Dozier, USN
Department of Operations Research
Sponsor: Naval Sea Systems Command

OBJECTIVE: Analytical support to joint high-speed vessel (JHSV) program office.

CENTER FOR ARMY ANALYSIS ANALYTICAL SUPPORT
LTC Lee Ewing, USA, Military Faculty
Department of Operations Research
Sponsor: Center for Army Analysis

OBJECTIVE: To provide research, support, and development of analytical tools to assist the Director of the Center for Army Analysis in the fulfillment of his mission.

DEVELOPING AND EVALUATING ADVANCED STATISTICAL METHODS FOR EARLY DETECTION OF BIOTERRORISM VIA SYNDROMIC SURVEILLANCE WITH APPLICATION TO HOMELAND SECURITY
Ronald D. Fricker, Jr., Associate Professor
Department of Operations Research
Sponsor: Naval Postgraduate School

OBJECTIVE: A critical problem related to biological terrorism is the early detection of the release of a biological toxin - the faster an incident of bioterrorism can be detected, the quicker measures can be taken to mitigate its effect. The objectives of this research are to 1) appropriately modify and extend existing statistical methods, 2) develop new methods, and 3) assess the various methods’ performance for the problem of syndromic surveillance, which is the real-time or near real-time analysis of health care data related to pre-identified sets of symptoms that are potential precursors of a bioterrorism incident.
OBJECTIVE: To develop quantitative evaluations of asset and algorithmic portfolios for adequate actionable information exchange between the finer-grained tactical picture and continuous broad-area surveillance for maritime-domain protection.

SUMMARY: Supported and enhanced the testing capabilities of the Director, Operational Test and Evaluation (DOT&E); assisted DOT&E in vigorously promoting the value of appropriate testing; and tested result analysis and application. Direction and efforts were reviewed and guided by the DOT&E Science Advisor (SA, D).

SUMMARY: Monies to support Naval Postgraduate School (NPS) Temasek research.

SUMMARY: Conducted a 3-day planning meeting to create focus study plans.

SUMMARY: Funded student and faculty research sponsored by the Naval Warfare Development Command (NWDC) per the memorandum of agreement of 14 May 2002 between NWDC and the Naval Postgraduate School.
OPERATIONS RESEARCH

JOINT DEFENDER TEST AND EVALUATION
CAPT Jeffrey E. Kline, USN (Ret.), Senior Lecturer
Department of Operations Research
Sponsor: Naval Warfare Development Command

SUMMARY: This research supported the testing, evaluation, and modification of the operational prototype planning tool Joint Defender, an optimization-based system for locating platforms for Theater Ballistic Missile Defense. Joint Defender was created and delivered to the Navy Warfare Development Command (NWDC) in May 2006 by the Naval Postgraduate School Department of Operations Research. This research involved two phases at the request of the NWDC.

MARITIME SECURITY EDUCATION
CAPT Jeffrey E. Kline, USN (Ret.), Senior Lecturer
Department of Operations Research
Sponsor: Naval Postgraduate School

OBJECTIVE: Presentation of issues and approaches in field of maritime security for graduate education.

NAVAL POSTGRADUATE SCHOOL COST ANALYSIS SUPPORT FOR CAIG
Robert A. Koyak, Associate Professor
Department of Operations Research
Sponsor: Office of the Secretary of Defense Program Analysis and Evaluation

OBJECTIVE: To support activities related to the Principal Investigator's role as chairman of cost analysis at the Naval Postgraduate School during calendar year 2006. This includes support for faculty and students.

RESEARCH ON DEFINING THE RELATIONSHIP BETWEEN ETS AND NAVAL AVIATION MAINTENANCE PERFORMANCE
Robert A. Koyak, Associate Professor
Department of Operations Research
Sponsor: Naval Air Systems Command

SUMMARY: The Naval Postgraduate School research team of Buttrey, Koyak, Whitaker, and Read (contractor) outlined a comprehensive program to improve the position of NATEC in its effort to measure the value of the engineering and technical services that it provides to Naval aviation squadrons. In fiscal year 2006 an initial effort was made to bring these ideas to fruition, concentrating on surveys and case studies. In fiscal year 2007 this work will be extended to developing a data-driven system for monitoring the needs of NATEC's customer base.

U.S. SPECIAL OPERATIONS COMMAND - THE NAVAL POSTGRADUATE SCHOOL COOPERATIVE FIELD EXPERIMENTATION PROGRAM
Moshe Kress, Professor
Department of Operations Research
Sponsor: Naval Postgraduate School
DECISION MAKING UNDER UNCERTAINTY WITH MILITARY APPLICATIONS
Kyle Y. Lin, Assistant Professor
Department of Operations Research
Sponsor: Naval Postgraduate School

OBJECTIVE: To apply mathematical tools to help make better decisions when the outcome of a decision involves chances. Specifically, this proposal contains three parts: 1) develop the optimal transmission policy for an energy-constrained transmitter, which has applications in sensors and electronic warfare, 2) investigate joint control for inventory replenishment and dispatch, which has applications in military supply chain and logistics management, and 3) explore and identify research problems relevant to counter-terrorism efforts and homeland security issues.

ASSESSING DISTRIBUTED CAPABILITIES AND TACTICS, TECHNIQUES, AND PROCEDURES FOR FUTURE ARMY SYSTEMS
Thomas W. Lucas, Associate Professor
Department of Operations Research
Sponsor: TRADOC Analysis Center-Monterey

OBJECTIVE: As the Army's future force develops, decisions need to be made about how these new units should be equipped, organized, and employed. As part of the analytical underpinning of these decisions, the U.S. Army Training and Doctrine Command Analysis Center is investigating distributed capabilities and Tactics, Techniques, and Procedures (TTPs) using subject matter experts and modeling and simulation. The investigators will team with TRAC-Monterey and student-officers at the Naval Postgraduate School in simulation studies of distributed capabilities and TTPs in support of the Future Force Warrior (FFW). The objective is to help the FFW program develop simulation-supported analytical methodologies for use in developing and analyzing TTPs and distributed capabilities for small combat units.

ENHANCING COMPUTATIONAL CAPABILITIES IN SUPPORT OF ANALYSIS FOR THE FUTURE FORCE WARRIOR
Thomas W. Lucas, Associate Professor
Susan Sanchez, Professor
Department of Operations Research
Sponsor: TRADOC Analysis Center-Monterey

SUMMARY: The U.S. Army Training and Doctrine Command Analysis Center is supporting the Future Force Warrior program by investigating small-unit distributed capabilities and tactics, techniques, and procedures using subject matter experts and modeling and simulation.

EXPLORING COMMAND AND CONTROL ISSUES IN NETWORKED FORCES
Thomas W. Lucas, Associate Professor
Susan Sanchez, Professor
Department of Operations Research
Sponsor: U.S. Marine Corps Warfighting Laboratory

OBJECTIVE: To conduct computational experiments to examine how a variety of command and control systems and processes may perform over a breadth of scenarios and conditions. The results may be useful in assisting decision-makers in designing and employing networked forces. Wherever possible, the computational experiments will be augmented or compared with controlled human experimentation. The computational experiments will be performed primarily with Project Albert models, such as SOCRATES, MANA, and PYTHAGORAS. The particular questions and scenarios to be studied will be determined through consultations with the Director of Project Albert, the Marine Corps Warfighting Laboratory, and other interested operational forces.
MODELING INDIVIDUAL SOLDIERS IN CLOSE COMBAT

Thomas W. Lucas, Associate Professor
Susan Sanchez, Professor
Department of Operations Research
Sponsor: TRADOC Analysis Center-Monterey

SUMMARY: Recent operations on urban terrain have highlighted the need to better understand close combat skills at the individual soldier level.

DEVELOPMENT OF HUMANITARIAN ASSISTANCE/DISASTER RELIEF LOAD LIST FOR AMPHIBIOUS OPERATIONS

LT Valerie McCall, USN
Department of Operations Research
Sponsor: Navy Operational Logistics Support Center-Norfolk

SUMMARY: Despite the stochastic nature of the timing of disasters, their eventual occurrence can be anticipated. Certain materials can be identified as essential to all missions of this nature. Using this knowledge could provide a better way to do business.

HIGH SPEED NAVAL OPERATIONS, VESSEL MOTION, AND HUMAN PERFORMANCE

Michael E. McCauley, Research Professor
Department of Operations Research
Sponsor: Naval Surface Warfare Center-Coastal Systems Station, Naval Surface Warfare Center-Panama City

OBJECTIVE: The Naval Postgraduate School will team with Naval Surface Warfare Center-Panama City Human Factors Group to perform research on the influence of high-speed ship motion on crew performance and combat readiness of military passengers. The dynamic environment experienced by crewmembers and passengers will be investigated on hull designs relevant to the Littoral Combat Ship.

VEHICLE MOTION AND OTHER HUMAN SYSTEMS INTEGRATION ISSUES IN FUTURE COMBAT SYSTEMS GROUND VEHICLE DESIGN AND DEVELOPMENT

Michael E. McCauley, Research Professor
Department of Operations Research
Sponsor: BAE Systems Land and Armaments, L.P.

SUMMARY: The U.S. Army's Future Combat Systems (FCS) Transformation Program will include a networked “system of systems” to integrate soldiers with a variety of manned and unmanned platforms and sensors. Manned ground combat vehicles are an important family of systems in the FCS program and will be designed, developed, and integrated by a cooperative design team under a Lead System Integrator (LSI). In 2003, it was announced that the Army and the Defense Advanced Research Project Agency had selected Boeing/SAC as the LSI, and that two organizations, General Dynamics Land Systems and United Defense Limited Partnership, will constitute the integrated design team.
APPLYING THE DYNAMIC MODEL OF SITUATED COGNITION TO THE ASSESSMENT OF FUTURE COMBAT SYSTEM COMMAND AND CONTROL IN A DISTRIBUTED ENVIRONMENT

Nita L. Miller, Research Assistant Professor
Lawrence G. Shattuck, Senior Lecturer
Department of Operations Research
Sponsor: TRADOC Analysis Center-Monterey

OBJECTIVE: Using the Dynamic Model of Situated Cognition (developed by Miller and Lawrence G. Shattuck, Senior Lecturer in 2003), Principal Investigators will partner with TRAC-Monterey and Mitre Corporation to observe and analyze performance of participants in a future combat system command and control simulation sponsored by DARPA (Multi-Cell and Dismounted Command and Control Program Experiment #7). The model will facilitate the analytical process by providing investigators with the ability to trace data and information flow through a complex system composed of human and machine agents.

LONGITUDINAL STUDY OF SLEEP PATTERNS OF U.S. MILITARY ACADEMY CADETS (2003-2007) YEAR 3

Nita L. Miller, Research Assistant Professor
Department of Operations Research
Sponsor: U.S. Military Academy

OBJECTIVE: To support data collection for the third year of a four-year longitudinal effort to assess the quantity and quality of sleep received by cadets attending the United States Military Academy in West Point, New York. Researchers acknowledge the tremendous impact that sleep deprivation has on cognitive performance, particularly acquisition and retention of new knowledge. However, much is unknown about the sleep patterns of college-age populations. This effort attempts to address the lack of knowledge in that field. It serves also as a testbed for determining the effects of intervention strategies that seek to remedy the sleep deprivation experienced by this military population.

NAVAL POSTGRADUATE SCHOOL COST ANALYSIS SUPPORT FOR CAIG

Gregory Mislick, Lecturer
Department of Operations Research
Sponsor: Office of the Secretary of Defense

OBJECTIVE: To support activities related to the Principal Investigator's role as the Chair of Cost Analysis at the Naval Postgraduate School during calendar year 2006. This includes support for faculty and students.

DEPARTMENT OF THE NAVY COST ESTIMATING AND ANALYSIS COMMUNITY STUDY

Daniel Nussbaum, Visiting Professor
Department of Operations Research
Sponsor: Office of the Assistant Secretary of the Navy

OBJECTIVE: To conduct an assessment and transformation study of the Department of the Navy’s cost-estimating and analysis (CE/A) community. The project will provide a comprehensive, objective, and detailed assessment and analysis comparing the current status of people, processes, technologies and capabilities within CE/A to those needed in the 21st century.
OPERATIONS RESEARCH

IMPROVING AND INCORPORATING COST ESTIMATING AND ANALYSIS INTO ADVANCED CONCEPT TECHNOLOGY DEMONSTRATIONS

Daniel Nussbaum, Visiting Professor
Department of Operations Research
Sponsor: Office of the Under Secretary of Defense

SUMMARY: This research addressed how to provide senior Deputy Under Secretary of Defense (AS&C) decision makers with improved, consistent, credible, and reliable cost estimates for use in the Advanced Concept Technology Demonstrations (ACTD) program, including enhancing understanding of the unique characteristics of ACTDs and the relevance of incorporating cost estimating and analysis into the ACTD selection and transition processes.

IMPROVING MANAGEMENT OF THE ARMY'S TACTICAL WHEELED VEHICLE FLEET: A DECISION AID TO OPTIMIZE THE ALLOCATION OF CONSTRAINED FINANCIAL RESOURCES

Daniel Nussbaum, Visiting Professor
Department of Operations Research
Sponsor: Headquarters Department of the Army

OBJECTIVE: To improve management of the Army's tactical wheeled vehicle fleet by evaluating a portfolio of options ranging from acquiring new vehicles to recapping current vehicles.

REVIEW AND TRANSFORMATION OF DEPARTMENT OF THE ARMY COST ESTIMATING, ANALYSIS, AND MANAGEMENT CAPABILITIES

Daniel Nussbaum, Visiting Professor
Department of Operations Research
Sponsor: Headquarters Department of the Army

OBJECTIVE: To conduct an assessment and transformation study of Department of the Army Cost Estimating, Analysis, and Management communities. The project will provide a comprehensive, objective, and detailed assessment and analysis comparing the current status of people, processes, technologies, and capabilities within these communities to meet the challenges of the Department of the Army in the 21st century.

SUPPORT OF BUSINESS CASE ANALYSIS FOR THE ADVANCED TECHNOLOGY ORDNANCE SURVEILLANCE ADVANCED CONCEPT TECHNOLOGY DEMONSTRATION

Daniel Nussbaum, Visiting Professor
Department of Operations Research
Sponsor: Naval Surface Warfare Center-Indian Head Division

MILITARY APPLICATIONS OF OPTIMIZATION
Richard E. Rosenthal, Professor
W. Matthew Carlyle, Associate Professor
Department of Operations Research
Sponsor: Office of Naval Research

OBJECTIVE: To provide continuing support to Navy problem-solving through building, testing, and evaluating optimization models and associated decision support systems for military applications.

TOMAHAWK LAND ATTACK MISSILE PRE-DESIGNATION
Richard E. Rosenthal, Professor
Javier Salmeron, Research Assistant Professor
Department of Operations Research
Sponsor: Naval Surface Warfare Center-Dahlgren Division

SUMMARY: The Tomahawk Land-Attack Missile is the weapon of choice in strike warfare for U.S. military forces. Pre-designation refers to the phase where the Tomahawk Strike Coordinator allocates targets to ships and submarines.

CENTER FOR EDGE POWER
Susan Sanchez, Professor
Thomas W. Lucas, Associate Professor
Department of Operations Research
Sponsor: Office of the Assistant Secretary of Defense

OBJECTIVE: To coordinate and perform research on edge organizations.

EXPEDITIONARY WARFARE LOGISTICS TESTBED
David A. Schrady, Distinguished Professor
Department of Operations Research
Sponsor: Marine Corps Systems Command

OBJECTIVE: To develop logistics chain planning prototypes and assess their value for the operating forces and for long-term functionality in GCSS-MC.

FOUR YEAR LONGITUDINAL STUDY OF SLEEP AND FATIGUE OF CADETS ENROLLED AT THE UNITED STATES MILITARY ACADEMY AT WEST POINT, NEW YORK
Lawrence G. Shattuck, Senior Lecturer
Nita L. Miller, Research Assistant Professor
Department of Operations Research
Sponsor: U.S. Military Academy

OBJECTIVE: To continue the 4-year longitudinal study of sleep patterns of cadets enrolled at the United States Military Academy at West Point, New York.
LAND WARRIOR/MOUNTED WARRIOR DOTMLPF ASSESSMENT SUPPORT
Lawrence G. Shattuck, Senior Lecturer
Nita L. Miller, Research Assistant Professor
Department of Operations Research
Sponsor: TRADOC Analysis Center-Monterey

OBJECTIVE: TRAC-Monterey will lead the Land Warrior/Mounted Warrior DOTMLPF assessment survey/interview effort. The surveys/interviews will be conducted primarily in October 2006 with analysis of the data occurring thereafter. The effort will consist of survey/interview planning, requirements integration, design, piloting, administration, analysis, and reporting. TRAC-Monterey will also participate as members of the assessment data collection team.

LONGITUDINAL STUDY OF CADET SLEEP PATTERNS
Lawrence G. Shattuck, Senior Lecturer
Nita L. Miller, Research Assistant Professor
Department of Operations Research
Sponsor: U.S. Military Academy

OBJECTIVE: To continue the study of U.S. Military Academy (USMA) cadet sleep patterns; examine the effects of sleep deprivation on performance; apply lessons learned at USMA to help predict soldier performance on the battlefield; and develop an easy-to-use tool so that commanders can assess the “fightability” of their unit.

REPRESENTING PLAN EXECUTION IN A DYNAMIC BATTLEFIELD ENVIRONMENT
Lawrence G. Shattuck, Senior Lecturer
Department of Operations Research
Sponsor: U.S. Army Research Laboratory

OBJECTIVE: To continue development and evaluation of a prototype interface designed to provide more effective decision support for mobile commanders. This interface incorporates four types of graphical representations: friendly combat sources, enemy combat resources, friendly plan-execution, and enemy plan execution. Realistic qualitative scenarios will be devised for use in evaluating and redesigning the prototype.

SEAPRINT-ADMINISTRATIVE SUPPORT OF THE HUMAN SYSTEMS INTEGRATION (HSI) MASTER’S DEGREE PROGRAM AND DEVELOPMENT OF THE HSI CERTIFICATE PROGRAM
Lawrence G. Shattuck, Senior Lecturer
Department of Operations Research
Sponsor: Space and Naval Warfare Systems Command

SUMMARY: Provided administrative support for the Human Systems Integration program at the Naval Postgraduate School for fiscal year 2006. Funding was also used to begin design and development of an online Human Systems Integration certificate program.
OPERATIONS RESEARCH

SENSOR TO COMMANDER METRICS
Lawrence G. Shattuck, Senior Lecturer
Nita L. Miller, Research Assistant Professor
Department of Operations Research
Sponsor: TRADOC Analysis Center-Monterey

OBJECTIVE: To develop mathematical models and feedback mechanisms for Army sensor management using the conceptual model of situated cognition as a framework.

SUPPORT OF THE ARMY RESEARCH LABORATORY'S COLLABORATIVE TECHNOLOGIES ALLIANCE (ADVANCED DECISION ARCHITECTURES CONSORTIUM)
Lawrence G. Shattuck, Senior Lecturer
Department of Operations Research
Sponsor: Army Research Laboratory

OBJECTIVE: To provide military subject matter expertise and managerial oversight to the Army Research Laboratory's Advanced Decision Architecture Consortium.

ARMY INFRASTRUCTURE ANALYSIS SUPPORT
Bill Tarantino, Research Associate
Department of Information Sciences
Sponsor: Deputy Assistant Secretary of the Army

OBJECTIVE: To provide research, support, and development of analytical tools to assist the Deputy Assistant Secretary of the Army (IA) in fulfilling his mission. The proposed research focuses on 1) technical review and quality control of DASA (IA) analytical efforts, and 2) research on long-term DASA (IA) efforts. This project will provide the DASA (IA) with an objective review of research efforts and an additional source to support research thrusts.

ANTI-TORPEDO TORPEDO ENGAGEMENT CONTROLLER
Alan R. Washburn, Professor
Department of Operations Research
Sponsor: Office of Naval Research

SUMMARY: This research was motivated by recent Office of Naval Research-supported work on an Anti-Torpedo Torpedo (ATT) system at Penn State University Applied Research Laboratory. The ATT is intended to function as one part of the WSQ-11 Torpedo Defense System (TDS). The TDS has other parts, some of which share resources with the ATT. A ship that is attacked has several options for defense, including maneuvers and the employment of soft-kill countermeasures. If hard-kill countermeasures (ATTs) are employed, there are still questions about timing and parameter adjustment.

INTEGRATED, MECHANICAL DIAGNOSTIC HEALTH-AND-USAGE MONITORING SYSTEM
Lyn R. Whitaker, Associate Professor
Department of Operations Research
Sponsor: Goodrich Corporation

SUMMARY: The Goodrich integrated, mechanical diagnostic (IMD) health-and-usage monitoring system provides aircraft maintainers with an extensive set of functions to support rotorcraft health and diagnostic processing.
A STUDY FOR ADVANCED HELICOPTER ITEM DEVELOPMENT (ARH) PROGRAM
 Lyn R. Whitaker, Associate Professor
 Department of Operations Research
 Sponsor: U.S. Army Yuma Proving Ground

SUMMARY: The methods traditionally used by the Yuma Test Center (YTC) for analyzing test results for laser designation systems mounted on helicopters do not include methods for the newer capabilities of or requirements for these systems. The Principal Investigators studied the various laser processes to determine whether the methods of analyzing test results for the processes previously used at YTC are still valid. Recommendations for updating and enhancing analysis methods were provided.

REDUCING THE VULNERABILITY OF ELECTRIC POWER GRIDS TO TERRORIST ATTACKS
 R. Kevin Wood, Professor
 Javier Salmeron, Research Assistant Professor
 Department of Operations Research
 Sponsor: Department of Energy

OBJECTIVE: To develop and validate mathematical models and optimization techniques for improving the security of electrical power grids in the U.S. that are subject disruption caused by terrorist attacks.
DEPARTMENT OF OPERATIONS RESEARCH

2006
Faculty Publications and Presentations


GRADUATE SCHOOL OF ENGINEERING AND APPLIED SCIENCES

JAMES KAYS
DEAN
DEPARTMENT OF
APPLIED MATHEMATICS

CLYDE SCANDRETT
CHAIRMAN
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 SERVED:

- 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
- Discrete Mathematics
- Numerical Modeling

RESEARCH PROGRAM (Research and Academic)-FY2006:

The Naval Postgraduate School’s sponsored program exceeded $81 million in FY2006. 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: $269K
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<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Department</th>
<th>Phone</th>
<th>Email</th>
</tr>
</thead>
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<tr>
<td>Scandrett, Clyde</td>
<td>Professor and Chairman</td>
<td>Applied Mathematics</td>
<td>656-2206/2677</td>
<td><a href="mailto:cscand@nps.edu">cscand@nps.edu</a></td>
</tr>
<tr>
<td>Borges, Carlos</td>
<td>Associate Professor</td>
<td></td>
<td>656-2124</td>
<td><a href="mailto:borges@nps.edu">borges@nps.edu</a></td>
</tr>
<tr>
<td>Canright, David</td>
<td>Associate Professor</td>
<td>MA/Ca</td>
<td>656-2782</td>
<td><a href="mailto:dcanright@nps.edu">dcanright@nps.edu</a></td>
</tr>
<tr>
<td>Frenzen, Christopher L.</td>
<td>Associate Professor</td>
<td>MA/Fr</td>
<td>656-2435</td>
<td><a href="mailto:cfrenzen@nps.edu">cfrenzen@nps.edu</a></td>
</tr>
<tr>
<td>Neta, Beny</td>
<td>Professor</td>
<td></td>
<td>656-2235</td>
<td><a href="mailto:bneta@nps.edu">bneta@nps.edu</a></td>
</tr>
<tr>
<td>Carr, Les</td>
<td>Lecturer</td>
<td></td>
<td>656-3629</td>
<td><a href="mailto:lecarr@nps.edu">lecarr@nps.edu</a></td>
</tr>
<tr>
<td>Gera, Raluca</td>
<td>Assistant Professor</td>
<td></td>
<td>656-2206</td>
<td><a href="mailto:rgera@nps.edu">rgera@nps.edu</a></td>
</tr>
<tr>
<td>Owen, Guillermo</td>
<td></td>
<td></td>
<td>656-2720</td>
<td><a href="mailto:gowen@nps.edu">gowen@nps.edu</a></td>
</tr>
<tr>
<td>Danielson, Donald A.</td>
<td>Professor</td>
<td></td>
<td>656-2622</td>
<td><a href="mailto:dad@nps.edu">dad@nps.edu</a></td>
</tr>
<tr>
<td>Gagg, William B.</td>
<td>Professor</td>
<td></td>
<td>656-2194</td>
<td><a href="mailto:gragg@nps.edu">gragg@nps.edu</a></td>
</tr>
<tr>
<td>Rasmussen, Craig</td>
<td>Associate Professor</td>
<td></td>
<td>656-2763</td>
<td><a href="mailto:ras@nps.edu">ras@nps.edu</a></td>
</tr>
<tr>
<td>Daughtry, Doyle</td>
<td>Lecturer</td>
<td></td>
<td>656-3478</td>
<td><a href="mailto:ddaughtr@nps.edu">ddaughtr@nps.edu</a></td>
</tr>
<tr>
<td>Jayachandran, Toke</td>
<td>Professor Emeritus</td>
<td></td>
<td>656-2600</td>
<td><a href="mailto:tj@nps.edu">tj@nps.edu</a></td>
</tr>
<tr>
<td>Schoenstadt, Art</td>
<td></td>
<td></td>
<td>656-2662</td>
<td><a href="mailto:alschoen@nps.edu">alschoen@nps.edu</a></td>
</tr>
<tr>
<td>Fahroo, Fariba</td>
<td>Associate Professor</td>
<td></td>
<td>656-2664</td>
<td><a href="mailto:ffahroo@nps.edu">ffahroo@nps.edu</a></td>
</tr>
<tr>
<td>Kang, Wei</td>
<td>Associate Professor</td>
<td></td>
<td>656-3337</td>
<td><a href="mailto:wkang@nps.edu">wkang@nps.edu</a></td>
</tr>
<tr>
<td>Stanica, Pantelimon</td>
<td>Associate Professor</td>
<td></td>
<td>656-2714</td>
<td><a href="mailto:stanica@nps.edu">stanica@nps.edu</a></td>
</tr>
<tr>
<td>Franke, Richard H.</td>
<td>Professor Emeritus</td>
<td></td>
<td>656-3249</td>
<td><a href="mailto:half@nps.edu">half@nps.edu</a></td>
</tr>
<tr>
<td>Latta, Gordon E.</td>
<td>Professor Emeritus</td>
<td></td>
<td>656-2695</td>
<td><a href="mailto:bardman@nps.edu">bardman@nps.edu</a></td>
</tr>
<tr>
<td>Weir, Maurice D.</td>
<td></td>
<td></td>
<td>656-2608</td>
<td><a href="mailto:mweir@nps.edu">mweir@nps.edu</a></td>
</tr>
<tr>
<td>Fredricksen, Hal</td>
<td>Professor</td>
<td></td>
<td>656-3249</td>
<td><a href="mailto:half@nps.edu">half@nps.edu</a></td>
</tr>
<tr>
<td>Mansager, Bard K.</td>
<td>Senior Lecturer</td>
<td></td>
<td>656-2695</td>
<td><a href="mailto:bardman@nps.edu">bardman@nps.edu</a></td>
</tr>
<tr>
<td>Zhou, Hong</td>
<td>Assistant Professor</td>
<td></td>
<td>656-2600</td>
<td><a href="mailto:hzhou@nps.edu">hzhou@nps.edu</a></td>
</tr>
</tbody>
</table>
APPLIED MATHEMATICS

COMPUTATIONAL MATHEMATICS PROGRAM
Fariba Fahroo, Associate Professor
Department of Applied 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 manages 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 supports the national Air Force program in high performance computing. Duties involve managing the portfolio by knowing the latest trends in computational algorithm developments (as related to the Air Force), visiting the Principal Investigators, 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.

DEVELOPMENT OF RECONFIGURABLE COMPUTING APPLICATIONS
Paul A. Frederickson, Research Associate
Department of Meteorology
Christopher L. Frenzen, Associate Professor
Department of Applied Mathematics
Sponsor: National Security Agency

OBJECTIVE: To upgrade the existing SRC-6 model 4.2.0.0.0 reconfigurable computer to a model 4.2.16.4 by adding a 16-port hi-bar switch and 8 g-bytes of common memory.

EXPERIMENTS USING PROTOTYPE RECONFIGURABLE MACHINES
Paul A. Frederickson, Research Associate
Department of Meteorology
Sponsor: National Security Agency

OBJECTIVE: During the third year of this effort, researchers will branch out into new areas of a more mathematical nature to use computers with reconfigurable architectures. Researchers will investigate problems of combinatorial structures for communications applications, analysis of surrogate data sets for biological sequencing, and some analyses of high speed and high accuracy numeric computation using the SRC MAPstation. The ideas are novel and to some degree speculative. On the other hand, project researchers have considerable experience in the problem areas proposed.

SECURITY AD HOC NETWORKS
Ralucca Gera, Assistant Professor
Department of Applied Mathematics
Sponsor: Naval Postgraduate School

OBJECTIVE: To study ad hoc networks, different types of domination in networks that satisfy certain graph coloring restrictions to model secure ad hoc networks, and new scenarios that could be modeled by new domination parameters. Results from this project will serve as preliminary results for the Principal Investigator to seek external funding for the future.
NON-LINEAR MULTIVARIABLE RUN-TO-RUN CONTROL OF PHOTOLITHOGRAPHY
Wei Kang, Professor
Department of Applied Mathematics
Sponsor: Intel Corporation

SUMMARY: Goal of proposed research is to design critical-dimension control methodology based on nonlinear models to regulate the lithographic progress with multiple parameters in a run-to-run control system. The study is to achieve the desired CE, to maintain the CD stability and uniformity, and to reduce or minimize influence of unknown disturbances on the performance of the system.

REAL-TIME ESTIMATION FOR A NETWORKED SATELLITE SYSTEM
Wei Kang, Professor
Isaac Michael Ross, Professor
Department of Applied Mathematics
Department of Mechanical and Astronautical Engineering
Sponsor: Air Force Research Laboratory

SUMMARY: Studied the sensor system requirements, limitations, and constraints for Air Force space missions. Modeled onboard sensor network for multi-satellite systems; explored the observability and feasibility of nonlinear estimation for multi-satellite systems; explored nonlinear filters appropriate for onboard real-time estimation of position and altitude (both absolute and relative) without ground support; and demonstrated the initial model and basic concepts and algorithms by simulations.

SENSOR TO COMMANDER METRICS
Wei Kang, Professor
Department of Applied Mathematics
Sponsor: TRADOC Analysis Center-Monterey

OBJECTIVE: To develop mathematical models and feedback mechanisms for Army sensor management using the conceptual model of situated cognition as a framework.

SEVENTH INTERNATIONAL SYMPOSIUM ON TECHNOLOGY AND THE MINE PROBLEM
Clyde Scandrett, Professor
Department of Applied Mathematics
Sponsor: Office of Naval Research

OBJECTIVE: To support the planning and execution of a technical symposium on mines. The purpose of the symposium is to continue the examination of the potential for emergent technologies to enhance the capabilities of the U.S. and its allies in mining, mine countermeasures, and humanitarian demining, which includes area remediation. The theme of this symposium will be mines, improvised explosive devices, and harbor protection/port security. As with the six preceding symposia, this symposium is a joint undertaking of several U.S. government agencies. The planned dates for the seventh symposium are 2-5 May 2006.

DESIGN CRITERIA OF CRYPTOGRAPHIC BOOLEAN FUNCTIONS
Pantelimon Stanica, Associate Professor
Department of Applied Mathematics
Sponsor: Naval Postgraduate School

SUMMARY: The security of schemes based on a combination of permutations and substitutions strongly depends on the characteristics of the substitution tables (S-Boxes). The relevance of the criteria can be based on information theoretic grounds on specific attacks that are possible if certain conditions are not fulfilled.
OBJECTIVE: To study the mathematical modeling and computational framework for investigating flow-induced morphology; to use the framework to study the morphology induced by shear flow; and to study the property enhancement induced by adding nanocomposites in polymeric flows. The results from this project will serve as preliminary results for the Principal Investigator to seek external funding to study the morphology and interactions with nanocomposites in the full 3D polymeric flow.
DEPARTMENT OF
APPLIED MATHEMATICS

2006
Faculty Publications
and Presentations


PRESENTATIONS


Gera, R., “Alliance Partition Number in Graphs,” Twentieth Midwest Conference on Combinatorics, Cryptography, and Computing (MCCCC), Wichita State University, Kansas, 5-7 October 2006.


**BOOK CHAPTER**


**RESEARCH REPORTS**


McCormick, G. and Owen, G., “Deceptive Signals.”

McCormick, G. and Owen, G., “Noisy Searches.”
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 are grouped into ten major areas of emphasis that support the curricula served by the department and Department of Defense plans. Unique to the ECE department and NPS 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, our curricula and courses will remain at the cutting edge, we can recruit and retain quality faculty, and 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 W. Adler, Associate Professor David Jenn, Professor Michael Morgan, Research Associate Andrew A. 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)-FY2006:

The Naval Postgraduate School’s sponsored program exceeded $81 million in FY2006. 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: $5.7M
Knorr, Jeffrey B.  
Professor and Chairman  
EC/Ko  
656-2081  
jknorr@nps.edu

Tummala, Murali  
Professor and  
Associate Chairman for Research  
EC/Tu  
656-2645  
mtummala@nps.edu

Adamiak, Dave, Maj, USMC  
Military Instructor  
EC/Ad  
656-2730  
dvadami@nps.edu

Ciezki, John G.  
Associate Professor  
EC/Cy  
656-3001  
jgciezki@nps.edu

Ives, Robert, LCDR, USN  
Military Assistant Professor  
EC/Ir  
656-2764  
rwives@nps.edu

Adler, Richard W.  
Associate Professor  
EC/Ab  
656-2352  
rwadler@nps.edu

Cristi, Roberto  
Associate Professor  
EC/Cx  
656-2223  
cristi@nps.edu

Janaswamy, Ramakrishma  
Professor  
EC/Js  
656-3217  
janaswam@nps.edu

Ashton, Robert W.  
Associate Professor  
EC/Ah  
656-2928  
rwashton@nps.edu

Fargues, Monique P.  
Associate Professor  
EC/Fa  
656-2859  
fargues@nps.edu

Jenn, David C.  
Associate Professor  
EC/Jn  
656-2254  
jenn@nps.edu

Barsanti, Bob, LCDR, USN  
Military Assistant Professor  
EC/Br  
656-5044  
rbarsanti@nps.edu

Fouts, Douglas J.  
Associate Professor  
EC/Fs  
656-2852  
fouts@nps.edu

Lebaric, Jovan E.  
Visiting Associate Professor  
EC/Lb  
656-2390  
jelebari@nps.edu

Bernstein, Raymond F.  
Research Assistant Professor  
EC/Be  
656-2726  
rmbernst@nps.edu

Ha, Tri T.  
Professor  
EC/HA  
656-2788  
ha@nps.edu

Loomis, Herschel H., Jr.  
Professor  
EC/Lm  
656-3214/3149  
hloomis@nps.edu

Borchardt, Randy  
Research Associate  
EC/Bt  
656-2110  
rlborcha@nps.edu

Hippenstiel, Ralph D.  
Associate Professor  
EC/Hi  
656-2633  
hippenst@nps.edu

McEachen, John  
Assistant Professor  
EC/Mj  
656-3652  
mceachen@nps.edu

Butler, Jon T.  
Professor  
EC/Bu  
656-3299  
butler@nps.edu

Hutchins, Gary  
Associate Professor  
EC/Hu  
656-3289  
hutchins@nps.edu

Michael, Sherif  
Associate Professor  
EC/Mi  
656-2252  
michael@nps.edu
<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Email Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morgan, Michael A.</td>
<td>Professor</td>
<td><a href="mailto:mmorgan@nps.edu">mmorgan@nps.edu</a></td>
</tr>
<tr>
<td>Robertson, R. Clark</td>
<td>Professor</td>
<td><a href="mailto:crobertson@nps.edu">crobertson@nps.edu</a></td>
</tr>
<tr>
<td>Weatherford, Todd</td>
<td>Assistant Professor</td>
<td><a href="mailto:weatherf@nps.edu">weatherf@nps.edu</a></td>
</tr>
<tr>
<td>Pace, Phillip E.</td>
<td>Professor</td>
<td><a href="mailto:pace@nps.edu">pace@nps.edu</a></td>
</tr>
<tr>
<td>Therrien, Charles W.</td>
<td>Professor</td>
<td><a href="mailto:therrient@nps.edu">therrient@nps.edu</a></td>
</tr>
<tr>
<td>Wight, Randy L.</td>
<td>Visiting Instructor</td>
<td><a href="mailto:rwight@nps.edu">rwight@nps.edu</a></td>
</tr>
<tr>
<td>Panholzer, Rudolf</td>
<td>Professor</td>
<td><a href="mailto:rpanholzer@nps.edu">rpanholzer@nps.edu</a></td>
</tr>
<tr>
<td>Tyo, J. Scott, Capt, USAF</td>
<td>Military Assistant Professor</td>
<td><a href="mailto:jstyo@nps.edu">jstyo@nps.edu</a></td>
</tr>
<tr>
<td>Van Hise, John W., Jr.</td>
<td>Research Associate</td>
<td><a href="mailto:jwvanhis@nps.edu">jwvanhis@nps.edu</a></td>
</tr>
<tr>
<td>Yun, Xiaoping</td>
<td>Associate Professor</td>
<td><a href="mailto:yun@nps.edu">yun@nps.edu</a></td>
</tr>
<tr>
<td>Pieper, Ron J.</td>
<td>Visiting Associate Professor</td>
<td><a href="mailto:rjpieper@nps.edu">rjpieper@nps.edu</a></td>
</tr>
<tr>
<td>Vincent, W. Ray</td>
<td>Research Associate Professor</td>
<td><a href="mailto:vincent@nps.edu">vincent@nps.edu</a></td>
</tr>
<tr>
<td>Ziomek, Lawrence J.</td>
<td>Professor</td>
<td><a href="mailto:ziomek@nps.edu">ziomek@nps.edu</a></td>
</tr>
<tr>
<td>Powers, John P.</td>
<td>Distinguished Professor</td>
<td><a href="mailto:jppowers@nps.edu">jppowers@nps.edu</a></td>
</tr>
<tr>
<td>Wadsworth, Don</td>
<td>Senior Lecturer</td>
<td><a href="mailto:dwadsworth@nps.edu">dwadsworth@nps.edu</a></td>
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COMMUNICATIONS EMITTER SENSING AND ATTACKING SYSTEM WAVEDRIVER ANTENNA SYSTEMS FOR OPERATIONAL USE
Richard W. Adler, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Marine Corps Systems Command

**OBJECTIVE:** To deliver twelve high-performance WaveDriver antenna subsystems for use in the Communications Emitter Sensing and Attacking System. This will provide improved performance in combination with compact size and ruggedness for operational use.

ELECTRONIC ATTACK ARRAY ANTENNA SYSTEM
Richard W. Adler, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Office of Naval Research

**OBJECTIVE:** To develop, implement, and test an array antenna subsystem for use on ground vehicles for DF and electronic attack applications.

ENCAPSULATED WAVEPEARL ULTRAWIDEBAND ANTENNA SUBSYSTEM FOR SHIPBOARD USE
Richard W. Adler, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Information Warfare Activity

**OBJECTIVE:** To develop and implement an improved version of the direct excitation WaveDriver antenna subsystem, with foam-filled all-weather sealed (encapsulated) radome for improved resilience to shock and vibration. The intended operating frequency range is from 100 Mhz to 12 Ghz. A pair of subsystems will be delivered, ready for all-weather full-operation on a surface ship.

INTERFERENCE AND NOISE MEASUREMENTS IN PORTIONS OF THE RADIO SPECTRUM
Richard W. Adler, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: National Science Foundation

**OBJECTIVE:** To conduct a measurement survey of the interference and noise found in the wireless communications bands in and around selected urban and city environments. The results of the survey will provide the wireless communications industry and the Federal Communications Commission (FCC) with the information necessary to plan future use and licensing of the wireless bands.

LZO RADIO NOISE PROGRAM SUPPORT
Richard W. Adler, Research Associate Professor
Andrew A. Parker, Research Associate
Department of Electrical and Computer Engineering
Sponsor: Argon Engineering

**SUMMARY:** The Naval Postgraduate School provided equipment and engineering support on site LZO in Okinawa during a radio noise survey during October-December 2005. Reporting occurred through January 2006.
SUMMARY: A series of measurements of the occupancy and use of wireless bands was completed by the Naval Postgraduate School for the National Science Foundation. These included measurements in the unlicensed 915-, 2450-, and 5800-mhz bands, as well as a few measurements in the licensed bands. Locations examined were suburban, remote areas, wireless classrooms, and various field exercises where wireless radio was used for critical communications tasks. While the above measurements have been highly informative, measurements in other locations and other radio-signal and radio-environments are desired to provide a more complete understanding of the wide variety of occupancy and use conditions found by the past measurements.

OBJECTIVE: To further develop rapid prototype processes with an emphasis on electromagnetic materials for Navy systems. The Naval Postgraduate School (NPS) team has extensive experience in UWB technology development for RF-based systems, military platforms, and tactical communications (including wearable antennas), as well as in electromagnetics and performance validation. The NPS team is well positioned to perform RF experimental work on both classified and unclassified materials and components. The program will study the results of techniques, such as Electrostatic Self Assembly and inkjet printing, to fabricate electromagnetic test devices and structures. Devices will be characterized for electromagnetic applications.

OBJECTIVE: To develop and deliver a Full-Spectrum Stare Receiver subsystem for capturing new and unknown signals, such as transient signals of short duration and “random” (non-periodic) occurrence. The proposed receiver architecture will also mitigate the receiver desensitization due to the presence of strong interferers (intentional or unintentional) that would otherwise “mask” the much weaker signals of interest.

OBJECTIVE: To deliver ten high-performance antenna systems, with optimum weight and performance, for the EP3 aircraft. Each system will include a pair of dual-polarized (vertical and horizontal) ultra-wideband WaveDrivers (one port and one starboard) and one ultra-wideband vertically-polarized omniwave in the centerline POD underneath the aircraft, to provide both ultra-wideband frequency coverage and 360-degree azimuth field of view.
SPECTRUMSHIELD COUNTER-IMPROVISED EXPLOSIVE DEVICE SYSTEM
Richard W. Adler, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Marine Corps Systems Command

OBJECTIVE: To develop a Spectrumshield ultra-portable, ultra-wideband electronic attack system based on commercially available components and subsystems, save for a custom-designed, ultra-wideband Wave-driver antenna and custom-developed software to implement the desired system functionality.

SPECTRUMSHIELD ULTRA-PORTABLE SYSTEM: INITIAL ANALYSIS FOR HIGH FREQUENCY BAND ANTENNA SUBSYSTEM
Richard W. Adler, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Marine Corps Systems Command

OBJECTIVE: To conduct an initial study for the development of a high-frequency band antenna subsystem in support of the Spectrumshield ultra-portable system development for the U.S. Marine Corps.

UNMANNED AERIAL VEHICLE AIRCRAFT ANTENNA ANALYSIS AND DEVELOPMENT
Richard W. Adler, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Air Force Information Warfare Center

OBJECTIVE: To assist with the Unmanned Aerial Vehicle Battlelab Hoover Initiative antenna development and performance analysis for airborne applications.

WAVEPORT MULTIFUNCTIONAL ULTRA-WIDEBAND SMART ANTENNA SYSTEM FOR VEHICLE USE
Richard W. Adler, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Marine Corps Systems Command

OBJECTIVE: To develop, prototype, validate, and deliver a waveport smart antenna system to improve communications link performance and provide direction-finding capability on vehicles, such as the HMMWV.

THE APPLICATION OF SILICON CARBIDE SEMICONDUCTOR POWER SWITCHES
Robert W. Ashton, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Office of Naval Research

SUMMARY: An independent team was established to design a silicon carbide-based 2.7MVA solid state power substation and to evaluate its impact on a future aircraft carrier electrical system through modeling and simulation.
DESIGN EVALUATION OF A POWER CONVERSION SYSTEM FOR A 36.5MW HOMOPOLAR MOTOR
Robert W. Ashton, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Office of Naval Research

SUMMARY: The Principle Investigator provided technical support to the Office of Naval Research Project Manager by participating with the Integrated Product Team in the development and execution of plans for homopolar motor science and technology development. This support included design evaluation of a power conversion system for a large-scale homopolar motor intended for ship propulsion.

POWER CONVERSION MODULES AND DISTRIBUTION SYSTEM TESTING AND ANALYSIS
Robert W. Ashton, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Sea Systems Command

SUMMARY: The Principle Investigator will provide technical support relative to research and development efforts associated with power conversion modules and electrical distribution systems. These efforts included engineering and testing support as needed and specified by the project manager.

KNOWLEDGEABLE NETWORK ADDRESSABLE TERMINALS ENABLING MULTI-POINT WIRELESS NETWORK TOPOLOGY APPLIED ON MICRO LEVEL TO ROBOTS AND SENSORS
Capt. Rob Bledsoe, USMC
Department of Electrical and Computer Engineering
Sponsor: SPAWAR Systems Center-San Diego

SUMMARY: Knowledge and information transfer in the battlespace is absolutely critical for future military operations. A vital element in this information transfer is intelligence provided by distributed sensors and autonomous vehicles. Specifically, such information must be made available to other military vehicles, as well as human warfighters, for network centric operations.

DEVELOPMENT OF RECONFIGURABLE COMPUTING APPLICATIONS
Jon T. Butler, Professor
Department of Electrical and Computer Engineering
Sponsor: National Security Agency

OBJECTIVE: To investigate use of a lookup table cascade to realize high-speed, high-accuracy numeric functions, useful in digital signal processing, rendering graphics displays, and accelerating CPU operations.

MARINE EXPEDITIONARY FORCE TACTICAL AD HOC DATA NETWORK ENGINEERING AND DESIGN
Capt. Billy Cornell, USMC
Department of Electrical and Computer Engineering
Sponsor: Marine Corps Tactical Systems Support Activity

SUMMARY: The main thrust of this thesis was to research, identify, implement, test, analyze, and document TCP/IP tactical data networking schemes that conform to commercial best practices and Marine Expeditionary Force Standard Operating Procedures. The focus was on the network back-bone Wide Area Network (WAN) architecture and the external connections to the Defense Information System Network. The study limited the contribution of Local Area Networks (LANs) to the core/distribution layer network topologies. LAN access layer topologies and sub-networks were excluded from this study. The thesis used
the Joint Net-Centric Modeling and Simulation Tool NETWARS and a WAN modeling and simulation tool from Cisco Systems to capture performance data and conduct analysis.

**DEVELOPMENT SYSTEM FOR SOFTWARE DEFINED RADIOS**

Roberto Cristi, Professor  
Department of Electrical and Computer Engineering  
Sponsor: Marine Corps Systems Command

**SUMMARY:** Developed digital signal processing software for Field Programmable Gate Arrays to be used as modules in software defined radio development.

**DETECTION OF IEDS USING MULTI-SENSOR...**

Monique P. Fargues, Associate Professor  
Department of Electrical and Computer Engineering  
Sponsor: Office of Naval Research

**OBJECTIVE:** To investigate 1) whether merging information collected from the different sensors considered by MCWL will result in increased IED-detection performance, 2) a detection scheme, and 3) to provide resulting IED detection-performance values.

**INVESTIGATION OF SPEECH DATA COLLECTED VIA AN EAR-INSERT MICROPHONE**

Monique P. Fargues, Associate Professor  
Department of Electrical and Computer Engineering  
Sponsor: Marine Corps Systems Command

**SUMMARY:** There are many applications that require detection and identification of speech while in high-noise environments, such as factory, automobile, aircraft, or other settings. In such conditions, collecting speech at locations other than the mouth may lead to speech of better quality than can be obtained at the mouth. An earlier study focused on a commercial, off-the-shelf, foam-encased, in-ear microphone device well suited for multiple users and various environments.

**DIS-512 MODIFICATIONS AND KOR ADVANCED CLUTTER/TARGET SIMULATOR DRFM**

Douglas J. Fouts, Professor  
Phillip E. Pace, Professor  
Department of Electrical and Computer Engineering  
Sponsor: Office of Naval Research

**OBJECTIVE:** To investigate the metallization-6 problems on the current DIS-512 and the purchase of a modified DIS-512 (MOSIS/TSMC device); to investigate the purchase of a KOR electronics DRFM card.

**DIS-512 TEST AND EVALUATION**

Douglas J. Fouts, Professor  
Phillip E. Pace, Professor  
Department of Electrical and Computer Engineering  
Sponsor: Office of Naval Research

**OBJECTIVE:** To engineer a test-set to enable the test and evaluation of recently received DIS-512 chips packaged in Plastic Ball Grid Array (PBGA) packages. A series of tests will be conducted to determine the functionality of the DIS-512 packaged in the PBGA package. Test results will be compiled and will include the optical inspection results of chips packaged in the PBGA.
ELECTRONIC WARFARE RECONFIGURABLE SIGNAL PROCESSING COMPUTER UPGRADE
Douglas J. Fouts, Professor
Department of Electrical and Computer Engineering
Sponsor: Office of Naval Research

OBJECTIVE: To upgrade the hardware, system software, and compilers of the SRC reconfigurable computer to make it suitable for use in the development and benchmarking of signal processing software for electronic attack, electronic protection, and electronic support applications.

LIBRARY DEVELOPMENT AND EXPERIMENTS USING PROTOTYPE RECONFIGURABLE COMPUTING MACHINES
Douglas J. Fouts, Professor
Department of Electrical and Computer Engineering
Sponsor: National Security Agency

OBJECTIVE: During the third year of this three-year effort, researchers will complete the investigation of the use of computers with reconfigurable architectures for real-time radar and electronic warfare digital-signal processing applications using the SRC-6e reconfigurable computer and the U.S. Navy AN/SPS-65V(1) high-resolution, surface-search radar. Principal Investigators will also expand the scope of the research and investigate the use of computers with reconfigurable architectures for real-time, near-real-time, and non-real-time ELINT digital-signal-processing applications.

COVERT TRANSMISSIONS OF IEEE STANDARD 802.11G
Tri T. Ha, Professor
Department of Electrical and Computer Engineering
Sponsor: National Reconnaissance Office

OBJECTIVE: To explore the IEEE 802.11g standard for use with covert communications. The wireless standard will be evaluated for ease of modification, potential range and data rate characteristics, and potential use for covert communications via total diversity combining.

DESIGN AND DEVELOPMENT OF A SHIPBOARD OPPORTUNISTIC ARRAY
David C. Jenn, Professor
Rodney W. Johnson, Visiting Professor
Department of Electrical and Computer Engineering
Sponsor: Office of Naval Research

SUMMARY: In Phase I of this research, various aspects of a new antenna concept, referred to as an “opportunistic array,” were investigated. An opportunistic array is an integrated, ship-wide, digital-phased array, where elements are placed at available open areas over the entire length of the ship. The elements are self-standing Transmit/Received (T/R) modules in that they have no hardware connections other than prime power. Phase Two continued looking at the integration of new technologies and techniques into the opportunistic array concept, and proposed that a small demonstration array be constructed.

DIGITAL ANTENNA TECHNOLOGY FOR RADAR AND COMMUNICATION SYSTEMS
David C. Jenn, Professor
Department of Electrical and Computer Engineering
Sponsor: National University of Singapore

SUMMARY: This research examined the current wireless chip technology to determine if existing commercial, off-the-shelf (COTS) devices can be used to construct digital transmit and receive antennas.
The specific tasks included researching manufacturer’s hardware data sheets for modulators and demodulators, procuring development boards, performing measurements to characterize the board’s electrical performance, and running computer simulations of digital arrays using the measured board data. The following goals were achieved: 1) the Analog Devices AD8347 demodulator board was selected as the primary receive antenna component after a study of several COTS components; 2) testing and characterization of the AD8347 board was performed, including digitization of signals and integration with a host controller; 3) synchronization of multiple demodulator.

TECHNOLOGY AND CONCEPTS FOR POSITION DETERMINATION OF DISTRIBUTED SENSOR AND ARRAY ELEMENTS
David C. Jenn, Professor
Michael E. Melich, Research Professor
Rodney W. Johnson, Visiting Professor
Department of Electrical and Computer Engineering
Sponsor: Office of Naval Research

SUMMARY: Recent developments in digital antenna and sensor technology make it practical to use random or irregularly spaced self-contained sensor elements that are distributed over relatively large areas. A primary example is an HF or VHF array consisting of elements placed at “locations of opportunity” over the surface of a ship. On a ship or other dynamic platform, the element positions are continuously changing, and this fact must be taken into account in the digital beamforming to avoid degradation in the sidelobes, gain, and beam pointing. This research examined a wide range of solutions to the position determination problem. They were evaluated based on cost, performance, complexity, and technical risk. The techniques were incorporated into system simulations and analyses, and an investigation into the current state of the art of applicable hardware was also conducted.

IMPROVING SHIP POWER RELIABILITY, MAINTAINABILITY, AND AVAILABILITY THROUGH POWER SYSTEMS MODELING AND ANALYSIS
Alexander Julian, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School

SUMMARY: Developed simulation and analysis tools to more accurately model power system behavior at every level, from stability of power distribution at the top level down to electrical stress at the component level. Investigated and documented the performance limits of digital control applied to solid-state power management. This research focused on performance attributes that best serve the needs of the Navy.

DEVELOPMENT OF ADVANCED WEATHER SURVEILLANCE ALGORITHMS AND TECHNIQUES FOR RAPID SCANNING TACTICAL RADARS
Jeffrey B. Knorr, Professor
Department of Electrical and Computer Engineering
Sponsor: Prosensing, Inc.

OBJECTIVE: To develop advanced algorithms and techniques for a weather surveillance mode for a rapid-scanning phased-array radar system. Prosensing, Inc. recently developed an add-on weather radar processor for the military tactical radar and demonstrated the ability of the radar to generate rapidly updated images of reflectivity and velocity in precipitation to ranges in excess of 30km.
WEATHER RADAR PROCESS FOR RAPID SCANNING TACTICAL RADARS
Jeffrey B. Knorr, Professor
Department of Electrical and Computer Engineering
Sponsor: Prosensing, Inc.

**SUMMARY:** The Naval Postgraduate School (NPS) and Prosensing, Inc. will work together to modify an existing AN/MPQ-64 tactical radar to operate as an electronically- and mechanically-scanned antenna. The MPQ-64 will provide an exceptional tool for studying rapidly developing convective storms, including thunderstorms and tornadoes. Prosensing provided the tactical weather processor, processor and software installation and functional testing, post-processing software for data display and interpretation, and documentation as required for NPS to operate the radar with the weather processor and use the post-processing software.

ANALYSIS OF THE EMERGING IEEE 802.11N STANDARD
Frank Kragh, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: National Security Agency

**SUMMARY:** Designed, analyzed, and simulated IEEE 802.11n transceivers.

BANDWIDTH EFFICIENT MODULATION
Frank Kragh, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Office of the Secretary of the Air Force

**OBJECTIVE:** To explore enhanced bandwidth efficient modulation schemes emphasizing constant envelope modulation, pulse shaping, and forward error correction coding.

CO-CHANNEL MITIGATION STUDY
Frank Kragh, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Secretary of the Air Force

**OBJECTIVE:** To quantitatively evaluate the narrowband co-channel interference problem for Gaussian Minimum Shift Keying signals in corrupted by co-channel interference, to design receivers that mitigate the effects of co-channel interference, and to implement the design in a soft radio.

SOFT RADIO FOR MILITARY APPLICATION-LABORATORY DEVELOPMENT
Frank Kragh, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Joint Tactical Radio System Joint Program Executive Office

**SUMMARY:** Developed a laboratory component for the course EC4530: Soft Radio.
GUSTY ORIOLE, COMPUTER ARCHITECTURES, AND ALGORITHMS FOR SPACE APPLICATIONS
Herschel H. Loomis, Jr., Professor
Department of Electrical and Computer Engineering
Sponsor: Secretary of the Air Force

OBJECTIVE: This project is concerned with the application of computer algorithms to specific military space projects, the development of specialized computer architectures for military space applications, and the support of space-systems curricula.

MARITIME DOMAIN AWARENESS EVALUATION TEST ENVIRONMENT
Herschel H. Loomis, Jr., Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School

SUMMARY: Developed a tool set for data manipulation, fusion, and display, and thus demonstrated improved maritime domain awareness.

SPECIAL OPERATIONS FORCES LIGHTWEIGHT SIGNALS INTELLIGENCE FOR GROUND AND UNMANNED AERIAL VEHICLE SUPPORT TO JOINT THREAT WARNING SYSTEM RESEARCH, DEVELOPMENT, TEST, AND EVALUATION
John C. McEachen, Associate Professor
Weilian Su, Assistant Professor
Murali Tummala, Professor
Department of Electrical and Computer Engineering
Sponsor: U.S. Special Operations Command

SUMMARY: Described research, development, test, and evaluation actions to support the Joint Threat Warning System (JTWS) program. This included investigating integration of smart dust technology into the JTWS Component Architecture Framework, investigating integration of computer network operations into lightweight Special Operations Forces signals intelligence ground and unmanned aerial vehicle systems, and classified signal analysis.

SPECIAL OPERATIONS FORCES SIGNALS INTELLIGENCE MARITIME ENVIRONMENT SUPPORT TO JOINT THREAT WARNING SYSTEM RESEARCH, DEVELOPMENT, TEST, AND EVALUATION
John C. McEachen, Associate Professor
Weilian Su, Assistant Professor
Murali Tummala, Professor
Alexander Bordetsky, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: U.S. Special Operations Command

SUMMARY: Described research, development, test, and evaluation actions to support the Joint Threat Warning System (JTWS) program. This included investigating integration of smart dust technology into the JTWS Component Architecture Framework, investigating integration of Special Operations Forces signals intelligence maritime capabilities into the tactical network topology effort, and classified signals analysis.
THE DESIGN, FABRICATION, AND TESTING OF RADIATION TOLERANT ASIC AND VLSI DEVICES FOR SPACE-BASED SYSTEMS
Sherif Michael, Professor
Department of Electrical and Computer Engineering
Sponsor: Secretary of the Air Force

SUMMARY: This project proposed a general-purpose digitally-programmable VLSI network for a space-based system. The design was based on a technique 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 ASIC chips were also irradiated using the Naval Postgraduate School LINAC, or other facilities, for testing performance under a radiation environment. Past experimental results using this technique have shown great improvements in the circuit's radiation performance. Incorporating these designs using SOI fabrication techniques was also considered.

HIGH POWER RF AND MICROWAVE MODELING AND DESIGN
Michael A. Morgan, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Surface Warfare Center-Dahlgren Division

SUMMARY: Computational design and support was provided for high-power microwave development.

LOW-FREQUENCY ELECTROMAGNETIC FIELD PENETRATION
Michael A. Morgan, Professor
Department of Electrical and Computer Engineering
Sponsor: Office of Naval Research

OBJECTIVE: To develop and validate a computational tool for predicting penetration of low-frequency electromagnetic fields through layered ferromagnetic and conducting cylindrical structures.

LOW-FREQUENCY ELECTROMAGNETIC FIELD PENETRATION THROUGH FERROMAGNETIC AND CONDUCTING STRUCTURES
Michael A. Morgan, Professor
Department of Electrical and Computer Engineering
Sponsor: Office of Naval Research

OBJECTIVE: To develop analysis and design tools to investigate low-frequency electromagnetic field penetration through complex ferromagnetic and conducting structures.

WIRELESS SMART SHIPBOARD SENSOR NETWORK
LTJG Andrew Nozik, USN
Department of Electrical and Computer Engineering
Sponsor: SPAWAR Systems Center-San Diego

OBJECTIVE: To build and test a wireless “smart” sensor that can be used on equipment in a shipboard sensor network. “Smart” means that if a pressure reading from a piece of equipment is desired, the sensor will know what piece of equipment it is being used on, the range of pressure readings required from it, and how to connect and send its information to the network. This research will expand upon previous work performed by Professor Yun and others on network-based shipboard sensors and the closed-loop calibrations of those sensors on wireless LANs, however, the current research will include the use of an Ipsil Flowstack chip in conjunction with the Zigbee wireless standard to create a wireless network to be used in the engineering spaces on Naval vessels.
ANTI-RADIATION MISSILE SEEKERS AND RANDOM NOISE RADAR WAVEFORMS
Phillip E. Pace, Professor
Department of Electrical and Computer Engineering
Sponsor: Los Angeles Air Force Base


AUTONOMOUS DETECTION AND CLASSIFICATION SCHEMES TO CORRECTLY IDENTIFY LOW PROBABILITY OF INTERCEPT WAVEFORMS
Phillip E. Pace, Professor
Department of Electrical and Computer Engineering
Sponsor: Office of Naval Research

OBJECTIVE: To investigate an autonomous detection and classification scheme to correctly identify all of the well-known low probability of intercept waveforms, and subsequently, to extract the waveform parameters. Simulated signals with correct signal-to-noise ratio and actual digitized signals will be used for evaluating the feasibility of this approach.

N433 THREAT MISSILE SIMULATOR VALIDATION WORKING GROUP
Phillip E. Pace, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Research Laboratory

OBJECTIVE: To provide technical leadership to the Navy surface anti-ship cruise missile threat Simulator Validation Working Group (SVWG). Three types of simulations are currently being validated by the SVWG for use in test and evaluation. These include radio-frequency missile-hardware simulators, infrared missile-hardware simulators, and computer models of missile seekers and related electronics.

SIGNAL PROCESSING TO DETECT AND TRACK EMITTERS OF INTEREST
Phillip E. Pace, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Research Laboratory

OBJECTIVE: To set up an area in the SCIF and to perform the signal processing necessary to detect and track emitters of interest.

ANALYSIS OF FREQUENCY-HOPPED WAVEFORMS
Ralph Clark Robertson, Professor
Department of Electrical and Computer Engineering
Sponsor: National Security Agency

OBJECTIVE: To analyze digitized frequency-hopped waveforms and to apply previously developed interference reduction techniques for frequency-hopped signals in order to determine the efficacy and practicality of these techniques.
FILTERING TECHNIQUES FOR FREQUENCY-HOPPED SIGNALS
Ralph Clark Robertson, Professor
Department of Electrical and Computer Engineering
Sponsor: National Security Agency

OBJECTIVE: Conventional frequency-hopping signals hop over a wide range of frequencies. It is possible that they will hop over a frequency band that will include both narrowband and wideband signals. This research will investigate the effect of filtering unwanted wideband signals present in the frequency-hopping bandwidth.

NATIONAL SECURITY AGENCY/APPLIED TECHNOLOGY DIVISION CRYPTOLOGIC RESEARCH LAB AND THESIS RESEARCH SUPPORT
Ralph Clark Robertson, Professor
Department of Electrical and Computer Engineering
James F. Ehler, National Security Agency Cryptologic Chair Professor
Department of Information Sciences
Sponsor: National Security Agency

SUMMARY: Supported the Cryptologic Research Laboratory at the Naval Postgraduate School wherein graduate students and faculty perform research in support of the National Security Agency's Applied Technology Division.

NATIONAL SECURITY AGENCY/APPLIED TECHNOLOGY DIVISION CRYPTOLOGIC RESEARCH LAB AND THESIS RESEARCH SUPPORT
Ralph Clark Robertson, Professor
Frank Kragh, Assistant Professor
Tri T. Ha, 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 perform research in support of the National Security Agency's Applied Technology Division.

PERFORMANCE AND CONTROL OF DYNAMIC TCS LINKS
Ralph Clark Robertson, Professor
Department of Electrical and Computer Engineering
Sponsor: National Reconnaissance Office

SUMMARY: The principle focus of this research was to investigate the performance of adaptive communication links. Adaptive links are expected to provide significant overall improvement in communication channel throughput. The first objective of this research was to investigate the fundamental theory of an adaptive link with special focus on a control algorithm needed to manipulate the link. The second objective was to develop a flexible software simulation that will enable easier investigation of varying combinations of modulation and coding schemes, channel conditions, and interference scenarios. This research focused on a single point-to-point communications link.
REAL-TIME COMMUNICATION PROTOCOLS FOR SENSOR NETWORKS WITH HARDWARE/SOFTWARE SYSTEM EVALUATION
Weilian Su, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: To enable real-time wireless sensor networks. This research will focus on developing communication protocols (e.g., transport, network, and data link protocols) and building hardware/software testing infrastructure for wireless sensor networks. The hardware/software infrastructure will be used to test/validate the proposed communication protocols.

SIGNAL PROCESSING FOR STRATEGIC SYSTEMS
Charles W. Therrien, Professor Emeritus
Department of Electrical and Computer Engineering
Sponsor: Strategic Systems Programs

OBJECTIVE: To study the use of jointly deployed sensors to perform tasks of detection, estimation, and classification for objects of interest. The sensors maybe of different types (acoustic, electromagnetic, optical, or other) and are typically characterized by different discrete-time sampling rates.

QUALITY OF SERVICE, CALL MANAGEMENT, AND HANDOFF ISSUES IN VOICE OVER INTERNET PROTOCOL
Murali Tummala, Professor
John C. McEachen, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Marine Corps Systems Command

OBJECTIVE: To investigate the quality of service (QOS), unified signaling for seamless operation across heterogeneous networks, related call manager improvements, and handoff procedures in the Marine Corps' application of Voice Over Internet Protocol in packet switched networks. Emphasis will be on methods for QOS guarantees across multiple networks. Tradeoff between higher QOS and increased signal compression and QOS-assisted voice compression schemes will be examined.

GALLIUM NITRIDE TRANSISTORS ON DIAMOND SUBSTRATES
Todd Weatherford, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: SP3 Diamond Technologies, Inc.

SUMMARY: The Naval Postgraduate School performed electrical and thermal simulations of Gallium Nitride transistors on diamond substrates in support SP3 Incorporated's STTR award MDA FA8650-04-M-4228.

LINEAR ACCELERATOR/FLASH X-RAY RADIATION TESTING OPERATIONS
Todd Weatherford, Associate Professor
Andrew A. Parker, Research Associate
Department of Electrical and Computer Engineering
Sponsor: Various

SUMMARY: The Naval Postgraduate School (NPS) provided beam time and technical support on the NPS flash X-ray facility.
SUPPORT FOR SPACE VEHICLES DIRECTORATE
Todd Weatherford, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Air Force Research Laboratory

OBJECTIVE: To support the Air Force Research Laboratory’s Kirtland space-vehicles directorate in evaluating new technologies in space environment.

AUTOMATIC TARGET DETECTION
Lonnie A. Wilson, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: National University of Singapore

OBJECTIVE: To develop high-performance and robust target-detection algorithms for TSDI synthetic–aperture radar (SAR) sensors. The automatic target-detection processor provides SAR imagine-screening support and potential target-detection cueing information to simplify and speed up manual target-detection analysis.

ITALD JEA PAYLOAD PROJECT
Lonnie A. Wilson, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Air Systems Command

SUMMARY: Evaluated the ITALD vehicle for ITALD-J application with EW/electronic attack payloads.

UNINTENTIONAL-MODULATION-ON-THE-PULSE SOURCE INVESTIGATION
Lonnie A. Wilson, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Secretary of the Air Force

OBJECTIVE: To perform Unintentional-Modulation-on-the-Pulse measurements and parameter analysis, and radar emitter characterization analysis and technical assessments of maritime navigation radars and replacement modules.

U.S. SPECIAL OPERATIONS COMMAND - NAVAL POSTGRADUATE SCHOOL
COOPERATIVE FIELD EXPERIMENTATION PROGRAM
Lonnie A. Wilson, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: Development and testing of high-sensitivity RF receiver system.

REDUCED CREW SIZE METROLOGY USING WIRELESS LOCAL AREA NETWORKS AND WEARABLE PERSONAL COMPUTERS
Xiaoping Yun, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Surface Warfare Center-Corona

OBJECTIVE: To assist the metrology program to improve and field the pressure calibration system, to initiate the design and prototyping of other calibration systems (including that for temperature gages), and
to generally assist MSD in identifying common areas for the Naval Postgraduate School and MSD to further the objectives of both activities.

**WIRELESS SHIPBOARD SENSOR NETWORK UTILIZING ZIGBEE TECHNOLOGY**

LT Chimi Zacot, USN  
Department of Electrical and Computer Engineering  
Sponsor: SPAWAR Systems Center-San Diego

**OBJECTIVE:** To perform a feasibility study of the 802.15.4/Zigbee wireless standard for use in a shipboard sensor network.
DEPARTMENT OF
ELECTRICAL AND
COMPUTER ENGINEERING

2006
Faculty Publications
and Presentations
CONFERENCE PUBLICATIONS


DEPARTMENT OF MECHANICAL AND ASTRONAUTICAL ENGINEERING

A. J. HEALEY
CHAIRMAN
OVERVIEW:

The Department of Mechanical and Astronautical Engineering (MAE) provides a strong academic program, which spans the engineering disciplines of thermal-fluid sciences, structural mechanics, dynamic systems, guidance and control, materials science and engineering, propulsion, and systems engineering, including total ship systems engineering, spacecraft, and missile design. These disciplines are blended together with a strong emphasis on naval engineering applications required by surface vessels, submarines, and spacecraft. Furthermore, the department provides advanced education in classified topics in Astronautical Engineering. Programs leading to the degree master of science in mechanical engineering or master of science in astronautical engineering are accredited by the engineering accreditation commission of the Accreditation Board for Engineering and Technology (ABET). A specific curriculum must be consistent with the general minimum requirements for the degree as determined by the academic council. Any program leading to a degree must be approved by the department chairman at least two quarters before completion. In general, approved programs will require more than the stated minimum degree requirements in order to conform to the needs and objectives of the United States Navy, and satisfy the applicable subspecialty-code requirements.

RESEARCH MISSION:

The research mission of MAE 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 MAE department serves the naval and mechanical-engineering curriculum (570), the mechanical- and reactors-engineering curriculum (571), and the space-systems engineering curriculum (591). These curricula are in support of Navy needs for individuals having advanced technical education in mechanical and astronautical 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. The space-systems engineering program provides officers with a comprehensive scientific and technical knowledge of national security, military and naval space systems.

DEGREES GRANTED:

- Master of Science in Mechanical Engineering
- Master of Science in Astronautical Engineering
- Mechanical Engineer
- Astronautical Engineer
- Doctor of Philosophy
- Doctor of Engineering

RESEARCH THRUSTS:

There are many 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; Space Systems; and Total Ship Systems Engineering
FACULTY EXPERTISE:

- Fluid Dynamics, Heat Transfer and Turbomachinery:
  Professor Knox Millsaps, Jr., Associate Professor Ashok Gopinath, Professor Garth Hobson.
- Dynamic Systems, Controls and Robotics:
  Distinguished Professor Brij Agrawal, Distinguished Professor Anthony Healey, Professor Morris Driels, Professor Issac Kaminer, Associate Professor Fotis Papoulia, Assistant Professor Marcello Romano, Professor I. Michael Ross.
- Solid Mechanics, Vibration, and Shock:
  Professor Young Shin, Professor Young Kwon, Associate Professor Joshua Gordis.
- Materials Science and Engineering:
  Professor Terry McNelley, Professor Indranath Dutta.
- Space Systems:
  Distinguished Professor Brij Agrawal, Professor Issac Kaminer, Assistant Professor Marcello Romano, Professor I. Michael Ross.
- Total Ship Systems Engineering: Associate Professor Fotis Papoulia.

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)-FY2006:

The Naval Postgraduate School’s sponsored program exceeded $80.43 million in FY2006. Sponsored programs include both research and educational activities funded from an external source. A profile of the sponsored program for the Department of Mechanical and Astronautical Engineering is provided below.

![Pie chart showing the distribution of funding sources.](chart.png)

Size of Program: $3.8M
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<tr>
<td>Healey, Anthony J.</td>
<td>Distinguished Professor and Chairman</td>
<td>656-3462/7533</td>
<td><a href="mailto:healey@nps.edu">healey@nps.edu</a></td>
</tr>
<tr>
<td>Millsaps, Knox T.</td>
<td>Professor and Associate Chairman for</td>
<td>656-3382</td>
<td><a href="mailto:millsaps@nps.edu">millsaps@nps.edu</a></td>
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<td>Papoulias, Fotis A.</td>
<td>Associate Professor and Associate Chairman for Academics</td>
<td>656-3381</td>
<td><a href="mailto:papoulias@nps.edu">papoulias@nps.edu</a></td>
</tr>
<tr>
<td>Agrawal, Brij N.</td>
<td>Distinguished Professor</td>
<td>656-3338</td>
<td><a href="mailto:agrawal@nps.edu">agrawal@nps.edu</a></td>
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<td>Driels, Morris R.</td>
<td>Professor</td>
<td>656-3383</td>
<td><a href="mailto:mrdriels@nps.edu">mrdriels@nps.edu</a></td>
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<td>Ball, Robert E.</td>
<td>Distinguished Professor Emeritus</td>
<td>656-2885</td>
<td><a href="mailto:reball@nps.edu">reball@nps.edu</a></td>
</tr>
<tr>
<td>Biblarz, Oscar</td>
<td>Professor Emeritus</td>
<td>656-3096</td>
<td><a href="mailto:obiblarz@nps.edu">obiblarz@nps.edu</a></td>
</tr>
<tr>
<td>Gordis, Joshua H.</td>
<td>Associate Professor</td>
<td>656-2866</td>
<td><a href="mailto:gordinath@nps.edu">gordinath@nps.edu</a></td>
</tr>
<tr>
<td>Brophy, Christopher M.</td>
<td>Research Associate Professor</td>
<td>656-2327</td>
<td><a href="mailto:cmbrophy@nps.edu">cmbrophy@nps.edu</a></td>
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<tr>
<td>Calvano, Charles N.</td>
<td>Professor Emeritus</td>
<td>656-2364</td>
<td><a href="mailto:calvano@nps.edu">calvano@nps.edu</a></td>
</tr>
<tr>
<td>Chandrasekhara, Muguru S.</td>
<td>Research Professor</td>
<td>656-3585</td>
<td><a href="mailto:mchandra@nps.edu">mchandra@nps.edu</a></td>
</tr>
<tr>
<td>Didoszak, Jarema</td>
<td>Research Associate Professor</td>
<td>656-2604</td>
<td><a href="mailto:jmdidosz@nps.edu">jmdidosz@nps.edu</a></td>
</tr>
<tr>
<td>Dobrokhodov, Vladimir</td>
<td>Research Assistant Professor</td>
<td>656-7714</td>
<td><a href="mailto:vldobr@nps.edu">vldobr@nps.edu</a></td>
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<td>Dobrzhanski, Jarema</td>
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<td><a href="mailto:jmdidosz@nps.edu">jmdidosz@nps.edu</a></td>
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<td>Hribar, Sheshagiri K.</td>
<td>Senior Lecturer</td>
<td>656-1103</td>
<td><a href="mailto:shebbar@nps.edu">shebbar@nps.edu</a></td>
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<td>Horner, Douglas P.</td>
<td>Research Assistant Professor</td>
<td>656-0829</td>
<td><a href="mailto:dphorner@nps.edu">dphorner@nps.edu</a></td>
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<td>Hobson, Garth V.</td>
<td>Professor</td>
<td>656-2888</td>
<td><a href="mailto:ghobson@nps.edu">ghobson@nps.edu</a></td>
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<td>Kaminer, Isaac I.</td>
<td>Associate Professor</td>
<td>656-3459</td>
<td><a href="mailto:kaminer@nps.edu">kaminer@nps.edu</a></td>
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<td>Kelleher, Matthew D.</td>
<td>Professor</td>
<td>656-2530</td>
<td><a href="mailto:mkelleher@nps.edu">mkelleher@nps.edu</a></td>
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<td>Kolar, Ramesh</td>
<td>Research Assistant Professor</td>
<td>656-2854</td>
<td><a href="mailto:rkolar@nps.edu">rkolar@nps.edu</a></td>
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<td>Kwon, Young W.</td>
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<td>656-3385</td>
<td><a href="mailto:ywkwon@nps.edu">ywkwon@nps.edu</a></td>
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<td>McElhenney, Terry R.</td>
<td>Distinguished Professor Emeritus</td>
<td>656-2589</td>
<td><a href="mailto:tmcelhenney@nps.edu">tmcelhenney@nps.edu</a></td>
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<td>Platzer, Maximilian F.</td>
<td>Distinguished Professor Emeritus</td>
<td>656-2586</td>
<td><a href="mailto:mplatzer@nps.edu">mplatzer@nps.edu</a></td>
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ADAPTIVE OPTICS CONTROL OF A LASER BEAM
Brij N. Agrawal, Distinguished Professor
Department of Mechanical and Astronautical Engineering
Sponsor: National Reconnaissance Office

OBJECTIVE: To upgrade the Naval Postgraduate School laser jitter control testbed to add adaptive optics and to perform research on eliminating higher-order optical-beam disturbances by using it. The current testbed allows research only for tip/tilt disturbance due to jitter by using fast steering mirrors. The upgrade will include adding one wavefront sensor, two deformable mirrors (one to create disturbance and the other to correct disturbance), and a control computer and software to the testbed. Two graduate students, a Ph.D. and a Master’s student, plan to do their thesis work on adaptive optical control. This is a new research area at the Center and is multidisciplinary in optics, structures, and control.

ADAPTIVE POINTING CONTROL FOR SPACECRAFT
Brij N. Agrawal, Distinguished Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Secretary of the Air Force

OBJECTIVE: To develop advanced control techniques to improve pointing performance of spacecraft. In 2006, the particle filter was evaluated for attitude estimation and compared with the extended kalman filter approach. In the proposed research effort, the objective is to develop adaptive algorithms for fine pointing control of flexible spacecraft.

LARGE-APERATURE LIGHTWEIGHT SPACE-BASED OPTICS
Brij N. Agrawal, Distinguished Professor
Department of Mechanical and Astronautical Engineering
Sponsor: National Reconnaissance Office

OBJECTIVE: To develop technologies in adaptive optics for flexible mirror surface control to minimize aberration in images, and to develop technologies in advance control to minimize the impact of mirror structural flexibility on point control and settling time during slew maneuvers. The emphasis in this project will be on adaptive optics. This is a joint AFIT/Naval Postgraduate School project. During Phase I, the focus will be to set up a testbed and demonstrate the correction of mirror surface and image aberration by using adaptive optics. In Phase II, the focus will be on developing and testing various wavefront sensors for monitoring the surface of the primary mirror and adjusting it. The deformable mirror used in the Phase I testbed will be replaced by a telescope with a mirror with active surface control. In Phase III, the main objective is to integrate adaptive optics techniques developed at NPS and at AFIT into the NPS jitter control testbed and bifocal relay mirror testbed.

ON-ORBIT SYSTEM IDENTIFICATION AND SLEW MANEUVER FOR FLEXIBLE SPACECRAFT
Brij N. Agrawal, Distinguished Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Secretary of the Air Force

OBJECTIVE: To develop and evaluate different techniques for on-orbit system identification (spacecraft inertia and structural frequencies) and slew maneuver control of flexible spacecraft to minimize settling time. The research performed in 2006 showed both analytically and experimentally that advanced control techniques can improve the performance for spacecraft pointing and reduce the effective time for slew maneuver when they are applied to a single-axis, flexible, spacecraft control.
OBJECTIVE: To develop a bifocal relay mirror testbed, with a single axis of rotation between the apertures, to investigate dual line of sight control issues. Using analytical simulations and experiments on the testbed, improved integration beam control and attitude control techniques will be developed and demonstrated. The emphasis of this project will be on the optical payload and beam control for the testbed.

OBJECTIVE: To extend collaborative research work between the Air Force Research Laboratory (AFRL) and the Spacecraft Research and Design Center (SRDC) at the Naval Postgraduate School in the development of space technologies. There are several research areas of common interest in spacecraft technologies, such as vibration isolation and control, shape control, jitter control, acquisition, tracking and pointing of optical payload spacecraft, and spacecraft system design. The specific areas and tasks will be defined each year as agreed. The research performed at SRDC will be presented at AFRL annually.

OBJECTIVE: To develop improved control algorithms for acquisition, tracking and pointing of imaging spacecraft, and adaptive optics. The Principal Investigator will provide subject matter expertise on this project.

OBJECTIVE: To develop and operate spacecraft laboratories to provide noteworthy improvements to the space engineering curriculum.

OBJECTIVE: To conduct spacecraft studies in two areas: evaluation of three-axis stabilization versus dual-spin stabilization for communications satellites and independent control of multiple payloads by multiple users. This is classified work.
SPACE SITUATIONAL AWARENESS RESEARCH CENTER
Kyle Alfriend, Navy Tactical Exploitation of National Capabilities (TENCAP) Space Chair
Department of Mechanical and Astronautical Engineering
Sponsor: Air Force Office of Scientific Research

OBJECTIVE: To establish a Joint Space Situational Awareness Research Center with the Air Force Maui Optical Site, to perform research vital to this country in Space Situational Awareness (SSA), and to educate military officers and government civilians about SSA.

CHARACTERIZATION OF PULSE DETONATION ENGINE OPERATION AND PERFORMANCE
Christopher M. Brophy, Research Associate Professor
Jose O. Sinibaldi, Research Assistant Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Office of Naval Research

OBJECTIVE: To determine the operational limits and performance of a valveless PDE operation on ethylene and JP10 fuels with air; to investigate the characteristics and applicability of a transient plasma ignition strategy for the effective initiation of detonations in fuel/air mixtures.

DEVELOPMENT OF ALTERNATIVE FUEL/AIR INITIATION TECHNIQUES
Christopher M. Brophy, Research Associate Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Pratt & Whitney

SUMMARY: One of the test cells and the rocket propulsion lab was made available from 3 January through 1 July 2006. The test cell can currently meet primary air flow rate requirements and cruise temperature requirements. A portion of the allotted work was used to improve the air delivery system to meet all the air flow requirements for the test matrix previously discussed. The flowrate requirements were demonstrated prior to 3 January 2006 by operating the facility at two test conditions. Resulting flowrate, temperature, and pressure versus time histories were provided to P&W SAC.

EVALUATION OF COMBUSTION PROPERTIES OF VARIOUS ALUMINIZED SOLID PROPELLANT FORMULATIONS
Christopher M. Brophy, Research Associate Professor
Department of Mechanical and Astronautical Engineering
Sponsor: ATK Aerospace Company, Inc.

OBJECTIVE: To evaluate the combustion properties of various aluminized solid propellant formulations supplied from ATK Thiokol, and to deliver a report describing the particle size distributions as a function of propellant type and distance from the burning surface.

HIGH ENERGY DENSITY HYDROCARBON NANOCLUSTER PROPELLANTS
Christopher M. Brophy, Research Associate Professor
Department of Mechanical and Astronautical Engineering
Sponsor: TDA Research, Inc.

SUMMARY: The Naval Postgraduate School conducted impact, friction, and unconfined burn tests on fullerenic compounds.
PERCORP ENHANCEMENT FOR IMPROVED SOOT MODELING
Christopher M. Brophy, Research Associate Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Sierra Engineering, Inc.

SUMMARY: Sierra Engineering, Inc. is under contract from the Air Force to improve the state-of-the-art exhaust plume prediction of hydrocarbon-burning engines through improved modeling of soot production, morphology, and depletion. This objective was addressed through the development and verification of physical engineering tools to model the physical process of soot morphology in liquid rocket engine combustion. The Naval Postgraduate School (NPS) provided the test facility, test hardware, test materials, soot diagnostic equipment, near field spectral radiance diagnostic equipment, and test personnel. NPS performed the data reduction and preliminary data analysis from tests performed. Work was performed at the NPS Rocket Combustion Laboratory under the direction of Christopher M. Brophy, Research Associate Professor.

EXPERT SUPPORT FOR UNSTEADY, FLOW CONTROL EXPERIMENTS
Muguru Chandrasekhar, Research Professor
Department of Mechanical and Astronautical Engineering
Sponsor: NASA Ames Research Center

OBJECTIVE: To support upcoming experimental, unsteady, flow control research related to dynamic stall and helicopter rotor separation control through active participation in acquisition and analysis of compressible flow data at the U.S. Army, aeroflight dynamics directorate, located at Moffett Field, California. The effort may also involve evaluation and possible use of special test facilities at Moffett Field and at off-site research locations, such as the Air Force Academy in Colorado Springs, Colorado.

A FUNDAMENTAL STUDY OF COMPRESSIBLE DYNAMIC STALL AND ITS CONTROL OVER A VARIABLE DROOP LEADING EDGE AIRFOIL
Muguru Chandrasekhar, Research Professor
Department of Mechanical and Astronautical Engineering
Sponsor: U.S. Army Research Office

OBJECTIVE: The variable, deforming, leading-edge airfoil has demonstrated dynamic stall vortex free behavior in incompressible flow numerical calculations, indicating distinctly superior vorticity dynamics. This research will experimentally establish the fundamental fluid flow processes involved for the more practical but complex compressible helicopter retreating blade conditions that produce the favorable vorticity dynamics in this novel dynamic stall control approach, with the hope that it leads to better rotor designs.

ACCURACY MODEL IMPROVEMENT
Morris Driels, Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Aeronautical Systems Center

SUMMARY: Performed tasks of interest to the Joint Technical Coordinating Group, focusing on improving current accuracy models for various unguided and guided weapons systems.
DEVELOPING A COMMON METHODOLOGY FOR THE DELIVERY ACCURACY OF LASER GUIDED WEAPONS
Morris Driels, Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Aeronautical Systems Center

**SUMMARY:** Performed tasks of interest to the Joint Technical Coordinating Group, focusing on the review and consolidation of methodologies for predicting the accuracy of laser guided weapons.

REPORT ON WEAPONEERING METHODOLOGIES
Morris Driels, Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Joint Technical Coordinating Group

**SUMMARY:** Reported on several recent tasks of interest to the Joint Technical Coordinating Group, focusing on improving current effectiveness models for various unguided and guided weapons systems.

GOALI: CREEP AND MICROSTRUCTURAL COARSENING OF LEAD FREE SOLDERS IN MICRO-ELECTRONIC PACKAGING APPLICATIONS
Indranath Dutta, Professor
Department of Mechanical and Astronautical Engineering
Sponsor: National Science Foundation

**OBJECTIVE:** To 1) devise a methodology for rapid creep characterization of FC and BGA solder balls with minimal sample preparation, based on the impression creep approach, 2) develop a unified creep model incorporating the effect of phase coarsening applicable to lead-free solders of two representative microstructural types, 3) generate comprehensive creep and coarsening kinetics data for solder joints of two selected lead-free alloys belonging to these microstructural types, and 4) provide fundamental mechanistic insight into the roles of microstructural scale and compositional artifacts on the evolution of creep behavior during TMC.

INTERFACIAL CREEP IN THIN FILM INTERCONNECT STRUCTURES IN MICRO-SYSTEMS
Indranath Dutta, Professor
Department of Mechanical and Astronautical Engineering
Sponsor: National Science Foundation

**OBJECTIVE:** To conduct a comprehensive experimental and analytical effort to obtain fundamental, mechanistic insight into interfacial creep at thin film-substrate interfaces under thermomechanical, as well as thermomechanical-cum—electrical loads. The efforts will combine creep testing with and without applied electrical current, detailed interfacial characterization, constitutive modeling, and experimental/analytical investigations of microelectronic device structures.
MINIATURIZED IMPRESSION CREEP TEST FOR BALL-GRID ARRAY AND FLIP-CHIP SOLDER JOINTS
Indranath Dutta, Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Semiconductor Research Corporation

OBJECTIVE: An investigation into ball-grid arrays and flip-chip solder joints to ascertain impression creeping.

ROLE OF ELECTRICAL SKIN EFFECTS IN RAILGUNS
Indranath Dutta, Professor
Department of Mechanical and Astronautical Engineering
Sponsor: University of Texas at Austin

SUMMARY: Characterization of scaled-down armature-rail contacts produced at the University of Texas at Austin. Make, text, and characterize model-system contacts to understand microstructural evolution at armature contacts under stationary conditions.

COMPUTATIONAL FLUID DYNAMICS SIMULATION OF THE BASICS OF UNDERWATER LAUNCH FLOW
Ashok Gopinath, Associate Professor
Donald v. Z. Wadsworth, Senior Lecturer
Department of Mechanical and Astronautical Engineering
Sponsor: Strategic Systems Programs

OBJECTIVE: To begin development of the basic numerical simulation capability to predict the essential fluid dynamic characteristics associated with an underwater missile launch. A suitable commercial-off-the-shelf Computational Fluid Dynamics package will be used for the simulation and the results will be validated against existing flight and numerical data. The long-term multi-year objective is to increase the sophistication and complexity of the numerical simulation and to incorporate new features, such as shallow water launch characteristics and future generation missile technology. This research covers the first year of a multi-year research effort at the Naval Postgraduate School sponsored by the Strategic Systems Programs.

MEASUREMENT OF MOLTEN METAL FLOW RATES AT HIGH TEMPERATURES
Ashok Gopinath, Associate Professor
Knox T. Millsaps, Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Department of Energy

OBJECTIVE: To build and test a device/sensor that could be used for the measurement of molten metal flow rates. The device should be accurate and robust and be calibrated against a standard reference. The work will be carried out in two phases; the first phase will have a low-melting, metallic eutectic to demonstrate proof of concept, and the second phase will have a higher melting point material. The object is to demonstrate operation at close to 1000 degree C temperatures.
MODELING AND SIMULATION OF UNMANNED VEHICLE LAUNCH FROM THE LITTORAL COMBAT SHIP
Joshua H. Gordis, Associate Professor
Fotis A. Papoulias, Associate Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Naval Surface Warfare Center-Panama City

OBJECTIVE: The stern-mounted launch and recovery system of the littoral combat ship will suspend unmanned vehicles (RMV/RHIB) in a pendular fashion from cantilevered support rails.

TECHNICAL EVALUATION OF ADVANCED ROLL-ON/ROLL-OFF RAMP TECHNOLOGIES: PHASE ONE
Joshua H. Gordis, Associate Professor
Fotis A. Papoulias, Associate Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Office of Naval Research

OBJECTIVE: To provide technical evaluation of proposed roll-on/roll-off ramp technologies. The evaluation will focus on an initial assessment of the ability of proposed ramp designs to function in Sea State Three and above, while having a significantly reduced weight as compared with existing ramp designs. Recommendations regarding potential success of candidate designs will be provided.

DEVELOPMENT OF AUTONOMOUS UNDERWATER VEHICLE TECHNOLOGIES
Anthony J. Healey, Distinguished Professor
Department of Mechanical and Astronautical Engineering
Sponsor: National University of Singapore

OBJECTIVE: First-year work was aimed at developing the AUV WorkBench, a simulation system for mission planning and control for autonomous underwater vehicles (AUVs). Later phases evaluate graduated nonconvexity algorithms developed using the AUV WorkBench for their performance in water trials using Aries.

DYNAMIC IMAGE-BASED NAVIGATION, SEARCH, AND TERMINAL HOMING FOR UNMANNED UNDERWATER VEHICLES
Anthony J. Healey, Distinguished Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Office of Naval Research

OBJECTIVE: To develop theory and its experimental validation for dynamic, image-based navigation with blazed-array forward-looking sonar, local area search methods, and terminal homing for neutralization of mines using unmanned underwater vehicles.

FBN AND PLS PLUS UP
Anthony J. Healey, Distinguished Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Office of Naval Research

OBJECTIVE: To provide extra equipment in support of the ongoing FBN program at the Office of Naval Research.
FORWARD LOOK SONAR OBSTACLE AVOIDANCE
Anthony J. Healey, Distinguished Professor
Douglas P. Horner, Research Assistant Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Office of Naval Research

OBJECTIVE: To develop theory and its experimental validation for advanced obstacle detection and avoidance control for AUVs.

HIGH-CYCLE FATIGUE/SPIN TEST RESEARCH
Garth V. Hobson, Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Naval Air Warfare Center-Aircraft Division

OBJECTIVE: To continue the development of high-cycle fatigue (HCF) spin-test techniques, while conducting full-scale engine rotor tests required in the joint Navy-Air Force turbine engine science and technology program. Concentration will focus on developing high-blade excitation amplitudes using oil-jet excitation, while avoiding surface erosion, for test durations of one to two hours. An evaluation of the effectiveness and HCF durability of alternate damping systems in the AE3007 fan rotor will be conducted when a suitable excitation system has been proven using un-damped blades. Consideration will be given to the problem of simulating engine temperatures.

HIGH-CYCLE FATIGUE/SPIN TEST RESEARCH II
Garth V. Hobson, Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Naval Air Systems Command

OBJECTIVE: To continue the development of high-cycle fatigue (HCF) spin-test techniques, while conducting full-scale engine rotor tests required in the joint Navy-Air Force turbine engine science and technology program.

RAM EXPANDER NOZZLE TEST
Garth V. Hobson, Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Ramgen Power Systems, Inc.

OBJECTIVE: The Naval Postgraduate School (NPS) will 1) provide Ramgen personnel access to the supersonic testing facility in the NPS Gas Dynamics Laboratory and the testing equipment therein, 2) provide technical support during testing of the Ramgen Static Ram Expander Nozzle model, and 3) deliver a data set consisting of the total pressure variance at the outlet of the nozzle for the flow conditions below:
MECHANICAL AND ASTRONAUTICAL ENGINEERING

- Nozzle side wall with no tip gap
- Nozzle side wall with a 2mm gap
- Nozzle side wall with a 4mm gap

TRANSONIC FAN-STEAM INGESTION STUDY
Garth V. Hobson, Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Naval Air Systems Command

OBJECTIVE: This research stems from prior exposure to the problem of ingestion on the F414 engine and an awareness of the potential criticality to a single-engine aircraft, such as the Joint Strike Fighter. The Transonic Compressor Rig has been enhanced with a steam generator for the introduction of steam into its inlet at various flow rates. The primary objective is to obtain controlled data on the effect of steam ingestion and inlet flow distortion on stall behavior. Post processing of the computational fluid dynamics studies of the F414 fan will also be completed.

COORDINATE AUTONOMY FOR PERSISTENCE PRESENCE IN HARBOR AND RIVERINE ENVIRONMENTS
Douglas P. Horner, Research Assistant Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Office of Naval Research

SUMMARY: Investigated the use of a heterogeneous mix of autonomous unmanned vehicles and sensors for persistence operations in harbor and riverine environments. This was a joint project with the Virginia Polytechnic Institute.

AERODYNAMICS AND CONTROL OF A FLAPPING-WING MICRO AIR VEHICLE
Kevin D. Jones, Research Associate Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Pacific Soft

OBJECTIVE: A flapping-wing Micro Air Vehicle (MAV) design previously developed at the Naval Postgraduate School will essentially be inverted, from a pusher to a tractor design. The tractor design is more challenging from a structural and actuation point of view, but is statically stable in hover. Static stability in hover is a major design objective, as it provides for a robust, efficient means of achieving hovering flight for extended periods. A wind-tunnel test model of the tractor design will be designed and fabricated. Wind tunnel test results will provide data for validation of numerical simulations performed by Pacific Soft. Results from the numerical simulations will be used to guide the design of a radio controlled flying model.

SUMMARY: This is an ongoing project. To date, an initial test model has been constructed proving the feasibility of the tractor flapping-wing design. Initial thrust data and low-speed flow visualization data have been recorded and presented at an interim meeting with Air Force technical representatives.

KEYWORDS: Flapping-Wing Propulsion, Micro Air Vehicle
DEVELOPMENT OF A LOW-COST TRACKING ANTENNA SYSTEM FOR MEDIUM RANGE COMMUNICATIONS WITH REMOTE MANNED OR UNMANNED AIR AND SURFACE VEHICLES

Kevin D. Jones, Research Associate Professor
Department of Mechanical and Astronautical Engineering
Sponsor: National Security Agency

OBJECTIVE: To develop, test, and evaluate a limited number of GPS-based auto-tracking antenna prototype systems to work with an NTIO-developed prototype line-of-sight (LOS) radio. This new prototype capability, if successful, will provide a very cost effective communications system with 1-3MHz of bandwidth that could be used by both military tactical ground units and tactical UAV platforms as a medium-range (5-25 miles) IP-based communications link. The primary goal of this initiative is to conduct demonstrations of this new prototype capability to military customers during the Naval Postgraduate School-sponsored TNT exercises.

SUMMARY: Several prototype systems were designed, manufactured, and tested. Initial tests demonstrated that the systems perform as intended. Follow-on work has begun to integrate an IMU for automatic orientation detection and mobile applications, and plans are underway for heavier duty systems for larger high-gain dish antennae. This work is ongoing.

KEYWORDS: Tracking Antenna, Medium Range Radio, Line of Sight Radio, UAV

AN EXPERIMENTAL AND COMPUTATIONAL INVESTIGATION OF OSCILLATING AIRFOIL UNSTEADY AERODYNAMICS AT LARGE MEAN INCIDENCE

Kevin D. Jones, Research Associate Professor
Department of Mechanical and Astronautical Engineering
Sponsor: University of Kentucky

SUMMARY: Task 1: Unsteady aerodynamic computations of the flow in NASA-GRC TFC and the NACA 0012 airfoil case: computation of the NASA-GRC TFV airfoil and NACA 0012 test cases for fully turbulent and transitional flow. Task 2: Date integration: a) assessing the experimental data from the NACA-GRC TDC and NACA 0012 airfoil test cases; b) comparing predictions based on Naval Postgraduate School and TURBP codes; and c) coordinating efforts and preparing a comprehensive final report for NASA.
FEASIBILITY STUDY FOR THE USE OF FLAPPING WINGS FOR MULTI-HULL SHIP PROPULSION

Kevin D. Jones, Research Associate Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Naval Surface Warfare Center Carderock Division

OBJECTIVE: To perform a feasibility study on the use of flapping wings for propulsion on modern multi-hull ships. The investigation will include two-dimensional simulations of flapping wings using panel and Navier-Stokes flow solvers. The primary objective is to determine if flapping wings can compete with conventional propulsion devices for high-speed ships. Power, thrust, and efficiency will be predicted over a practical range of speeds and compared with existing data for conventional devices.

SUMMARY: Single and biplane-flapping-wing systems were investigated, comparable to those used to fly the Naval Postgraduate School flapping-wing micro air vehicle, but scaled appropriately for vessels on the same scale as the HSV-2 Swift. Fluid-dynamic performance of the flapping-wing systems is shown to be far better than available data for the Lips jets used on the Incat Swift. Further work needs to be done to look at losses due to surface effects, three-dimensionality, and mechanical issues.

KEYWORDS: High Speed Vessels, Flapping-Wing Propulsion

DEVELOPMENT OF THE MODELING AND SIMULATION TOOLS FOR GUIDED AIRDROP SYSTEMS

Isaac I. Kaminer, Professor
Department of Mechanical and Astronautical Engineering
Sponsor: U.S. Army Yuma Proving Ground

SUMMARY: Continued development and testing of perspective pose estimation techniques for estimating center of rotation and payload attitude of a round canopy delivery system using video data obtained during the drop.

PRELIMINARY ANALYSIS OF TOUCH DOWN PERFORMANCE BY A PASSIVE, HIGH GLIDE, PAYLOAD DELIVERY SYSTEM

Isaac I. Kaminer, Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Naval Surface Warfare Center-Carderock Division

OBJECTIVE: To integrate geometry of the high-glide payload delivery system into Naval Postgraduate School (NPS) 8-DOF simulations, redesign NPS control laws to fit this model, and conduct a touch down performance study to support Naval Surface Warfare Center-Carderock Division-sponsored SBIR.

U.S. SPECIAL OPERATIONS COMMAND - THE NAVAL POSTGRADUATE SCHOOL COOPERATIVE FIELD EXPERIMENTATION PROGRAM

Isaac I. Kaminer, Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Naval Postgraduate School
A METHOD TO PREDICT THE THERMAL PERFORMANCE OF SHIPBOARD EQUIPMENT USING ARTIFICIAL NEURAL NETWORKS
Matthew D. Kelleher, Professor Emeritus
Department of Mechanical and Astronautical Engineering
Sponsor: Office of Naval Research

OBJECTIVE: To develop a model to predict the thermal performance of shipboard systems using computational algorithms based on artificial neural networks.

COMPETENCY EDUCATION PACKAGES FOR AIRCRAFT STRUCTURES
Ramesh Kolar, Research Assistant Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Naval Air Systems Command

OBJECTIVE: To develop and teach courses in aircraft fracture and fatigue and structural repair, analysis, and evaluation for Naval Air Systems Command and Naval Aviation Depot engineers and officers in structures competency.

FRACTOGRAPHIC ANALYSIS OF P3C SPAR CAPS AND PROBABILISTIC RISK ANALYSIS OF P3C ORION AIRCRAFT
Ramesh Kolar, Research Assistant Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Naval Air Warfare Center-Aircraft Division

SUMMARY: This investigation addressed fatigue cracks on P3C Orion spar caps and evaluated probabilistic risk analysis of P3C Orion aircraft; performed fractographical analysis of depot-supplied P3C Orion spar caps and determined fatigue crack characteristics; and evaluated probabilistic risk analysis methodology of P3C Orion aircraft based on fleet-supplied, tear-down, crack data for the P3C aircraft.

INTERNATIONAL WORKSHOP ON PREDICTIVE MODELING OF COMPOSITE MATERIALS
Young Kwon, Professor
Department of Mechanical and Astronautical Engineering
Sponsor: National Science Foundation

OBJECTIVE: To organize the Third Annual International Workshop on Stretching the Endurance Boundary of Composite Materials: Pushing the Performance Limit of Composite Structures. The first and second NSF/ EPSRC meetings and workshops on a related subject were held in Europe in May 2001 and in the U.S. in September 2006.

STUDY OF COMPOSITE SCARF BONDED JOINTS
Young Kwon, Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Naval Surface Warfare Center-Carderock Division

OBJECTIVE: To assist the Naval Surface Warfare Center-Carderock Division team for “Advanced Hull Materials and Structures Technology,” in particular the technology area of bonded composite joints. Computer modeling and simulation and an experimental study will be conducted to understand the failure mechanism, modes, strength under tension and compression loading, and the effects of carbon nanotubes on interface strength of the joints.
EFFECTS OF STRESS STATE ON DEFORMATION AND FAILURE MECHANISM IN SUPERPLASTIC AA5083
Terry R. Mc Nelley, Distinguished Professor
Department of Mechanical and Astronautical Engineering
Sponsor: University of Texas at Austin

OBJECTIVE: To assess the grain boundary sliding to solute drag creep transition during deformation under various stress states (including uniaxial and biaxial conditions), and to compare experimental and model textures for this transition. Microtexture analysis of cavity initiation and growth will be extended to determine the contribution of grain boundary sliding under various stress states and will include three-dimensional examination of growing cavities in relation to the dispersed constituent particles. Mechanical testing of thermo-mechanically processed direct-chill cast material will be conducted to assess the role of grain refinement in the transition.

THE FORMATION OF HIGH-ANGLE GRAIN BOUNDARIES AND EVOLUTION OF TEXTURE DURING SEVERE PLASTIC DEFORMATION PROCESSING OF ALUMINUM ALLOYS
Terry R. Mc Nelley, Distinguished Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Air Force Office of Scientific Research

OBJECTIVE: To evaluate the hypothesis that high-angle boundaries form from the interfaces between blocks or bands having lattice orientations that are variants of characteristic shear texture components during SPD by Equi-Channel Angular Pressing (ECAP). The influence of alloy constitution, ECAP processing parameters, and stability of microstructures during post-processing annealing will also be evaluated. Mechanical testing will provide data to assess the roles of grain refinement by ECAP and alloy constitution on properties.

FORMATION OF HIGH-ANGLE GRAIN BOUNDARIES BY SEVERE PLASTIC DEFORMATION
Terry R. Mc Nelley, Distinguished Professor
Department of Mechanical and Astronautical Engineering
Sponsor: AFOSR

OBJECTIVE: To determine mechanisms by which ultra-fine grain structures form in severely deformed materials processed by equi-channel angular (ECA) pressing and high-pressure torsion.

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 strains 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.
PUBLICATIONS:


PRESENTATIONS:


KEYWORDS: Aluminum, Grain Refinement, Nano-Grain Materials, Recrystallization, Grain Boundaries, Materials Processing
THE MECHANICAL AND MICROSTRUCTURAL CHARACTERIZATION OF COMMERCIAL AA5083 MATERIALS
Terry R. Mc Nelley, Distinguished Professor
Department of Mechanical and Astronautical Engineering
Sponsor: University of Texas at Austin

OBJECTIVE: To assess grain boundary character in selected AA5083 materials. Recently developed orientation imaging microscopy methods will be the primary means used to evaluate the microstructure and microtexture. Results will be provided to the University of Texas, where they will be coupled with mechanical property measurements and used to determine fundamental deformation mechanisms in these materials. This will aid in the construction of valid deformation mechanism maps.

THE MECHANICAL AND MICROSTRUCTURAL CHARACTERIZATION OF COMMERCIAL AA5083 MATERIALS
Terry R. McNelley, Distinguished Professor
Department of Mechanical and Astronautical Engineering
Sponsor: University of Texas-Austin and General Motors Corp.

OBJECTIVE: To determine the mechanisms of elevated temperature deformation and failure under uniaxial, plane strain, and biaxial deformation conditions. The microstructure dependence of the transition from grain boundary sliding to solute-drag controlled dislocation creep and the mechanisms of failure by cavity formation and growth during superplastic deformation under these various loading conditions will also be determined.

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 elevated temperature forming characteristics, corrosion resistance, weldability, and post-forming mechanical properties that make it suitable for a wide range of components. This alloy is currently being utilized in an innovative application, termed “Quick Plastic Forming” (QPF) by General Motors Corporation, which involves forming of sheet metal parts by differential gas pressure at elevated temperature. There are two particular difficulties in advancing this technology: 1) empirically developed methods for production of fine-grained AA5083 sheet material result in high cost, and 2) 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 are being employed to investigate grain size refinement during thermomechanical processing and transitions from grain boundary sliding to dislocation deformation mechanisms. Of particular concern are the relationships among alloy constitution, deformation mechanism, and failure by the formation and coalescence of cavities. The influence of stress state will be considered as well by including materials deformed under balanced biaxial tension and plane strain conditions, as well as under uniaxial tension.

PUBLICATIONS:


PRESENTATION:
KEYWORDS: Aluminum, Superplasticity, Recrystallization, Grain Boundaries, Thermomechanical Processing

MICROSTRUCTURE EVOLUTION AND CONTROL DURING FRICTION STIR PROCESSING OF CAST NiAl BRONZE MATERIALS
Terry R. Mc Nelley, Distinguished Professor
Department of Mechanical and Astronautical Engineering
Sponsor: DARPA, ONR

OBJECTIVE: To determine the mechanisms of microstructure evolution during friction stir processing (FSP) of cast NiAl bronze (NAB) materials utilizing various micro-analytical methods; and to evaluate microstructure – mechanical property relationships in relation to FSP of NAB materials. The mechanisms leading to refinement of microstructure during FSP and the temperature distributions associated with this process will be assessed. The factors that control the ductility of processed materials are of particular concern; these factors may include particular microstructure constituents as well as defects introduced by the processing.

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 will be 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:


MECHANICAL AND ASTRONAUTICAL ENGINEERING

CONFERENCE PUBLICATION:


CONFERENCE PRESENTATIONS:


THESES DIRECTED:


KEYWORDS: Nickel Aluminum Bronze, Friction Stir Processing, Castings, Propellers, Stir Zone, Thermomechanically Affected Zone, Shear Deformation

MICROSTRUCTURE EVOLUTION AND MICROSTRUCTURE-PROCESSING-PROPERTY RELATIONSHIPS IN FRICTION STIR PROCESSING OF NIAL BRONZE

Terry R. McNelley, Distinguished Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Office of Naval Research

OBJECTIVE: To conduct an experimental investigation into mechanisms of microstructure evolution and microstructure-mechanical property relationships associated with friction stir processing of NiAl bronze propeller materials. Factors leading to low ductility in processed material will be of primary concern.

MICROSTRUCTURE-PROPERTY RELATIONSHIPS IN FRICTION STIR PROCESSING OF NIAL PROPELLER BRONZE

Terry R. McNelley, Distinguished Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Defense Advanced Research Project Agency

OBJECTIVE: To determine the evolution of microstructure in cast NiAl bronze materials as a function of friction-stir processing (FSP) parameters. The effort will include orientation-imaging microscopy methods to evaluate the refining and homogenizing effects of FSP on microstructure, micro-texture, and grain
boundary character, as well as its role in elimination of casting porosity.

ADVANCED MARINE GAS TURBINE TECHNOLOGY PROGRAMS
Knox T. Millsaps, Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Naval Surface Warfare Center-Carderock Division

SUMMARY: This project supported the Advanced Technology Group Manager (Code 91) in the Marine Gas Turbine Branch of the Naval Sea Systems Command for the life cycle support of the ship service and main propulsion gas turbines. This work included providing analysis of test data and methodologies for the detection and localization of compressor stall of the GE LM2500.

ADVANCED TOTAL SHIP SYSTEM ENGINEERING AND OPTIMIZATION
Fotis A. Papoulias, Associate Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Advanced Technology Institute

OBJECTIVE: To educate American youth about careers in naval architecture and marine engineering (NA&ME) through a pre-college program for ship design.

A GENERIC FRAMEWORK FOR CONDUCTING ANALYSIS OF ALTERNATIVE STUDIES IN NAVAL SHIP DESIGN
Fotis A. Papoulias, Associate Professor
Clifford Whitcomb, Associate Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Office of Naval Research

OBJECTIVE: To propose a standardized methodology for conducting and prioritizing analysis of alternative studies in the context of naval ship design. The proposed approach utilizes the methodologies developed at the ASDL/GATECH.

TOTAL SHIP SYSTEMS ENGINEERING/MASSACHUSETTS INSTITUTE OF TECHNOLOGY NAVAL ENGINEERING PROGRAM STUDENT RESEARCH EXCHANGE
Fotis A. Papoulias, Associate Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Naval Sea Systems Command

SUMMARY: Supported the Naval Postgraduate School Total Ship Systems Engineering students’ exchange of research results and findings with the Massachusetts Institute of Technology’s naval-engineering program (2N) between 1-30 September.

ANALYSIS AND GROUND EXPERIMENT OF A CLUSTER OF INTERACTING SPACECRAFT FOR AUTONOMOUS IN-ORBIT ASSEMBLY AND RECONFIGURATION
Marcello Romano, Assistant Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: To advance knowledge in the field of multi-spacecraft systems for autonomous in-orbit assembly and reconfiguration. This emerging space-engineering concept may lead to breakthrough applications for both Department of Defense and civilian space missions. The focus of the research will be on dynamics and control issues. Both analytical-numerical techniques and on-the-ground experimentation
will be used. The author intends to establish a new and unique laboratory in the field at the Naval Postgraduate School. The laboratory will be financially self-sustaining after the end of the RIP period.

**ANALYSIS AND LAB EXPERIMENTS OF ROBUST GNC METHODS FOR A CLUSTER OF INTERACTING SPACECRAFT FOR ON-ORBIT ASSEMBLY AND RECONFIGURATION**

Marcello Romano, Research Assistant Professor  
Department of Mechanical and Astronautical Engineering  
Sponsor: Defense Advanced Research Projects Agency

**OBJECTIVE:** To advance knowledge in the field of multi-spacecraft systems for autonomous in-orbit assembly and reconfiguration. This emerging space-engineering concept may lead to breakthrough applications for both Department of Defense and civilian space missions. The focus of the research will be on dynamics and control issues. Both analytical-numerical techniques and on-the-ground experimentation will be used.

**HIGH-FIDELITY FOOTPRINT GENERATION FOR ENTRY VEHICLES**

I. Michael Ross, Professor  
Department of Mechanical and Astronautical Engineering  
Sponsor: Air Force Research Laboratory

**OBJECTIVE:** To explore a variety of connected topics in support of the Air Force Research Laboratory's program on the guidance and control of entry vehicles.

**PSEUDOSPECTRAL METHODS FOR OPTIMAL CONTROL AND ESTIMATION WITH APPLICATIONS TO SPACE SYSTEMS**

I. Michael Ross, Professor  
Keebom Kang, Associate Professor  
Department of Mechanical and Astronautical Engineering  
Sponsor: Air Force Office of Scientific Research

**OBJECTIVE:** To develop a unified theoretical foundation for pseudospectral methods in the optimal control and estimation of a general nonlinear system; and to apply the method to achieve real-time optimal control of space systems. The goal is to advance the state-of-the-art by solving optimal control and estimation problems that are not solvable using existing methods.

**PSEUDOSPECTRAL METHODS FOR OPTIMAL TRAJECTORIES BY IMPLICIT SIMULATION (OTIS)**

I. Michael Ross, Professor  
Department of Mechanical and Astronautical Engineering  
Sponsor: NASA-Glenn Research Center

**OBJECTIVE:** To advise the OTIS upgrade team at NASA on matters pertaining to pseudospectral methods for trajectory optimization with an emphasis on low-thrust control.

**REAL-TIME-OPTIMIZATION FOR SLEW MANEUVER DESIGN AND CONTROL**

I. Michael Ross, Professor  
Department of Mechanical and Astronautical Engineering  
Sponsor: National Reconnaissance Office

**OBJECTIVE:** To develop, simulate, and ground-test the feasibility of a revolutionary real-time-optimization algorithm for spacecraft slew maneuvers. This is a multi-year multi-faculty research project.
TRAVEL TO NAVAL SEA SYSTEMS COMMAND
LCDR William Schultz, USN
Department of Mechanical and Astronautical Engineering
Sponsor: Naval Sea Systems Command

OBJECTIVE: Consultation with NAVSEA in person.

FSP BARGE UNDERWATER EXPLOSION SIMULATION
Young S. Shin, Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Naval Surface Warfare Center-Carderock Division

OBJECTIVE: Given a finite element model of a standard Navy test barge (in LS/DYNA) format, to develop the appropriate fluid island mesh and conduct a series of three simulations of a standard MIL-S-901D maximum-severity barge test (using a 60 lb., Hbx-1 explosive charge detonated at a depth of 24 feet beneath the water surface at a horizontal standoff to the edge of the barge of 20 ft.).

SHIP SHOCK TRIAL MODELING AND SIMULATION
Young S. Shin, Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Naval Sea Systems Command

SUMMARY: Performed LPD17 ship shock trial modeling and simulation, conducted shock and vibration analysis in support of DDG class shock follow-on actions, including DDG-81 flight IIA ship shock modeling and simulation, identified potential problem areas, and investigated damage potential from the standpoint of survivability of a ship system.

SHOCK AND VIBRATION ANALYSIS IN SUPPORT OF DD(X) AND DDG SHOCK FOLLOW-ON ACTIONS
Young S. Shin, Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Naval Sea Systems Command

OBJECTIVE: To provide engineering and analysis support for review of underwater explosion testing results, DD(X) and DDG ship shock trial modeling, and comparison of model predictions with collected data. Recommendations on the “way ahead” for DD(X) LFT&E shock analysis and ship shock trials will be provided.

AUTONOMOUS TRACKING OF AVIATION AND AIR DELIVERY TEST ARTICLES
Oleg Yakimenko, Research Associate Professor
Department of Mechanical and Astronautical Engineering
Sponsor: U.S. Army Yuma Proving Ground

OBJECTIVE: To develop, test, and support autonomous video-scoring software allowing obtaining inertial coordinates and possibly an attitude of a test article based on the video data provided by up to six stationary kineto-tracking mounts.
DEPARTMENT OF
MECHANICAL AND
ASTRONAUTICAL
ENGINEERING

2006
Faculty Publications
and Presentations
REferred Journal Publications


Conference Publications


CONFERENCE PRESENTATIONS (PUBLISHED ABSTRACT)


OTHER PRESENTATIONS


CHAPTERS IN BOOKS


REPORTS


DEPARTMENT OF METEOROLOGY

CARLYLE WASH
CHAIRMAN
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 S. Guest, Research Associate Paul Fredrichson

- Polar Meteorology:
  Research Associate Professor Peter S. 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)-FY2006:

The Naval Postgraduate School’s sponsored program exceeded $81 million in FY2006. Sponsored programs included both research and educational activities funded from an external source.

Size of Program: $1.6M
Wash, Carlyle H.
Professor and
Chairman
656-2516
wash@nps.edu

Davidson, Kenneth L.
Professor and
Associate Chairman for Research
656-2309/2563
davidson@nps.edu

Brown, David, LCDR
Military Instructor
656-7645
dbsbrown@nps.edu

Guest, Peter S.
Research Associate Professor
656-2451
pguest@nps.edu

Nuss, Wendell A.
Associate Professor
656-2308
nuss@nps.edu

Chang, C-P.
Distinguished Professor
656-2840
cpchang@nps.edu

Haney, Robert
Professor Emeritus
656-7571
rlhaney@nps.edu

Wang, Qing
Associate Professor
656-7716
gwang@nps.edu

Chen, Hway-Jen
Research Associate
656-3788
bonbon@nps.edu

Harr, Patrick A.
Associate Professor
656-3787
paharr@nps.edu

Williams, Forrest
Senior Lecturer Emeritus
656-3274
fwilliams@nps.edu

Durkee, Philip A.
Professor
MR/De
656-3465
durkee@nps.edu

Jordan, Mary S.
Research Associate
MR/Jr
656-3109
jordan@nps.edu

Williams, R. Terry
Professor Emeritus
656-2296
rtwillia@nps.edu

Elsberry, Russell L.
Distinguished Professor
656-2373
elsberry@nps.edu

Murphree, Tom
Senior Lecturer
656-2723
murphree@nps.edu

Frederickson, Paul
Research Associate
656-2407
pafreder@nps.edu

Nielsen, Kurt
Research Associate
656-1026
nielsen@nps.edu
AIRBORNE AEROSOL NUMBER FLUX MEASUREMENTS
Gintautas Buzorius, Research Assistant Professor
Department of Meteorology
Sponsor: National Science Foundation

OBJECTIVE: To determine airborne aerosol flux measurement system ability in detecting sea-spray aerosol emission.

BOUNDARY LAYER EFFECTS ON ATMOSPHERIC FRONTS
Chih Pei Chang, Distinguished Professor
Department of Meteorology
Sponsor: National Science Foundation

OBJECTIVE: One of the goals of the U.S. Weather Research Program is to improve the prediction of heavy precipitation events that are often associated with frontal systems. The objective of this research is to improve understanding of the influence of the planetary boundary layer on atmospheric fronts. Extensive research has been devoted to frontal dynamics and the underlying topography on them. However, the effect of the boundary layer on the development and modification of fronts as they move over various surfaces is not well understood. The structure of fronts that form over the ocean and subsequently move over land will be investigated.

INTERANNUAL VARIATION OF MONSOON AND EL NINO-SOUTHERN OSCILLATION
Chih Pei Chang, Distinguished Professor
Department of Meteorology
Sponsor: National Oceanic and Atmospheric Administration

OBJECTIVE: To study the relationship between the interannual variations of Asian-Australian monsoon and El Nino-southern oscillation.

MONSOON DISTURBANCES IN SOUTHEAST ASIA AND ADJACENT SEAS
Chih Pei Chang, Distinguished Professor
Department of Meteorology
Sponsor: Office of Naval Research

OBJECTIVE: To study behavior and predictability of monsoon disturbances in southeastern Asia and adjacent regions.

TROPICAL CYCLONOGENSEIS IN THE ATLANTIC BASIN AS REVEALED BY NOGAPS ANALYSIS AND FORECAST FIELDS
Chih Pei Chang, Distinguished Professor
Department of Meteorology
Sponsor: Naval Research Laboratory

OBJECTIVE: To evaluate the prediction of Atlantic tropical cyclonogenesis by the Naval Operational Global Forecast System.
METEOROLOGY

BUOY/METEOROLOGY AND OCEANOGRAPHY DATA COLLECTION SUPPORT TO IEEE 802 RADIO (SEA LANCET) FIELD TESTS
Kenneth L. Davidson, Professor
Paul A. Frederickson, Research Associate
Department of Meteorology
Sponsor: SPAWAR Systems Center-San Diego

OBJECTIVE: To prepare a Naval Postgraduate School (NPS) instrumental buoy as an at-sea test platform for a new radio being developed under a Phase II SBIR. This radio, the SBIR IEEE 802-Derived Radio (Sea Lancet), will be integrated into the buoy electronics system for a long-term test operating onboard the NPS buoy while moored off San Diego in fall 2006.

EVAPORATION DUCT/EO TURBULENCE MODELS
Kenneth L. Davidson, Professor
Paul A. Frederickson, Research Associate
Department of Meteorology
Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: To evaluate and transition lower-atmosphere models and application weather/temperature observed and predicted data for linkage to propagation effects models and tactical decision aids to maximize awareness of radar and IR detection of threat and own forces. Apply validated METOC and propagation models to special high-resolution data that will describe radar and IR surveillance impacts in Singapore region, in support of PAOM security initiative.

INTEGRATION TOOL (ADEPT) FOR ATMOSPHERE EFFECTS ON RADAR/INFRARED SURVEILLANCE FOR MARITIME DOMAIN AWARENESS
Kenneth L. Davidson, Professor
Department of Meteorology
Sponsor: Naval Postgraduate School

OAML DOCUMENTATION/APPROVAL OF BOUNDARY LAYER MODEL TO MEET RADIO FREQUENCY/INFRARED IMPACT REQUIREMENTS
Kenneth L. Davidson, Professor
Paul A. Frederickson, Research Associate
Department of Meteorology
Sponsor: Space and Naval Warfare Systems Command

SUMMARY: Documented the NPS boundary-layer model in the Oceanographic and Atmospheric Master Library (OAML) for estimation of vertical profiles and turbulence intensities for application in EM/EO propagation in the atmosphere surface layer over the ocean.

OPERATIONAL ASSESSMENT OF RADIO FREQUENCY/INFRARED SENSOR DETECTION OF NEAR-SURFACE LOW CROSS SECTION AND LOW OBSERVABLE TARGETS
Kenneth L. Davidson, Professor
Paul A. Frederickson, Research Associate
Department of Meteorology
Sponsor: Space and Naval Warfare Systems Command

SUMMARY: Expeditiously evaluated and transitioned lower-atmosphere models and applications weather/temperature observed and predicted data for linkage to propagation effects models and tactical decision aids to maximize decision makers’ awareness of radar and infrared (IR) detection of threat and own forces. Applied validated meteorology and oceanography and propagation models to special high-
resolution data that described radar and IR surveillance impacts for particular platforms in support of regional initiatives.

SINGAPORE/MALACCA STRAIT EVAPORATION DUCT/IR CHARACTERIZATION
Kenneth L. Davidson, Professor
Paul A. Frederickson, Research Associate
Department of Meteorology
Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: To characterize surveillance variability in a unified command (PACOM) identified high-priority terrorist security region, using data provided by partnering country (Singapore) and own demonstrated effects models and procedures.

U.S. SPECIAL OPERATIONS COMMAND - THE NAVAL POSTGRADUATE SCHOOL’S COOPERATIVE FIELD EXPERIMENTATION PROGRAM
Kenneth L. Davidson, Professor
Department of Meteorology
Sponsor: Naval Postgraduate School

USE OF THE SATELLITE-BORNE SENSOR DATA IN REAL-TIME ASSESSMENT OF EA/IO/ISR EFFECTIVENESS AND DETECTION VULNERABILITY
Kenneth L. Davidson, Professor
Paul A. Frederickson, Research Associate
Department of Meteorology
Sponsor: Navy Tactical Exploitation of National Capabilities

OBJECTIVE: To determine the potential value of, and develop an approach for, incorporating satellite-derived lower atmospheric and ocean surface information into existing in situ data sets to predict environmental impacts on EA/IO/ISR effectiveness and detection vulnerability.

ALGORITHM DEVELOPMENT FOR THE NATIONAL AIR AND SPACE INTELLIGENCE CENTER DEMONSTRATION
Philip A. Durkee, Professor
Department of Meteorology
Sponsor: National Air and Space Intelligence Center

OBJECTIVE: To develop algorithms for active programs of the National Air and Space Intelligence Center, Dayton, Ohio. Details of the algorithms are classified.

ATMOSPHERIC MEASUREMENT SUPPORT
Philip A. Durkee, Professor
Department of Meteorology
Sponsor: Naval Research Laboratory

OBJECTIVE: To support atmospheric measurements for the Naval Research Laboratory.
IMPROVED AEROSOL ANALYSIS FOR IMAGE CORRECTION
Philip A. Durkee, Professor
Kurt E. Nielsen, Research Associate
Department of Meteorology
Sponsor: Secretary of the Air Force

OBJECTIVE: To create a robust image correction process for atmospheric aerosol properties using ancillary satellite imagery, analysis center products, and in-scene image analysis. First year funding will develop a new model for atmospheric correction of aerosol extinction for use in par with current, operational, meteorological satellites incorporated in this new model to provide first-order aerosol information. The emphasis of this research will be classified.

METEOROLOGY AND OCEANOGRAPHY SENSOR ENGINEERING SATELLITE-DERIVED MARINE ATMOSPHERIC BOUNDARY LAYER AND EM/EO PROPERTIES
Philip A. Durkee, Professor
Mary S. Jordan, Research Associate
Department of Meteorology
Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: To provide direct support between curriculum sponsor, curriculum students, faculty, and their research.

METHODS FOR COMPREHENSIVE SATELLITE ANALYSIS
Philip A. Durkee, Professor
Department of Meteorology
Sponsor: National Oceanic and Atmospheric Administration

OBJECTIVE: To explore and develop methods to combine information from multiple satellite platforms into a comprehensive satellite analysis scheme. This is the second year of the project.

METHODS FOR COMPREHENSIVE SATELLITE ANALYSIS
Philip A. Durkee, Professor
Department of Meteorology
Sponsor: National Polar-Orbiting Environmental Satellite System Integrated Project Office

OBJECTIVE: To explore and develop methods to combine information from multiple satellite platforms into a comprehensive satellite analysis scheme. This is the third year of the project.

SHIP DETECTION AND CORRELATION WITH SATELLITE OBSERVATIONS IN CLOUDY CONDITIONS
Philip A. Durkee, Professor
Kurt E. Nielsen, Research Associate
Department of Meteorology
Sponsor: Naval Engineering Logistics Office

OBJECTIVE: To correlate ship observations using meteorological satellite imagery with ship databases created with coastal AIS collections. To use this unique capability with GOES imagery to track ship movements and improve ship identification for future software tool development.
OBJECTIVE: To collect and analyze mean meteorological and atmospheric turbulence data from the NPS “flux” buoy during the Navy propagation measurement experiments. The ultimate goal is to determine the potential impact of atmospheric scintillation, refraction, and molecular and aerosol extinction on high energy laser propagation in a marine environment for ship self-defense applications against cruise missiles.

DEVELOPMENT OF THE NAVY SURFACE LAYER OPTICAL TURBULENCE MODEL

OBJECTIVE: To develop an improved and updated version of the NSLOT model, incorporating new model functions based primarily on analysis, comparison, and model verification with turbulent and optical scintillation data obtained during the Navy Atmospheric Propagation Measurement Campaign of 2004-2006. The improved NSLOT model will provide the Navy with enhanced capabilities for predicting the effects of optical turbulence and refraction on sensor and weapons system performance.

PREPARATION OF PRELIMINARY DATA SET FOR THE NAVY ATMOSPHERIC PROPAGATION EXPERIMENT OF AUGUST 2005

OBJECTIVE: To develop a preliminary master environmental data set for the Navy propagation experiments conducted in San Diego, California, in August 2005. The data set will contain and fully explain and describe the measured and computed data collected by NPS and other participating researchers in this project, as well as relevant data available from outside sources.

COLLABORATIVE RESEARCH: THE MAUD RISE NONLINEAR EQUATION OF STATE STUDY (MAUDNESS)

OBJECTIVE: To discover whether a nonlinear property of the equation of the state of seawater (thermobaricity) results in massive convection in the southern oceans.

IMPACT OF THE EXTRATROPICAL TRANSITION CYCLONES ON THE PREDICTABILITY OF DOWNSTREAM SYNOPTIC-SCALE WEATHER SYSTEMS OVER MID-LATITUDE OCEAN BASINS

OBJECTIVE: Poleward-moving tropical cyclones often transition into fast-moving, rapidly-developing extratropical cyclones. These events cause large perturbations in the downstream, mid-latitude atmospheric
flow. The objective of this research is to quantify the reduction in the predictability of weather patterns due to the perturbations downstream of extratropical transition events.

OBJECTIVE AND AUTOMATED ASSESSMENT OF OPERATIONAL GLOBAL FORECAST MODEL PREDICTIONS OF TROPICAL CYCLONE FORMATION AND LIFE CYCLE

Patrick A. Harr, Professor
Department of Meteorology
Sponsor: National Oceanic and Atmospheric Administration

OBJECTIVE: To transition an operational product to the National Hurricane Center that will extend the utility of operational global model forecasts of tropical cyclone formation.

TROPICAL CYCLONE FORMATION/STRUCTURE/MOTION STUDIES

Patrick A. Harr, Professor
Russell L. Elsberry, Distinguished Professor
Department of Meteorology
Sponsor: Office of Naval Research

OBJECTIVE: To improve understanding of the physical processes in tropical cyclone formation, structure change, and motion changes. Each of the three components are linked, and in the long-term the combined effort will contribute to improved tropical cyclone warnings to the fleet and shore bases.

COLLABORATIVE RESEARCH: DYNAMIC AND THERMODYNAMIC CONTROL OF TROPICAL INTENSITY IN SHEARED ENVIRONMENTS

Michael T. Montgomery, Professor
Department of Meteorology
Sponsor: National Science Foundation

OBJECTIVE: To undertake a comprehensive investigation of the physics of the interaction between tropical cyclones and the sheared flow in which they are embedded, focusing on the mutual operation of dynamic and thermodynamic processes. The Principal Investigator hypothesizes that tropical cyclones are weakened by the injection of low-entropy middle-level air into the vortex core by vortex Rossby waves excited by the interaction between the vortex and environmental shear flow.

HURRICANE FORMATION AND EVOLUTION DETERMINED FROM OBSERVATIONS AND HIGH-RESOLUTION SIMULATIONS

Michael T. Montgomery, Professor
Department of Meteorology
Sponsor: NASA Goddard Space Flight Center

OBJECTIVE: To continue high-resolution (~250m - 4km) numerical modeling of hurricanes from CAMEX-3, CAMEX-4, and ongoing simulations for TCSP at the Department of Meteorology, NPS. The emphasis of this ongoing collaborative research is on the use of various aircraft and satellite data for model validation, as well as examination of numerical simulations and observations for improved understanding of physical and dynamical processes within tropical cyclones.
THEORETICAL AND OBSERVATIONAL STUDY OF MID-LATITUDE MESOSCALE
CONVECTIVE VORTICE IN VERTICAL SHEAR
Michael T. Montgomery, Professor
Department of Meteorology
Sponsor: National Science Foundation

SUMMARY: Because of their longevity and ability to organize convection on the mesoscale, mesoscale convective vortices (MCVs) have been the focus of studies seeking to improve the prediction of widespread, heavy-precipitation events during the warm season. Although progress has been made in the past decade towards identifying conditions favorable for MCV generation, and in linking the strengthening of MCVs to convective regeneration in their vicinity, dynamical processes governing the MCV lifecycle are still not well understood. To better predict potential flooding events in association with MCVs requires a basic understanding of how MCVs form, and what permits them to maintain their coherence in adverse environmental flows. Both questions will be addressed in support of the bow echo and MCV experiment (BAMEX).

TROPICAL CYCLOGENESIS VIA NON-AXISYMMETRIC UPSCALE ENERGY CASCADE
AND ITS DISRUPTION BY VERTICAL SHEAR
Michael T. Montgomery, Professor
Department of Meteorology
Sponsor: National Science Foundation

SUMMARY: In addition to being of basic fluid dynamical interest, a hurricane is a high-impact weather phenomenon that frequently brings disaster to populated coastal areas in tropical regions. Despite decades of research on these rapidly-rotating, deadly storms, the physics describing their formation remains elusive. The Principal Investigator and his students have recently advanced a new hypothesis and theory for vortex development by vortex axisymmetrization of convectively-generated small-scale vorticity anomalies.

WAVE DYNAMICS IN TROPICAL CYCLONES
Michael T. Montgomery, Professor
Department of Meteorology
Sponsor: National Science Foundation

OBJECTIVE: These research efforts will lead to collaborations between modeling specialists, observational meteorologists, and applied mathematicians. In addition, the results will be immediately incorporated into advanced graduate level courses at Colorado State University. Results from this research will build a framework for interpreting the complex wave dynamics that are believed to partially regulate hurricane intensity.

DEVELOPING AND APPLYING METEOROLOGY AND OCEANOGRAPHY METRICS IN SEA
STRIKE OPERATIONS
Tom Murphree, Senior Lecturer
Department of Meteorology
Sponsor: Office of Naval Research

OBJECTIVE: To apply assessment and simulation methods developed in prior studies of meteorology and oceanography (METOC) impacts to analyze a unique Operation Iraqi Freedom data set containing information on environmental phenomena and METOC products, and their impacts on warfighter operations.
DEVELOPING AND APPLYING METEOROLOGY AND OCEANOGRAPHY METRICS IN SEA STRIKE OPERATIONS
Tom Murphree, Senior Lecturer
Department of Meteorology
Sponsor: Office of Naval Research

OBJECTIVE: To quantify and assess the contribution of meteorology and oceanography forces during Operation Iraqi Freedom and other recent military operations; and to develop tools to aid data collection, modeling and simulation, mission planning, and impacts analysis.

DEVELOPING AND APPLYING METEOROLOGY AND OCEANOGRAPHY METRICS IN SEA STRIKE OPERATIONS
Tom Murphree, Senior Lecturer
Department of Meteorology
Sponsor: Space and Naval Warfare Command

OBJECTIVE: To quantify and assess the contribution of METOC forces during Operation Iraqi Freedom and other recent military operations; and to develop tools to aid data collection, modeling and simulation, mission planning, and impacts analysis.

UNDERSTANDING AND PREDICTING CHANGES IN THE WORKFORCE FOR OCEAN SCIENCES, TECHNOLOGY, AND OPERATIONS
Tom Murphree, Senior Lecturer
Department of Meteorology
Sponsor: Office of Naval Research

OBJECTIVE: To produce an improved description of the present state of the ocean science, technology, and operations workforce; to anticipate future developments in this workforce; and to characterize the educational programs that will be needed to respond to those developments.

MARITIME DOMAIN AWARENESS EVALUATION TEST ENVIRONMENT AND SOFTWARE TESTING
Kurt E. Nielsen, Research Associate
Department of Meteorology
Sponsor: Naval Postgraduate School

SUMMARY: An extensive meteorological satellite data set was collected for the coastal area and offshore area of central California, and detailed analysis of the cloud signatures of ships in the imagery was performed. Case studies of these data in conjunction with other sources such as the USCG database are under analysis. Part of the study explores the relationship between these data sets. Another part involves software development for identifying the cloud signatures.

PRESCRIBED BURN WEATHER AND SMOKE FORECASTING
Wendell A. Nuss, Associate Professor
Department of Meteorology
Sponsor: U.S. Army Corps of Engineers

OBJECTIVE: To provide weather and smoke forecasting to the U.S. Army Corps of Engineers to conduct prescribed burns. Maintenance and upgrades of weather stations will be done. An analysis of the forecast reliability of the Calpuff Smoke Dispersion Model will be done. Automated weather support products will be available on the web page for use.
THE RESPONSE OF THE UPPER OCEAN TO VARYING METEOROLOGICAL CONDITIONS USING OCEAN MODELS AND SATELLITE IMAGERY

Wendell A. Nuss, Associate Professor
Department of Meteorology
Sponsor: San Jose State University Foundation

OBJECTIVE: To employ modeling and satellite imagery in the study of upper-ocean response to meteorological conditions.

INFORMATION VALUE REACHING THE TACTICAL AND OPERATIONAL DECISIONS MOST SENSITIVE TO METEOROLOGY AND OCEANOGRAPHY BATTLESPACE CHARACTERIZATION

CDR Rebecca Stone, USN
Department of Meteorology
Sponsor: Naval Postgraduate School

IMPROVING SURFACE FLUX PARAMETERIZATION

Qing Wang, Associate Professor
Department of Meteorology
Sponsor: Office of Naval Research

SUMMARY: This is a joint proposal with the Naval Research Laboratory (NRL), Monterey. NRL Principal Investigator, Dr. Shouping Wang, submitted the same proposal with a separate funding request to the Office of Naval Research. A three-year research plan for the follow-up of the CBLAST project is proposed. The overall objectives continue to be to understand air-sea interaction and improve the surface flux and boundary layer parameterization in the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS). This project focused on three issues: impact of SST variability in the context of the coupled atmospheric-oceanic boundary layers; improvements in the surface and boundary layer parameterizations with emphasis on the stable and fog conditions; and evaluation and transition of new parameterizations in COAMPS.

UNDERSTAND THE AIR-SEA COUPLING PROCESSES IN HIGH WIND CONDITIONS USING A SYNTHESIZED DATA ANALYSIS/MODELING APPROACH

Qing Wang, Associate Professor
Department of Meteorology
Sponsor: Office of Naval Research

OBJECTIVE: To understand the air-sea interaction processes in coastal regions in high wind conditions, and to improve the boundary layer and surface flux parameterizations for a high-resolution mesoscale model (COAMPS) in high wind conditions.

UNDERSTANDING AND PARAMETERIZATION OF NEAR-SURFACE TURBULENT FLUXES IN THE COASTAL ZONE

Qing Wang, Associate Professor
Department of Meteorology
Sponsor: Office of Naval Research

OBJECTIVE: To understand the temporal and spatial variation of turbulent surface fluxes in relation to coastal flow dynamics and clouds using aircraft observations from Autonomous Ocean Sampling Network and Adaptive Sampling and Prediction experiments. To improve surface flux parameterization in the marine atmospheric boundary layer using synthesized measurements from aircraft, buoys, and satellite with the focus on sea-state (waves and upwelling) dependent surface flux parameterization; and to use the results
to understand and evaluate the Coupled Ocean/Atmospheric Mesoscale Prediction System for simulating the coastal marine boundary layer.

**JOINT FORCES COM DESK**
Carlyle H. Wash, Professor  
Department of Meteorology  
Sponsor: Naval Postgraduate School

**METEOROLOGY AND OCEANOGRAPHY STUDIES**
Carlyle H. Wash, Professor  
Department of Meteorology  
Sponsor: Space and Naval Warfare Command

**OBJECTIVE:** To conduct validation and verification studies of the atmospheric data assimilation (NAVDAS) and high-resolution computer forecast models (COAMPS), and to support NPS student thesis research on CNMOC and FNMOC topics.

**METEOROLOGY AND OCEANOGRAPHY THESIS SUPPORT FOR OPERATIONAL FOCUSED TOPICS**
Carlyle H. Wash, Professor  
Department of Meteorology  
Sponsor: Space and Naval Warfare Systems Command

**OBJECTIVE:** To conduct COAMPS evaluation and verification studies and support over NPS METOC theses on FNMOC and regional METOC center problems.

**METEOROLOGICAL SUPPORT AND VALIDATION**
Carlyle H. Wash, Professor  
Department of Meteorology  
Sponsor: Secretary of the Air Force

**OBJECTIVE:** To conduct analysis and verification studies on classified cloud meteorological databases and forecasts.
DEPARTMENT OF METEOROLOGY

2006
Faculty Publications and Presentations


CONFERENCE PUBLICATIONS


TECHNICAL REPORTS


DEPARTMENT OF OCEANOGRAPHY

MARY L. BATTEEN
CHAIRMAN
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 C. 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 Smetter, Julie McClean, Robin Tokmakian, Ramsey Harcourt, Wieslaw Maslowski, Pierre Poulain, Arlene Guest, Le Ly
- G1&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)-FY2006:

The Naval Postgraduate School’s sponsored program exceeded $81 million in FY2006. 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: $7.3M
Batteen, Mary L.
Professor and Chairman
656-2673
mlbattee@nps.edu

Paduan, Jeffrey D.
Associate Professor
656-3350
paduan@nps.edu

Bourke, Robert H.
Professor Emeritus
656-2962
bourke@nps.edu

Haderlie, Eugene C.
Emeritus Distinguished Professor
656-2918
haderlie@nps.edu

Reeder, Benjamin, CDR, USN
Assistant Professor
656-3268
dbreeder@nps.edu

Chiu, Ching-Sang
Professor
656-3239
chiu@nps.edu

Herbers, Thomas H.C.
Professor and Associate Chairman for Research
656-2917
thherber@nps.edu

Rosenfeld, Leslie K.
Research Associate Professor
656-3253
lkrosenf@nps.edu

Chu, Peter
Professor
656-3688
pcchu@nps.edu

Kruse, Denise, CDR, USN
Military Faculty, Program Officer, METOC and USW
656-2045
dmkruse@nps.edu

Semtner, Albert J.
Professor Emeritus
656-3267
sbert@nps.edu

Collins, Curtis A.
Professor
656-3271
collins@nps.edu

Maslowski, Wieslaw
Research Associate Professor
656-3162
maslowsk@nps.edu

Stanton, Timothy P.
Research Associate Professor
656-3144
stanton@nps.edu

Garwood, Roland W.
Professor
656-3260
garwood@nps.edu

Radko, Timour
Assistant Professor
656-3318
tradko@nps.edu

Thornton, Edward B.
Distinguished Professor
656-2847
thornton@nps.edu

Guest, Arlene
Senior Lecturer
656-2226
aguest@nps.edu

Ramp, Steven R.
Research Professor
656-2201
sramp@nps.edu

Tokmakian, Robin
Research Associate Professor
656-3255
rtt@nps.edu
OBJECTIVE: To evaluate the detection performance and range-limit using bottom-mounted hydrophones for the purpose of characterization and classification of marine mammal vocalization.

SUMMARY: The Windy Islands Soliton Experiment was designed by Taiwan and U.S. physical oceanographers to observe the generation, evolution, and transformation of the transbasin, non-linear internal waves in the northeastern South China Sea for a period of one year beginning in April 2005.

OBJECTIVE: To build and test components and algorithms for an autonomous wide aperture cluster for surveillance of quiet targets operating in complex, littoral, shallow water environments. Specific technical objectives are to explore the limits and capabilities of the REMUS towed and hull-mounted array systems to autonomously detect, classify, and localize quiet targets. To evaluate current and develop new methods and capabilities of adaptive environmental and adaptive acoustical sampling, search and data assimilation techniques, including new adaptive data gathering schemes for optimal physical-acoustical-geoacoustical estimations. To develop mobile sources for in-situ TL measurements and for DCL testing. To explore the limits of signal processing, with the emphasis on dynamic array control using a cluster of REMUS vehicles for adaptive DCL of quiet targets, based on improving probability of detection and reducing false alarm rate. To explore and develop vehicle command and control methods based on adaptive environmental and acoustic sensing, and on models of vehicle and cluster behavior.

OBJECTIVE: To assist the manager of ONR’s ocean-acoustic program in project management, including supervision of NPS graduate students.

OBJECTIVE: To produce monthly mean temperature and salinity fields from observational data provided by the National Ocean Data Center using the optimal spectral decomposition method. Temporally varying sound-speed profiles can be computed from these temperature and salinity fields. This will greatly enhance the capability of the Navy’s anti-submarine warfare, mine warfare, and special operations.
DEVELOPMENT AND VALIDATION OF THE NAVY’S 3D MINE IMPACT BURIAL MODEL
(IMPTACT35)
Peter C. Chu, Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: This work will include extension of Impact35 for idealized mines (cylindrical mines) to real mines, such as PSI mines, Korean mines, and Bowen mines, etc.; verification of Impact35 with full-size mine experiments conducted by the Naval Research Laboratory groups in Carderock, Corpus Christi, and Cocodrie; verification of Impact35 using the underwater mine data; and ensemble impact burial model development and collaboration with other modeling components, such as environmental, scour and liquifaction, and expert system. The major collaborators are Peter Fleischer at NAVO, Phillip Valent at NRL-SSC, and Alan Brandt at Johns Hopkins University’s applied-physics laboratory.

LITTORAL ZONE OCEANOGRAPHY FOR MINE WARFARE
Peter C. Chu, Professor
Department of Oceanography
Sponsor: Naval Oceanographic Office

SUMMARY: This is a continuation of the long-term effort of the principle investigator and his students (Naval officers) on the oceanographic effect on mine warfare. The research included several aspects: development of the Navy's 3D Impact Burial Prediction Model (Impact35), investigation of the effects of nephloid layer on mine acoustic detection, and littoral ocean modeling for mine warfare. Five NPS students worked on these aspects for their Master’s degrees and were co-supervised by NAVO scientists (Steve Haeger, Peter Fleischer, and Mel Wagstaff) and NPS professor Peter C. Chu. Such an effort enhances both operations and education in the Navy.

MODEL DEVELOPMENT FOR PREDICTING RIGID BODY MOVEMENT IN AIR-WATER-SEDIMENT COLUMNS WITH FAST WATER ENTRY (STRIKE35)
Peter C. Chu, Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: To improve warhead lethality through predicting bomb maneuver in water and sediment columns, and to clear enemy mines with precise, accurate, and quick strike on enemy mines. The proposed work will include 1) development of the Bomb-Strike Prediction Model (Strike35), 2) development of Strike35 for body with a tangent ogive nose, 3) verification of Strike35 with full-size bomb-striking exercises conducted by ATR and SRT, and 4) ensemble model development. This work is an extension of the currently ONR-sponsored Mine Impact Burial Prediction Project (Impact35) for slow water entry (free fall) into fast water entry (300 to 900 feet per second).

OCEANOGRAPHY FOR CAMPAIGN ANALYSIS ON USW
Peter C. Chu, Professor
Department of Oceanography
Sponsor: Naval Oceanographic Office

OBJECTIVE: Campaign Analysis provides a method to demonstrate the benefits of incorporating METOC information into planning and execution of Naval missions. NAVOCEANO requires analysis to be performed to determine the impact of environmental data and ocean model products on Navy systems and missions for Naval Special Warfare (NSW) and Expeditionary Warfare (EXW). Future decisions to fund the development of new or upgraded capabilities will depend on the outcome of such analyses.
SUMMARY: During the performance period, Peter C. Chu improved the campaign analysis for the shallow water regions using the operational ocean and atmospheric models with data assimilation. He is supervising 3 Master of Science students (2 graduating in March 2007), published (or in press) 5 papers in peer-reviewed journals, 2 chapters in book volumes, and 3 papers in conference proceedings. He also presented 1 invited paper and 3 contributed papers in various workshops and professional societies.

REFEREED JOURNAL PUBLICATIONS:


CONFERENCE PUBLICATIONS:


BOOK CHAPTERS:


CONFERENCE PRESENTATIONS:

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 GDEM) should be first verified before investment on the improvement of satellite altimetry.

The purpose of this study is to assess the benefit of assimilating satellite altimeter data into the Modular Ocean Data Assimilation System (MODAS). To accomplish this, two different MODAS fields are used by the Weapon Acoustic Preset Program (WAPP) to determine suggested presets for a Mk 48 variant torpedo. The MODAS fields differ in that one uses altimeter data assimilated from three satellites while the other uses no altimeter data. The metric used to compare the two sets of outputs is the relative difference in acoustic coverage area generated by WAPP. Output presets are created for five different scenarios, two Anti-Surface Warfare scenarios and three Anti-Submarine Warfare scenarios, in each of three regions: the East China Sea, Sea of Japan, and an area south of Japan that includes the Kuroshio current. Analysis of the output reveals that, in some situations, WAPP output is very sensitive to the inclusion of the altimeter data because of the resulting differences in the subsurface predictions. The change in weapon presets could be so much that the effectiveness of the weapon might be affected.

SUMMARY: During the performance period, Peter C. Chu and his student LT Guillermo Amezaga worked with the scientists at NUWC Keyport WA to get the weapon acoustic preset, developed a statistical package of quantitative measures on MODAS SVP errors (i.e., deviation from Mark-80 table group SVPs) and skill score, investigated the statistical characteristics of the MODAS errors in various scenarios. He published 4 peer-reviewed journal articles, 3 proceeding papers, and presented 4 papers at national and international conferences, and directed 1 thesis student.

REFERRED JOURNAL ARTICLES:


**CONFERENCE PROCEEDINGS:**


**CONFERENCE PRESENTATIONS:**


**THESIS DIRECTED:**


**CHARACTERIZATION AND CLASSIFICATION OF MARINE MAMMAL VOCALIZATION**

*Curtis A. Collins, Professor*

*Department of Oceanography*

*Sponsor: Chief of Naval Operations, N45G*

**OBJECTIVE:** To evaluate the detection performance and range-limit using bottom-mounted hydrophones for the purpose of characterization and classification of marine mammal vocalizations.
ESTIMATION OF OCEAN CURRENTS AND WAVE-EDDY TURBULENCE FROM FLOAT OBSERVATIONS
Curtis A. Collins, Professor
Department of Oceanography
Sponsor: National Science Foundation

OBJECTIVE: To develop new mathematical techniques for understanding the physics of ocean circulation from float observations.

SHIPBOARD STUDIES OF THE CALIFORNIA CURRENT SYSTEM OFF CENTRAL CALIFORNIA
Curtis A. Collins, Professor
Department of Oceanography
Sponsor: University of California, Santa Cruz

OBJECTIVE: To continue quarterly shipboard measurements along Cal COFI lines 60 and 67 through August 2007, using the R/V Pt Sur and NOAA ship David Star Jordan. Data will be made available quickly to researchers via web-based archives and technical reports.

AN ANALYSIS OF OCEANOGRAPHIC AND ACOUSTIC FLUCTUATIONS FOR DEEP AND SHALLOW WATER ENVIRONMENTS
John Colosi, Associate Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: In the interest of improving ocean acoustic modeling and prediction capability, this study seeks to establish the connections between oceanographic sound speed variability and observed acoustic fluctuations from both deep and shallow water environments. The basic science of this proposal is well aligned with the interests of the Navy and the Department of Defense, as undersea acoustic surveillance and remote sensing relies critically on a clear knowledge of the oceanographic sound propagation environment and on a firm understanding of the appropriate acoustic physics given a particular environment.

NAVAL POSTGRADUATE SCHOOL OCEAN ACOUSTIC WAVE PROPAGATION LABORATORY
John Colosi, Associate Professor
Department of Oceanography
Sponsor: Naval Postgraduate School

OBJECTIVE: To establish an ocean acoustic wave propagation laboratory. The focus of the laboratory will be the collection and analysis of oceanographic sound speed fields and acoustic transmission data; and the numerical simulation and modeling of ocean acoustic wave propagation through random media. The laboratory will have interests in both shallow and deep-water environments. The basic science of this lab is well aligned with the interests of the Navy and the Department of Defense. Undersea acoustic surveillance and remote sensing relies critically on a clear knowledge of the oceanographic sound propagation environment and on a firm understanding of the appropriate acoustic propagation physics given a particular environment.
ATTENUATION OF OCEAN WAVES BY RIPPLES ON THE SEAFLOOR
Thomas H.C. Herbers, Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: To understand and predict the effects of sea floor morphology on the transformation of ocean waves across a continental shelf. Future Naval applications of the proposed work include remote sensing of seafloor properties to reduce uncertainties in planning for mine counter measures, anti-submarine warfare, and expeditionary warfare in denied areas.

COLLABORATIVE RESEARCH: NEARSHORE CANYON EXPERIMENT
Thomas H.C. Herbers, Professor
Department of Oceanography
Sponsor: National Science Foundation

OBJECTIVE: To understand the effects of complex, continental-shelf bathymetry on surface gravity waves and on the breaking-wave-driven circulation onshore of the irregular bathymetry.

NEARSHORE CANYON EXPERIMENT ANALYSIS
Thomas H.C. Herbers, Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: To understand and predict the transformation of ocean waves over complex nearshore bathymetry and the associated wave-driven nearshore circulation. This research will focus on the analysis of measurements obtained in the Office of Naval Research/National Science Foundation-funded Nearshore Canyon Experiment. Future naval applications of the proposed work include forecasting systems for the littoral battlespace environment.

AUTONOMOUS WIDE APERATURE CLUSTER FOR SURVEILLANCE
John Joseph, Research Associate Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: To build and test components and algorithms for an autonomous wide aperture cluster for surveillance of quiet targets operating in complex, littoral, shallow-water environments.

LITTORAL WARFARE TEAM ADAPTIVE SAMPLING INTEGRATION
John Joseph, Research Associate Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: To participate in the development of the algorithms, methodology, software, and interfaces for the Naval Oceanographic Office to utilize adaptive sampling to improve predictions.
APPLICATION OF PARALLEL OCEAN AND CLIMATE MODELS TO DECADE/CENTURY PREDICTION
Wieslaw Maslowski, Research Associate Professor
Robin Tokmakian, Research Associate Professor
Department of Oceanography
Sponsor: Department of Energy

OBJECTIVE: To advance the science of decade and century climate prediction. Using models developing under CHAMMP, researchers will examine the variability and predictability of the climatic system by a three-pronged approach: 1) representing the state of the global ocean at high resolution, 2) using an eddy-active global-ocean model with realistic natural variability and decadal atmospheric forcing to find modes of decadal variability and their causes and predictability, and 3) using a coupled climate model to explore decade- to multi-century variability and predict climate to the limits of predictability.

ARCTIC OCEAN MODEL INTERCOMPARISON PROJECT
Wieslaw Maslowski, Research Associate Professor
Department of Oceanography
Sponsor: Woods Hole Oceanographic Institute

OBJECTIVE: The Arctic Ocean Model-Intercomparison Project (AOMIP) is an international effort to determine the systematic errors in models of the Arctic Ocean forced with realistic atmospheric conditions. Organized by the International Arctic Research Center of the University of Alaska, Fairbanks, AOMIP involves a major test and comparison of model performance. The main goal is to examine qualitative and quantitative behavior of different models: their ability to simulate, past, present, and future variability of the Arctic climate and the major processes maintaining the ocean dynamics.

CARBON CYCLING IN THE CHUKCHI AND BEAUFORT SEAS: FIELD AND MODELING
Wieslaw Maslowski, Research Associate Professor
Department of Oceanography
Sponsor: National Science Foundation

OBJECTIVE: To determine the impacts of decadal environmental-regime shifts in the northern high latitudes on carbon cycling in the western Arctic Ocean. Researchers will examine carbon import from the Bering Sea, local production and transformation, and export from the Chukchi and Beaufort Shelves to the basin. The ultimate goal of this study is to obtain a more complete understanding of basin exchange, biogeochemical cycles, and the benchmarks useful in assessing global change of this sentinel ecosystem.

DEVELOPING AN UNDERSTANDING AND PREDICTIVE CAPABILITY OF THE INTERCONNECTIONS AMONG ARCTIC TERRESTRIAL, ATMOSPHERIC, AND MARINE SYSTEMS
Wieslaw Maslowski, Research Associate Professor
Department of Oceanography
Sponsor: San Diego State University

OBJECTIVE: To develop an in-depth understanding and predictive capability of the north Alaska coastal-system state and its variability in response to climate change.
ENVIROMENTAL VARIABILITY, BOWHEAD WHALE DISTRIBUTIONS, AND INUPIAT SUBSISTENCE WHALING: LINKAGE AND RESILIENCE OF AN ALASKAN COASTAL SYSTEM
Wieslaw Maslowski, Research Associate Professor
Department of Oceanography
Sponsor: National Science Foundation

OBJECTIVE: To make a comprehensive study of the Alaskan coastal system to quantify whale–environmental linkages and understand how physical–biological coupling influences bowhead-whale behavioral ecology, and ultimate, Native Alaskan subsistence harvests.

TOWARDS PREDICTION OF ARCTIC SEA ICE–OCEAN GLOBAL-CLIMATE INTERACTIONS AT SEASONAL TO DECADAL SCALES
Wieslaw Maslowski, Research Associate Professor
Department of Oceanography
Sponsor: NASA Goddard Space Flight Center

OBJECTIVE: To address the global model limitations in representing Arctic sea ice and ocean conditions through identification of the primary physical and numerical requirements of future/improved GCMS; to understand conditions in the Arctic sea ice and ocean (both in the present and over the past several decades), with emphasis on variability in the total ice volume and freshwater content in the Arctic Ocean, as well as on sea ice and freshwater fluxes into the north Atlantic; to predict future scenarios of a seasonally/partially sea ice-free Arctic Ocean in response to atmospheric forcing derived from global/regional climate model predictions and/or using a combination of extrapolated into the future northern hemisphere weather indices.

OCEAN-STATE ESTIMATION AND PREDICTION OF THE INTRA-AMERICAS SEA USING VARIATIONAL DATA ASSIMILATION
Andrew M. Moore, Visiting Professor
Department of Oceanography
Sponsor: Naval Postgraduate School

OBJECTIVE: To develop a state-of-the-art ocean state estimation and prediction system for the Gulf of Mexico and the Caribbean Sea based on 4-dimensional variational data assimilation techniques.

COLLABORATIVE RESEARCH: ESTIMATION AND ASSESSMENT OF ERRORS IN HIGH-FREQUENCY RADAR OCEAN CURRENT MEASUREMENTS
Jeffrey D. Paduan, Associate Professor
Department of Oceanography
Sponsor: National Science Foundation

OBJECTIVE: To conduct a simulation-based analysis of errors in high-frequency (HF), radar-derived, oceanic surface-current measurements, and to develop means for assessing these errors in observational systems in use today. The systematic identification and description of these errors is needed for assimilation of HF radar-derived current measurements into near-shore ocean circulation models. It is also needed for incorporation into the many new operational products that are being created based on continuous maps of ocean surface currents from HF radar networks. Conclusions will be applicable to HF radar-derived current measurements in general, but analyses will focus on systems that use compact, collocated antenna geometry and direction finding techniques, such as the Codar/Seasonde systems. This proposal is in collaboration with Professors J. Vesecky and K. Laws of the University of California, Santa Cruz.
CORE MOORING DATA SUPPORT
Jeffrey D. Paduan, Associate Professor
Leslie K. Rosenfeld, Research Associate Professor
Department of Oceanography
Sponsor: Monterey Bay Aquarium Research Institute

OBJECTIVE: A subset of mooring data, specifically surface and subsurface temperature and salinity, meteorological variables, position (GPS), and currents (ADCP), will be processed to the appropriate engineering units and quality controlled.

DATA ACQUISITION ASSIMILATION, DISTRIBUTION, AND VISUALIZATION EFFORTS IN SUPPORT OF THE CENTER FOR INTEGRATED MARINE TECHNOLOGIES
Jeffrey D. Paduan, Associate Professor
Leslie K. Rosenfeld, Research Associate Professor
Department of Oceanography
Sponsor: University of California, Santa Cruz

SUMMARY: This is a proposal to the University of California, Santa Cruz, for the second year of support of activities within the NOAA-sponsored Center for Integrated Marine Technologies (CIMT). Naval Postgraduate School (NPS) personnel will contribute 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 will be maintained, the data quality will be monitored, and various products will be generated from them. In addition, data quality for near-surface meteorological variables and ocean velocity, temperature, and salinity from MBARI's M1 and M2 moorings will be monitored. Modeling results from the NOPP/ICON and NOPP/SCOPE projects will be extended and linked to CIMT observational activities.

EVALUATION OF THE WAMOS II SHIPBOARD WAVE AND CURRENT RADAR
Jeffrey D. Paduan, Associate Professor
Thomas H.C. Herbers, Professor
Edward B. Thornton, Distinguished Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: To evaluate the directional surface wave estimates and the surface current maps derived from the WAMOS II connected to a standard x-band ship radar over time and in the presence of a large suite of in situ oceanographic instrumentation in the Monterey Bay region. A validated shipboard wave and current measurement system would greatly improve Navy operations worldwide (and particularly in littoral areas) through automated and improved directional surface wave observations and through direct observations of horizontal current shear during multi-ship operations.

GLOBEC MAPPING THE EVOLUTION OF MESOSCALE JETS AND EDDIES IN THE UPWELLING ECOSYSTEM OFF CAPE BLANCO, OREGON, USING LONG-RANGE HIGH-FREQUENCY RADAR
Jeffrey D. Paduan, Associate Professor
Department of Oceanography
Sponsor: National Science Foundation

OBJECTIVE: To demonstrate the viability of long-range high-frequency radar for mapping ocean currents out to 200 km from shore.
OBJECTIVE: This project is a joint effort between researchers at the Naval Postgraduate School, San Francisco State University, and the University of Delaware. The focus is on the adaptation of real-time ocean-surface current and satellite-derived surface temperature observations to the task of tracking and predicting the fate of buoyant particles, including spilled oil or missing persons.

CAREER: FLUXES AND STRUCTURES IN DOUBLE-DIFFUSIVE CONVECTION
Timour Radko, Assistant Professor
Department of Oceanography
Sponsor: National Science Foundation

OBJECTIVE: To conduct numerical simulations of the oceanic thermohaline staircases. These experiments will involve analysis of the acoustic scattering on the interfaces, a project of direct relevance to Navy research interests in general, and to the interests of the Department of Oceanography of the Naval Postgraduate School in particular.

COLLABORATIVE RESEARCH: STUDIES OF THE INFLUENCE OF THE ANTARCTIC CIRCUMPOLAR CURRENT ON THE ATLANTIC MERIDIONAL CIRCULATION
Timour Radko, Assistant Professor
Department of Oceanography
Sponsor: National Science Foundation

OBJECTIVE: To conduct numerical simulations of the oceanic thermohaline circulation in the mid-latitude Atlantic and in the Antarctic circumpolar current. The main goal of this modeling effort is to explain the role of mesoscale variability in the dynamic connection of these two regions. Properties of the ocean thermal fronts and eddies determine the Undersea Warfare tactics in the areas of high mesoscale activity, and therefore, these efforts to predict its distribution and strength are directly related to Navy research interests in general and to the interests of the Department of Oceanography of the Naval Postgraduate School in particular.

SMALL-SCALE MIXING AND ITS ROLE IN CONTROLLING THE STRATIFICATION OF THE UPPER OCEAN
Timour Radko, Assistant Professor
Department of Oceanography
Sponsor: Naval Postgraduate School

OBJECTIVE: To conduct numerical simulations of the small-scale processes in the upper ocean.

CMG COLLABORATIVE RESEARCH - A SYSTEMATIC APPROACH TO LARGE-AMPLITUDE INTERNAL WAVE DYNAMICS: AN INTEGRATED MATHEMATICAL/OBSERVATIONAL/REMOTE SENSING MODEL
Steven R. Ramp, Research Professor
Department of Oceanography
Sponsor: National Science Foundation

OBJECTIVE: To develop an effective and accurate theoretical model to investigate the generation, propagation, and transformation of large-amplitude, internal, solitary waves over variable bottom topography, and to then integrate the resulting internal wave model with an improved radar imaging model for remote sensing of the surface signatures of these strongly non-linear internal waves. This highly interdisciplinary project will provide a comprehensive but practical tool for predicting and monitoring internal wave activity in the ocean.
MOORED CURRENT OBSERVATION ALONG THE EUREKA TRANSECT
Steven R. Ramp, Research Professor
Department of Oceanography
Sponsor: National Oceanic and Atmospheric Administration

OBJECTIVE: A single current meter mooring (a bottom-mounted, upward-looking, acoustic doppler current profiler) will be deployed and maintained continuously for five years at midshelf along the proposed GLOBEC Long-Term Observation Program line extending offshore from Eureka, California (40.9 degree n). The mooring will be used to study the seasonal and interannual variability over the Northern California Continental Shelf, the timing of the local spring transition, and the along-and across-shore transport of salmonids and their prey.

OPTIMAL ASSET DISTRIBUTION FOR ENVIRONMENT
Steven R. Ramp, Research Professor
Department of Oceanography
Sponsor: Office of Naval Research

SUMMARY: Optimal asset distribution for environmental assessment and forecasting based on observations, adaptive sampling, and numerical prediction.

OPTIMAL ASSET DISTRIBUTION FOR ENVIRONMENTAL ASSESSMENT AND FORECASTING BASED ON OBSERVATIONS, ADAPTIVE SAMPLING, AND NUMERICAL PREDICTION
Steven R. Ramp, Research Professor
Department of Oceanography
Sponsor: Office of Naval Research

SUMMARY: The recent proliferation of unmanned air and undersea vehicles has spawned a research issue of pressing importance, namely, how does one develop and utilize these vehicles most efficiently to sample the ocean, assimilate the data into numerical models in real- or near-real time, and predict future conditions with minimal error? Implementation of an appropriate sampling plan requires an assessment of the initial oceanographic situation, an understanding of the capabilities and limitations of individual vehicles, vehicle coordination and control, and numerical models equipped to assimilate and utilize data that was irregularly sampled in space and time. These questions were addressed by a multi-disciplinary team consisting of physical oceanographers, acousticians, dynamicists and control systems engineers, communications experts, and numerical modelers. The operational principals thus derived are portable and relevant to a wide variety of space and time scales.

U.S.-GLOBEC NEP PHASE IIIA-CCS: LATITUDINAL VARIATION OF UPWELLING, RETENTION, NUTRIENT SUPPLY, AND FRESHWATER EFFECTS IN THE CALIFORNIA CURRENT SYSTEM
Steven R. Ramp, Research Professor
Department of Oceanography
Sponsor: National Oceanic and Atmospheric Administration

SUMMARY: CSCOR will reimburse the Naval Postgraduate School for analysis of mooring data to assess the impacts of environmental change on zooplankton and fish stock abundance, distribution, and recruitment. This project is associated with the Global Ocean Ecosystems Dynamics Northeast Pacific Program.
THE WINDY ISLANDS SOLITON EXPERIMENT
Steven R. Ramp, Research Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: To observe the generation, trans-basin propagation, and shoaling of strong non-linear internal waves and tides in the northeastern South China Sea, and to acquire the ability to predict their occurrence.

RIP PARTICIPATION IN THE WINDY ISLANDS SOLITON EXPERIMENT
CDR Benjamin Reeder, USN, Assistant Professor
Department of Oceanography
Sponsor: Naval Postgraduate School

SUMMARY: Conducted acoustic research in ocean propagation through transbasin non-linear internal waves in the South China Sea via participation in the Windy Islands Soliton Experiment.

ANALYSIS AND MODELING SYNTHESIS OF OCEAN VELOCITY MEASUREMENTS BELOW WIND-FORCED WAVES OBSERVED DURING COUPLED BOUNDARY LAYERS AND AIR-SEA TRANSFER-LOW
Timothy P. Stanton, Research Associate Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: To analyze unique measurements of velocity fields below wind waves obtained during summer and fall 2003 in a coastal environment as part of the low-wind component of the Coupled Boundary Layers and Air-Sea Transfer program. These measurements and the proposed analyses focus on improving parameterizations of momentum fluxes across the air-sea interface in the presence of breaking surface gravity waves and coherent structures within the ocean surface mixed layer.

AUTONOMOUS OCEAN FLUX BUOYS FOR ARCTIC STUDIES
Timothy P. Stanton, Research Associate Professor
Department of Oceanography
Sponsor: National Science Foundation

SUMMARY: The proposed buoy was designed to remotely measure vertical fluxes in the upper ocean that previously had been achieved only with manned ice camps. The buoy development and prototype deployments at the last three NPEO camps near the North Pole have resulted in a robust and reliable ocean-flux buoy capable of multi-annual measurements of upper ocean vertical fluxes of heat, salt, and momentum.

BOUNDARY LAYER PROCESSES IN THE SURF ZONE AND INNER SHELF IN CROSSTEX AND MISO
Timothy P. Stanton, Research Associate Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: To use detailed, bottom boundary layer hydrodynamic observations with concurrent morphology map time-series to improve predictive models of ripple bedforms on the continental shelf and surf zone. Two observational programs will be conducted. A collaborative measurement will be made at the OSU Large Wave Tank facility to extend existing observations of wave breaking and sediment transport in the surf zone. Observations of wave forcing and sand ripples will be measured using unique instruments.
developed at the MISO Inner Shelf Observatory at the Naval Postgraduate School as a component of the ONR Ripples DRI that directly addresses the need to develop improved ripple prediction models for operational mine counter measures surveys.

COLLABORATIVE RESEARCH: BENTHIC LAYER GEOCHEMISTRY AND PHYSICS AT THE KILO NALU OBSERVATORY
Timothy P. Stanton, Research Associate Professor
Department of Oceanography
Sponsor: National Science Foundation

OBJECTIVE: A scanned laser bedform imaging system and high-resolution velocity profiler developed at the Naval Postgraduate School will be deployed with collaborators’ instrumentation at a cabled ocean observatory in Hawaii to measure benthic turbulent fluxes over both sandy and coral beds. This program dovetails with two ONR programs that occurred in 2006 - the Ripples DRI and the Aesope DRI, both in Monterey Bay. In combination, these programs will enhance the ability to model near bed stresses, sediment entrainment, and internal tidal processes. Improved parameterizations for these poorly modeled processes and needed improvement of operational high-resolution, regional, ocean models.

COLLABORATIVE RESEARCH: ISPOL-1 TURBULENT FLUX PROJECT
Timothy P. Stanton, Research Associate Professor
Department of Oceanography
Sponsor: National Science Foundation

OBJECTIVE: To determine ocean fluxes contributing to bottom water formation in the western Weddell Sea using in suit ocean-flux measurements during a seventy-day, manned ice camp, led by the Alfred Wegner Institute.

COLLABORATIVE RESEARCH: THE MAUD RISE NON-LINEAR EQUATION OF STATE STUDY (MAUDNESS)
Timothy P. Stanton, Research Associate Professor
Department of Oceanography
Peter S. Guest, Research Associate Professor
Department of Meteorology
Sponsor: National Science Foundation

OBJECTIVE: To discover whether a nonlinear property of the equation of state of seawater (thermobaricity) results in massive convection in the southern oceans.

OCEAN-ICE INTERACTION MEASUREMENTS USING AUTONOMOUS OCEAN FLUX BUOYS IN THE ARCTIC OBSERVING SYSTEM
Timothy P. Stanton, Research Associate Professor
Department of Oceanography
Sponsor: National Science Foundation

OBJECTIVE: To provide the community with an important source of data that will significantly increase knowledge of ocean/ice fluxes and their variability at ice drift locations within the Arctic Ocean over a four year period. The publicly available data from the proposed array of ITP instruments will provide the basis for both process studies and model validation/assimilation research, work that will ultimately lead to a better understanding of the Arctic Ocean's role in global climate change.
OCEANOGRAPHY

BEACH WIZARD
Edward B. Thornton, Distinguished Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: To conduct further data analysis and support of Nowcasts of morphodynamic events observed over complex bathymetry at Monterey Bay, California, and to participate in collaborative meetings. Naval applications include amphibious landings, special warfare, mine, and mine-countermeasures.

COASTAL OCEAN CURRENTS MONITORING PROGRAM
Edward B. Thornton, Distinguished Professor
Jeffrey D. Paduan, Associate Professor
Department of Oceanography
Sponsor: San Francisco State University

SUMMARY: The Central/Northern California COCMP Component addresses the state of the Coastal Conservancy Coast Ocean Currents Monitoring Program (COCMP) mandate to monitor ocean circulation for the region between Pt. Conception and the California–Oregon border. Direct observations will allow estimates of the transport of near-surface substances (e.g., oil spills, fish/invertebrate larvae, algae blooms, freshwater) while modeling will provide estimates of subsurface and surf zone transport of substances that are often vertically distributed (e.g., nutrients, pollutants). The ultimate goal is to provide products relevant to the movement and resultant distribution of substances of concern in coastal waters. The U.S. Navy will benefit from improved understanding and modeling of material transport in the littoral zone related to environmental monitoring of domestic bases and environmental prediction in denied areas.

NEARSHORE WAVE AND SEDIMENT PROCESSES
Edward B. Thornton, Distinguished Professor
Timothy P. Stanton, Research Associate Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: To analyze data acquired during the NCEX and to participate in the heterogeneous beach experiment (MUDEX) in fiscal years 2005 and 2006. The scientific objectives of MUDEX are to measure and model directional wave spectral transformation, longshore currents and sediment transport over heterogeneous sediments, and to determine dissipation due to wave interaction with a muddy bottom. Naval applications include amphibious landings, special warfare, mine, and mine countermeasures.

A GEODESIC CLIMATE MODEL WITH QUASI-LAGRANGIAN VERTICAL COORDINATES
Robin Tokmakian, Research Associate Professor
Department of Oceanography
Sponsor: Colorado State University

OBJECTIVE: To develop a multi-component climate model on a geodesic coordinate grid with governing hydrodynamics treated by a highly conserving vorticity and divergence formulation.
DEPARTMENT OF OCEANOGRAPHY

2006
Faculty Publications and Presentations


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)-FY2006:

The Naval Postgraduate School’s sponsored program exceeded $81 million in FY2006. 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: $5.2M
<table>
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<tr>
<th>Name</th>
<th>Title</th>
<th>Phone</th>
<th>Email</th>
</tr>
</thead>
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<tr>
<td>Luscombe, James H.</td>
<td>Chairman and Professor</td>
<td>656-2941</td>
<td><a href="mailto:luscombe@nps.edu">luscombe@nps.edu</a></td>
</tr>
<tr>
<td>Smith, Kevin B.</td>
<td>Associate Professor and</td>
<td>656-2107</td>
<td><a href="mailto:Kevin@nps.edu">Kevin@nps.edu</a></td>
</tr>
<tr>
<td></td>
<td>Associate Chairman for Research</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Armstead, Robert L.</td>
<td>Associate Professor</td>
<td>656-2125</td>
<td><a href="mailto:armstead@nps.edu">armstead@nps.edu</a></td>
</tr>
<tr>
<td>Baker, Steven</td>
<td>Associate Professor PH/Ba</td>
<td>656-2732/2824</td>
<td><a href="mailto:baker@nps.edu">baker@nps.edu</a></td>
</tr>
<tr>
<td>Blau, Joseph A.</td>
<td>Lecturer</td>
<td>656-2635</td>
<td><a href="mailto:blau@nps.edu">blau@nps.edu</a></td>
</tr>
<tr>
<td>Brown, Ronald E.</td>
<td>Research Professor</td>
<td>656-2635</td>
<td><a href="mailto:rebrown@nps.edu">rebrown@nps.edu</a></td>
</tr>
<tr>
<td>Colson, William B.</td>
<td>Distinguished Professor</td>
<td>656-2765</td>
<td><a href="mailto:colson@nps.edu">colson@nps.edu</a></td>
</tr>
<tr>
<td>Cooper, Alfred W.</td>
<td>Professor</td>
<td>656-2452</td>
<td><a href="mailto:cooper@nps.edu">cooper@nps.edu</a></td>
</tr>
<tr>
<td>Crooker, Peter P.</td>
<td>Senior Lecturer</td>
<td>656-2232</td>
<td><a href="mailto:ppcrooke@nps.edu">ppcrooke@nps.edu</a></td>
</tr>
<tr>
<td>Davis, D. Scott</td>
<td>Associate Professor</td>
<td>656-2877</td>
<td><a href="mailto:sdavis@nps.edu">sdavis@nps.edu</a></td>
</tr>
<tr>
<td>Denardo, Bruce C.</td>
<td>Associate Professor</td>
<td>656-2952</td>
<td><a href="mailto:denardo@nps.edu">denardo@nps.edu</a></td>
</tr>
<tr>
<td>Haegel, Nancy</td>
<td>Professor</td>
<td>656-3954</td>
<td><a href="mailto:nmhaegel@nps.edu">nmhaegel@nps.edu</a></td>
</tr>
<tr>
<td>Harkins, Richard M.</td>
<td>Senior Lecturer</td>
<td>656-2828</td>
<td><a href="mailto:rharkins@nps.edu">rharkins@nps.edu</a></td>
</tr>
<tr>
<td>Hibbeln, Brian A.</td>
<td>Research Associate</td>
<td>(800) 727-1348</td>
<td><a href="mailto:hibbeln@nps.edu">hibbeln@nps.edu</a></td>
</tr>
<tr>
<td>Karunasiri, Gamani</td>
<td>Associate Professor</td>
<td>656-2886</td>
<td><a href="mailto:karunasiri@nps.edu">karunasiri@nps.edu</a></td>
</tr>
<tr>
<td>Kapolka, Daphne,</td>
<td>Senior Lecturer</td>
<td>656-1825</td>
<td><a href="mailto:dkapolka@nps.edu">dkapolka@nps.edu</a></td>
</tr>
<tr>
<td>Karunasiri, Gamani</td>
<td>Associate Professor</td>
<td>656-2886</td>
<td><a href="mailto:karunasiri@nps.edu">karunasiri@nps.edu</a></td>
</tr>
<tr>
<td>Maier, William B.</td>
<td>Senior Lecturer and Chairman</td>
<td>656-2896/3227</td>
<td><a href="mailto:wmaier@nps.edu">wmaier@nps.edu</a></td>
</tr>
<tr>
<td>Maruyama, Xavier</td>
<td>Professor</td>
<td>656-2431</td>
<td><a href="mailto:maruyama@nps.edu">maruyama@nps.edu</a></td>
</tr>
<tr>
<td>Olsen, R. Chris</td>
<td>Professor</td>
<td>656-2019</td>
<td><a href="mailto:olsen@nps.edu">olsen@nps.edu</a></td>
</tr>
<tr>
<td>Sanders, James V.</td>
<td>Associate Professor PH/Sd</td>
<td>656-3884</td>
<td><a href="mailto:jsanders@nps.edu">jsanders@nps.edu</a></td>
</tr>
<tr>
<td>Rice, Joseph A.</td>
<td>SSC San Diego Engineering Acoustic Chair</td>
<td>656-2982</td>
<td><a href="mailto:rice@nps.edu">rice@nps.edu</a></td>
</tr>
<tr>
<td>Trask, David M.</td>
<td>MASINT Chairman</td>
<td>656-2219</td>
<td><a href="mailto:dmtrask@nps.edu">dmtrask@nps.edu</a></td>
</tr>
</tbody>
</table>
Walters, Donald L.
Professor
656-2894
walters@nps.edu

Woehler, Karlheinz
Emeritus Professor
656-2121
kwoehler@nps.edu
PHYSICS

CREATE DVD ARCHIVE OF THE NAVAL POSTGRADUATE SCHOOL VIBRATION MEASUREMENTS MADE DURING 1996 PHALANX LIVE-FIRE TESTING

Steven R. Baker, Associate Professor
Department of Physics
Sponsor: Naval Sea Systems Command

OBJECTIVE: To create a DVD archive of the vibration measurements and analysis made by the Naval Postgraduate School during live-fire testing of the Phalanx Close-In Weapons System, conducted on 30 July and 1 August 1996 at Naval Surface Warfare Center, Dahlgren, Virginia.

ADVANCED METHODS IN RADAR IMAGING

Brett H. Borden, Associate Professor
Department of Physics
Sponsor: U.S. 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 generalized radar imaging model that allows for arbitrary pulse shape and collection geometries (including moving targets).

SUMMARY: The Office of Naval Research sponsored this effort, which also covered the Principal Investigator’s salary for a one-quarter extended visit to the Institute for Mathematics and Its Applications (IMA) at the University of Minnesota. The PI was an invited visiting scholar during the IMA thematic year on imaging science.

PUBLICATIONS:


THESES DIRECTED:


KEYWORDS: SAR, ISAR, Radar Ambiguity Function

ISAR IMAGING OF TARGETS IN OBSCURANT

Brett H. Borden, Associate Professor
Department of Physics
Sponsor: Office of Naval Research

SUMMARY: Provided support for the Principal Investigator while he served as a visiting scholar at the Institute for Mathematics and Its Applications (University of Minnesota) during its thematic year on “imaging.”
PHYSICS

WAVEFORMS FOR ACTIVE SENSING IN SUPPORT OF MILITARY OPERATIONS ON URBAN TERRAINS
Brett H. Borden, Associate Professor
Department of Physics
Sponsor: Colorado State University

OBJECTIVE: To investigate radar waveform design for target tracking, target estimation and classification, clutter and multi-path rejection, and system scheduling and optimization for urban environments. The partners will conduct specific research in target modeling and image and signal processing methodologies appropriate to same.

WAVEFORMS FOR ACTIVE SENSING IN SUPPORT OF MILITARY OPERATIONS ON URBAN TERRAINS
Brett H. Borden, Associate Professor
Department of Physics
Sponsor: Defense Advanced Research Projects Agency

OBJECTIVE: To address radar waveform design in support of military operations on urban terrains. The technical work is organized into subsystems for 1) space-time waveform design and transmission, 2) reception and processing, 3) estimation and classification, and 4) scheduling and optimization. In concert these address the problem of designing coordinated radar assets to improve situational awareness for the ground fighter. The candidate is a performer on items (1-3).

SUMMARY: Professor Borden is a member of a project sub-team that includes Professors Margaret Cheney and Birsen Yazici, both at Rensselaer Polytechnic University in Troy, New York. The Principal Investigator is Professor Chong at Colorado State University.

KEYWORDS: SAR, Radar Tracking, Clutter

FLEXIBLE POLYMER DISPLAYS FOR INDIVIDUAL IDENTIFICATION FRIEND OR FOE
LCDR Frank Bradley, USN
Department of Physics
Sponsor: Space and Naval Warfare Systems Command Systems Center - San Diego

OBJECTIVE: To develop an effective individual identification friend or foe system for use by ground combat troops in low-intensity situations to aid in the management of fratricide.

ADVANCED ENERGETICS: EXPLOSIVE POWER AMPLIFICATION
Ronald E. Brown, Research Professor
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: To a) develop technology bases for exploiting the effects of detonation merging on shaped charge performance, b) develop technical bases and plans for experimentally demonstrating the effectiveness of two novel concepts for intensifying underwater blast, and c) explore the potential application of the CL-20 explosive for underwater blast application.
BARRIER PENETRATION BY EXPLOSIVE ORDNANCE DISPOSAL PROJECTILES
Ronald E. Brown, Research Professor
Department of Physics
Sponsor: NAVEOD Center

BACKGROUND: The use of improvised explosive devices (IED) remains a major problem to coalition forces and civilians in current conflict areas throughout the world. IEDs are now potentially the largest single security threat affecting every segment of society. They are the most effective means of causing harm with the least associated costs. The biggest obstacle to neutralizing IEDs is that most are hidden behind some barrier. These barriers can be in the form of a metal container, tire, wall, or buried in the earth, and they obscure IEDs from soldiers and civilians. Explosive ordnance disposal (EOD) technicians have many disrupter tools to counter this threat. The biggest hurdle is to determine the best disrupter tool for neutralizing an IED hidden by a barrier.

OBJECTIVE: To take test data gathered at NAVEODTECHDIV, Indian Head, Maryland, of experiments conducted with various EOD tools and projectiles against various targets; and to collapse the experimental data into a predictive tool that can be used in the field to select the best EOD tool and projectile to penetrate a barrier and eventually neutralize the IED.

SUMMARY: Based on an assessment of over 700 tests conducted by NAVEOD, two models have been developed relating 1) penetration potential of various tools against semi-infinite barriers, and 2) residual penetration against aluminum and steel targets as a function of barrier thickness. Penetration potentials were estimated based on Southwest Research Institute’s compendium of data for projectiles similar in dimensions to those in the class of EOD of interest. With respect to residual velocity against finite barriers, relationships were derived and normalized across a wide spectrum of impact velocities. The variances of these relationships were found to have, in general, predictive accuracies greater than 90 percent.

Continuing work is directed towards 1) testing the modeling hypotheses and extending the database using a hydro-code, and 2) expanding the model, taking into consideration the effect of projectile and target density and strength.

PUBLICATION:

THESIS DIRECTED:

KEYWORDS: EOD Tools, Penetration Dynamics, Modeling, Hypervelocity Impact
CONTINUED INVESTIGATIONS IN SUPPORT OF THE UNDERSEA WARHEAD TECHNOLOGY PROGRAM: ENHANCED SHAPED CHARGE JETTING BY DETONATION MERGING
Ronald E. Brown, Research Professor
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: To explore and quantify means for amplifying detonation power output from explosives, and to exploit these mechanisms for enhancing the terminal performance of shaped charge explosive warheads for underwater weapons applications.

CONTINUED INVESTIGATIONS IN SUPPORT OF THE UNDERSEA WARHEAD TECHNOLOGY PROGRAM: DIRECTED ENERGY
Ronald E. Brown, Research Professor
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: To explore and quantify means for amplifying detonation power output from explosives, and to exploit these mechanisms for enhancing the terminal performance of bulk explosive warheads for underwater applications.

DETONABLE LIQUID TECHNOLOGIES FOR EXPLOSIVE ORDNANCE DISPOSAL AND SAFE AND ARM
Ronald E. Brown, Research Professor
Department of Physics
Sponsor: Office of Naval Research

BACKGROUND: Based on initial assessments of a novel, low-cost technique for neutralizing explosive threats, a contract was awarded during the first quarter of fiscal year 2007. The concept is based on the use of a shaped charge containing nitromethane (NM), a relatively safe liquid energetic material. The NM is packaged in a plastic body containing a shaped hollow cavity. In this form, there is a very low probability of initiation to detonation. When a metal liner and confinement are added, and a 0.1% by volume injection of a liquid sensitizer is added, the charge can be effectively added.

OBJECTIVE: Efforts during 2006 focused on demonstrating the feasibility of the key elements of the concept.

SUMMARY: Unique safe handling features key to the selection of nitromethane were demonstrated, including the extremely low probability of detonating the liquid in 25mm-diameter plastic containers by powerful blasting caps. The high initiation reliability and detonation velocity of NM containing 0.1% diethylene triamine was confirmed based on published data. The first shaped charge design was shown to penetrate over six calibers into semi-infinite aluminum. Based on these results, the Naval Postgraduate School received a startup award from the Office of Naval Research to further develop the concept and to also apply the binary initiation system for Safe and Arm devices.

FUTURE WORK: Immediate continuing efforts are directed towards investigating the effect of a shaped charge liner, including jet characterization, penetration performance and explosive neutralization effectiveness, and possible robotic integration.

CONFERENCE PUBLICATIONS:

**THESIS DIRECTED:**


**KEYWORDS:** EOD Tools, Shaped Charge, Nitromethane, Detonation Velocity, Penetration Dynamics, Modeling, Hypervelocity Impact

**DEVELOPMENT OF A PREDICTION TOOL FOR BARRIER PENETRATION BY EXPLOSIVE ORDNANCE DISPOSAL PROJECTILES**

Ronald E. Brown, Research Professor  
Department of Physics  
Ashok Gopinath, Associate Professor  
Department of Mechanical and Astronautical Engineering  
Sponsor: Naval Explosive Ordnance Disposal Technical Division

**OBJECTIVE:** To develop a basic physics-based model/tool that would capture the essential mechanisms responsible for the material and structural responses to projectile impact.

**EFFECTS OF HYDRO-REACTIVITY DURING HYPERVELOCITY IMPACT**

Ronald E. Brown, Research Professor  
Department of Physics  
Sponsor: Office of Naval Research

**BACKGROUND:** There are numerous evidences of chemical reaction during the hypervelocity impact of combustible fragments and long-rod penetrators. This so-called “vaporific effect,” usually assigned to the impact of aluminum projectiles, is used for blast enhancement. Several years ago evidence was found indicating that the terminal effectiveness of underwater, shaped charge warheads might be improved by replacing all or part of the liner with a reactive material.

**OBJECTIVE:** To understand the basic kinetic mechanism of chemical release during the impact and penetration of long-rod hypervelocity rods, and to make a determination of whether an exothermic reaction can be produced fast enough to affect terminal effects. The work will involve computational modeling and experimentation.

**SUMMARY:** The Naval Postgraduate School, working closely with the University of Illinois and the Ernst Mach Institute (Freiburg, Germany), has developed a kinetic model for estimating the generation of reactive mass and a computational technique for estimating baric and thermal conditions that might lead to reaction in a water environment. Experimental techniques have been developed for high-speed launching and investigating the kinetic and chemical interactions between hypervelocity long-rod and water and submerged targets. Continued work is directed towards using these techniques for purposes of quantifying the reactive mass generation models and their integration into kinetic-chemical energy penetrators, and quantifying the models for purposes of estimating hydro-reactive potential.

**POTENTIAL APPLICATION:** Insertion of reactive materials in high-performance shaped charges for causing pre-impact structural weakening and increasing perforation capability.
INVESTIGATIONS OF EXPLOSIVE POWER AMPLIFICATION
Ronald E. Brown, Research Professor
Department of Physics
Sponsor: Office of Naval Research

BACKGROUND: There are scientific, practical interests in developing techniques for increasing the detonation velocity and pressure of explosives. Much work is devoted to understanding the effect of molecular structure and creating new molecular systems. Even with occasional success, substantial resources and time are required to derive low-cost synthetic processes, investigate and resolve sensitivity issues, and optimize usage in new systems. Typical time commitments in modern history can be exemplified by the application of HMX into military systems after more than two decades from the invention of a reasonable, economical, synthetic route and almost half a century from discovery. CL-20, which is the most powerful explosive currently on the research bench, was first synthesized and classified over twenty years ago. No identifiable application of CL-20 has been identified because of its sensitivity and cost.

The dangers of using explosives on high-cost military platforms has also been the impetus for the development of insensitive munitions; another factor of required research and development commitment for all new explosives, the importance of which is exemplified by the status of CL-20.

OBJECTIVE: Over the last seven years, promising processes for enhancing present-day explosives have been the subject of research at the Naval Postgraduate School. It was experimentally demonstrated (in work originally started at BAE Systems prior to the Principle Investigator’s retirement) that the penetration performance of a conventional shaped charge containing a high aluminum content explosive could be increased by almost 40 percent. Since that time, NPS investigations have focused on quantifying the detonation characteristics responsible for the performance enhancement, and developing processes that could be applied to the most energetic explosive currently used in Department of Defense warhead systems.

SUMMARY: In 2004-5, model charges were developed for quantifying the detonation characteristics and underwater performance of a first generation, two-component, explosive amplification system. This system only provides means for elevating directed energy of relatively slow detonation explosives to that of plastic-bonded high-energy RDX and HMX explosives.

During the last two years a more universal method of amplifying any explosive at little additional system cost has been developed. In fact, the quantity of explosive required in a power-amplified weapon system is actually reduced. Experimentally validated computations have shown that the rate of detonation energy released can be increased by almost twice that of HMX and RDX. The techniques used to reach
these levels of performance also allow for the use of explosive compositions that are relatively low in energetic content; thereby providing means for meeting more demanding IM goals.

During 2006, NPS contracted to the Naval Air Warfare Center-China Lake a test program directed towards characterizing detonation characteristics of the first generation system: results from experiments completed in early 2007 show excellent correlation with prediction. Second generation designs developed during 2006 will be tested in 2007.

NEAR-FUTURE APPLICATION OF TECHNOLOGY: This technology offers a means to conduct basic investigation of overdriven detonation mechanisms and enhanced directed and fragmentation warheads, where either enhanced effects and/or reduced explosive volumes are required, and/or where low content explosives can be used to satisfy IM requirements.

The vision of potential applications focuses on the next generation (2010-2020) of torpedo systems, which will have to be more agile and multi-purpose, thus placing increasing demands on the volume and weight efficiencies of explosives.

PUBLICATION:

THESIS DIRECTED:

KEYWORDS: Detonation Physics, Directed Energy, Explosive, Modeling and Simulation, Underwater Warhead Technology, AUTODYN

SHAPED CHARGE TECHNOLOGY
Ronald E. Brown, Research Professor
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: To a) develop technology bases for exploiting the effects of detonation merging on shaped charge performance, b) develop technical bases and plans for experimentally demonstrating effectiveness of two novel concepts for intensifying underwater blast, and c) explore the potential applications of the CL-20 explosive for underwater blast application.

COMPUTATIONAL 100KW-MW FREE ELECTRON LASER RESEARCH
William B. Colson, Distinguished Professor
J. Blau, Professor
Department of Physics
Center for Directed Energy and Electric Weapons
Sponsor: Office of Naval Research

OBJECTIVE: To support research and development of the Jefferson Laboratory free electron laser, the “next” 100kW free electron laser, and the future MW free electron laser.

Recent developments at the Naval Postgraduate School have combined 3D transverse simulations with longitudinal simulations to form a complete 4D simulation of the FEL optical pulse in x, y, z, and t. The 4D simulation will address physical issues not addressed by any other existing codes.
PHYSICS

PUBLICATION:


CONFERENCE PUBLICATION:


PRESENTATIONS:


THESES DIRECTED:


KEYWORDS: High Power Lasers, Free Electron Lasers, Directed Energy

FREE ELECTRON LASER WEAPONS: MODELING AND SIMULATION
William B. Colson, Distinguished Professor
Department of Physics
Sponsor: High Energy Laser Joint Technology Office

OBJECTIVE: To develop end-to-end modeling and simulation of operational free laser directed energy weapons in collaboration with advanced energy systems, the U.S. Naval Academy, and Naval Air Systems Command, Patuxent River, Maryland.

HIGH ENERGY LASER WEAPONS: MODELING AND SIMULATION
William B. Colson, Distinguished Professor
Department of Physics
Sponsor: High Energy Laser Joint Technology Office

OBJECTIVE: To develop modeling and simulation of operational HEL directed energy laser weapons using solid-state laser and free electron laser technologies, and to study implementation and operation of a solid-state laser on the Joint Strike Fighter and the F/A-18 tactical fighter.
OBJECTIVE: The Naval Postgraduate School, in collaboration with the Naval Air Systems Command at Patuxent River Naval Air Station and the service academies, will study the modeling and simulation of high energy lasers for the Joint Technology Office.

Both the physics and engineering for a variety of HEL lasers will be studied. The concept of operations and mission scenarios will also be explored. While combat scenarios will be the focus of this effort, physics will be used to evaluate mission feasibility and parameters.

CONFERENCE PUBLICATIONS:


PRESENTATION:


THESES DIRECTED:


KEYWORDS: High Power Lasers, Free Electron Lasers, Directed Energy
PHYSICS

PUBLICATIONS:


PRESENTATIONS:


THESES DIRECTED:


KEYWORDS: High Power Lasers, Free Electron Lasers, Directed Energy

ANALYSIS AND TESTING OF A 3-5UM THERMAL IMAGER, DIFFERENTIAL COLOR FILTER, AND POLARIZATION FILTER EFFECTS

Alfred W.M. Cooper, Professor
Department of Physics
Sponsor: National University of Singapore

OBJECTIVE: To analyze and test a 3–5µm thermal imager and the enhancement in detection using color filters (multi-spectral) and polarimetry techniques.

MULTI-IR BAND DATA FUSION FOR TARGET RECOGNITION

Alfred W.M. Cooper, Professor
Department of Physics
Sponsor: National University of Singapore

OBJECTIVE: To develop data fusion between a mid-infrared (MIR) thermal imager and a Gen III NVD to enhance the night detection and recognition of target.

ACOUSTIC RADIATION FORCE

Bruce Denardo, Associate Professor
Department of Physics
Sponsor: Naval Postgraduate School Institutionally Funded Research

OBJECTIVE: Due to radiation pressure, a body is attracted to a high-intensity low-frequency source of diverging sound waves. However, other nonlinear effects, such as acoustic streaming, may also be present. One of the overall goals is to perform an experiment to measure the force and compare the values to
theoretical predictions based on radiation pressure. Another overall goal is to investigate possible applications, including an ultrasonic purifier for liquids or gases, where unwanted particles are attracted to a sound source and collected electrostatically or by another means. Such a device could be used to replace centrifuges for oil on submarines. Another possible application involves the recent discovery that a black hole is causing acoustic waves to be emitted into the surrounding plasma. Acoustical attraction may thus be a mechanism for the growth of black holes.

**SUMMARY:** Previous experimental work was hindered by the lack of an accurate means of determining the particle velocity, and a lack of the ability to maintain a constant high-intensity sound field while measurements are taken. The objective of the latest work was to overcome these problems so that an accurate comparison of theory and experiment can be made. Researchers first engaged in a failed attempt to use a pressure-gradient transducer to determine particle velocity. Researchers then successfully developed, tested, and calibrated a hot-wire velocity microphone. In addition, researchers designed, built, and tested a control system so that a constant-amplitude sound field can be maintained while data are gathered.

**THESIS DIRECTED:**


**KEYWORDS:** Acoustic Radiation Pressure, Acoustic Radiation Force

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**DIRECTED ENERGY VISITING SCHOLAR PROGRAM AT THE NAVAL POSTGRADUATE SCHOOL**

Bruce Denardo, Associate Professor
Andres Larrazas, Associate Professor
Department of Physics
Sponsor: High Energy Laser Joint Technology Office

**SUMMARY:** The Directed Energy Visiting Scholars Program offered undergraduate and graduate students the opportunity to participate in experimental, theoretical, and simulation aspects of directed energy research projects at the Naval Postgraduate School. In addition, scholars pursued a course of both directed and independent study in the field of directed energy systems.

**PHYSICS OF MAINTAINED OSCILLATORS**

Bruce Denardo, Associate Professor
Department of Physics
Sponsor: Naval Postgraduate School Institutionally Funded Research

**OBJECTIVE:** A maintained oscillator is one in which the energy source is steady in the absence of interaction with the oscillator. Through some feedback mechanism, which varies widely among different systems, the oscillator causes the source to periodically feed energy into the oscillations. Although maintained oscillators are much more common than other types of driven oscillators, they are substantially more difficult to understand. The overall objective is to investigate maintained oscillators through the use of demonstration experiments, computer simulations, analytical calculations, and searches of the scientific literature. Results will be incorporated into the Naval Postgraduate School course PH4459, Nonlinear Oscillations and Waves.

**SUMMARY:** Some simpler maintained oscillators were first examined, followed by an examination of complicated oscillators that are maintained by fluid flow. Next, two systems that involve contact friction were considered: a mass-and-spring oscillator in which the mass slides on a moving surface, and a plate that is supported by two counter-rotating rollers. Experimental, analytical, and computational investigations of both of these systems were performed. Next, different examples of thermally-maintained oscillations were considered. The focus was on the system in which an electric burner causes a pot to rock back-and-
forth indefinitely. Although this phenomenon is well-known, no scientific literature on it was found. A demonstration was built and several theories that could explain the behavior were suggested. Finally, experimental, analytical, and computational investigations of the Van der Pol equation (a standard model for some maintained oscillators) were performed.

THESIS DIRECTED:


KEYWORDS: Maintained Oscillators, Self-Excited Oscillators, Nonlinear Oscillations

DEVELOPMENT OF GAAS BLOCKED IMPURITY BAND DETECTORS
Nancy M. Haegel, Professor
Department of Physics
Sponsor: NASA (subcontract from the University of California-Berkeley)

OBJECTIVE: To extend the blocked-impurity-band (BIB) detector concepts to longer wavelengths through the use of GaAs as a host material. This would provide for long wavelength response to over 300 µm. The challenge is the production and characterization of a very high purity blocking layer for the long wavelength material. The contribution is the application of a numerical model for steady state BIB operation, which will allow for optimization of material and device parameters. This modeling work has already resulted in the publication of several papers and the development of an alternate operating mode designed specifically for long wavelength operation. BIB detectors have become the most sensitive arrays for the mid-infrared (IR) (wavelengths beyond about 5 µm). Though not used for standard IR imaging due to the extreme cooling requirements, they could impact other areas of chemical spectroscopy and potentially terahertz imaging. Research conducted this past year focused on modeling the capacitance-voltage characterization used to study key materials parameters in the devices.

PUBLICATION:

THESIS DIRECTED:


KEYWORDS: Blocked Impurity Band, BIB, Alternate Bias Mode, Far –IR BIB Detectors, CCVA Analysis

DEVELOPMENT OF AN IMAGING TRANSPORT INSTRUMENT FOR MATERIALS RESEARCH AND EDUCATION
Nancy M. Haegel, Professor
Department of Physics
Sponsor: National Science Foundation

OBJECTIVE: To develop an integrated transport system that can perform optical imaging of charge transport phenomena – combining the power of imaging with the need for easy access to local transport parameters. The primary goal is to obtain resolution of ~ 100 nm using a near-field optical microscope internal to the scanning electron microscope. The combination of high resolution transport imaging, standard CL imaging and spectroscopy, and variable temperature capability in one instrument will be
unique; and will provide opportunities for the study of systems, such as quantum wires, non-uniform electric field effects, wide bandgap materials, and new materials for solar cell applications. The new instrument was received in October 2006 and initial experiments are underway.

**PUBLICATION:**


**THESES DIRECTED:**


Ang, G.H.


**KEYWORDS:** Transport Imaging, NSOM, Near Field Optics, Nanoscale Resolution

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**FAR-INFRARED GAAS BLOCKED-IMPURITY-BAND ARRAYS**

*Nancy M. Haegel, Professor*

*Department of Physics*

*Sponsor: NASA Goddard Space Flight Center*

**OBJECTIVE:** Modeling will be performed to study the effects of variation in doping, layer thickness, and interface gradient in GaAs Blocked Impurity Band structures. The model is a finite difference calculation that shows the spatial distribution of the electric field, carrier concentration, space charge, and currents in the devices. Steady state field distributions will be produced for a range of doping levels and layer thicknesses corresponding to those obtained in the growth of the test structures. The model allows for calculation of the size of the depletion region as a function of important variables, such as compensation in the absorbing layer and doping gradations at the interfaces. The modeling will also be used to study the effects of illumination levels and to predict optimum responsivity of the device.

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**IMAGING TRANSPORT: FROM THE MOTION OF CHARGE TO THE DETECTION OF LIGHT**

*Nancy M. Haegel, Professor*

*Department of Physics*

*Sponsor: Fairfield University*

**OBJECTIVE:** To develop a technique for imaging the motion and recombination of charge on a micron scale. The technique will be used to study the transport behavior in regions of electric field non-uniformity or in devices dependent on micron-scale transport. The technique has the potential to provide new information on highly localized transport in semiconductor and other optoelectronic devices.
OBJECTIVE: To develop and field a lightweight, OPSEC-protected individual identification friend or foe device designed to work in low-light combat situations.

**PRESENTATIONS:**

IIFF Briefings, Marine Corps Warfighting Laboratory, U.S. Army Soldier Systems Command, Natick, Massachusetts.

**THESIS DIRECTED:**


Schumacher, J.


**KEYWORDS:** Fratricide, Identify Friend or Foe, Polymer Emitter, Infrared, Individual IFF
PHYSICS

SEMICONDUCTOR MATERIALS AND DETECTORS
Nancy M. Haegel, Professor
Department of Physics
Sponsor: Naval Postgraduate School Foundation

OBJECTIVE: Characterization of new materials for infrared sensors and detectors. Samples are studied using new techniques in the scanning electron microscope to image the transport of charge.

ACOUSTIC DETECTION OF ULTRA-HIGH ENERGY COSMIC RAY NEUTRINOS
Daphne Kapolka, Senior Lecturer
Department of Physics
Sponsor: Stanford University

SUMMARY: The Naval Postgraduate School provided services in support of Stanford University's project studying the possibility of detecting ultra-high neutrinos from cosmic rays using acoustic techniques.

ACOUSTIC SOURCE CHARACTERISTICS OF A SUBMERGED HIGH ENERGY LASER PULSE
Daphne Kapolka, Senior Lecturer
Department of Physics
Sponsor: Naval Sea Systems Command PMS405

OBJECTIVE: To extend work examining the acoustic signature of a high energy laser pulse incident on the sea-water interface to the signature expected from a submerged pulse. Efficiency, frequency, source level, and directivity will be examined with the goal of determining whether a ship-based free electron lasers (FEL) could be effectively used as an acoustic source for either underwater communications or as an acoustic decoy.

SUMMARY: Free electron lasers are being investigated as a possible weapon system for both land-based and shipboard applications. Past work has been limited to questions of airborne lasers of fixed frequencies. One of the advantages of FELs is the ability to tune it to produce different frequencies. A shipboard platform also permits the possibility of submerging the laser pulse below the surface to increase the pulse amplitude. Therefore, it is of interest to calculate the source characteristics achievable from a submerged (as opposed to a surface) pulse as a function of laser power, frequency, modulation frequency, spot size, and depth.

IMPROVING THE VISUAL PERCEPTION OF SONAR SIGNALS WITH STOCHASTIC RESONANCE
Daphne Kapolka, Senior Lecturer
Department of Physics
Sponsor: Naval Postgraduate School

OBJECTIVE: In 1997, Simonotto, et al., published an article in Physical Review Letters titled “Visual Perception of Stochastic Resonance,” in which he describes the improvement in image quality obtained by adding time-varying noise to an image. The goal of this project is to apply this technique to lofargrams to answer the general question of whether this technique can be used to improve the detectability of weak tonals.

SUMMARY: In a general sense, stochastic resonance is the enhancement of weak signals due to the addition of noise. Somewhat counterintuitive, it arises in situations where there is a threshold that must be overcome in order for some effect to exhibit itself. In the absence of noise, the weak signal may not be able to overcome the threshold. In this case, additional noise may boost the signal to the point where the threshold is exceeded. In the roughly 26 years since it was first introduced, stochastic resonance has been
widely applied to phenomena as diverse as climatology, bistable ring lasers, and psychiatry. In the past few years, a number of papers have been published investigating the possibility of applying stochastic resonance to sonar signal processing. This particular project – enhancing lofargrams through the addition of noise – was proposed by Scott Peacock of the Johns Hopkins University Applied Physics Laboratory, and is based on work by Enrico Simonotto. Simonotto reported that viewing movies of a picture with time-varying noise causes a stochastic resonance response in the optical nerves, which results in the image enhancement. The Naval Postgraduate School has a Memorandum of Understanding with JHU-APL to collaborate on algorithms of potential interest to the APB program.

MARITIME SURVEILLANCE SENSING USING UNDERWATER WIDE-BAND ACOUSTIC COMMUNICATION RECEIVERS
Daphne Kapolka, Senior Lecturer
Department of Physics
Sponsor: U.S. Special Operations Command

OBJECTIVE: The use of acoustic modems for underwater communications has enormous tactical potential. Some of the most obvious applications include secure communications at speed and depth for submarines and data telemetry from undersea instruments. This research seeks to further increase the utility of undersea modems by using them to passively detect the passage of small boats in an area of interest.

SUMMARY: The primary research question is whether acoustic communication devices can be used as passive acoustic sensors capable of automated detection of small boats transiting at close range through restricted waters. In order to decide whether acoustic modems can achieve automated passive detection of small targets, researchers will need to know what features in the signatures of small boats can be exploited for detection, classification, and identification. Possible features might include characteristics of propulsion, cavitation, machinery, fathometer, obstacle avoidance sonar, etc. Of specific interest is whether there are any high frequency (9-14kHz) components, other than active transmissions, that can be exploited at short range. Although this is considered unlikely, no currently available databases answer the question definitively. Automated detection is particularly susceptible to high false alarm rates. It is suspected that the best way to maximize the Pd/Pfa rates is to detect the Doppler shift in the lofargram of a target passing through CPA. This research will attempt to develop an algorithm that can automatically identify the target signature (broadband and/or narrowband) of a target passing through CPA.

CARBON NANOTUBE FURNACE FOR ADVANCED ELECTRON EMITTER RESEARCH
Gamani Karunasiri, Associate Professor
Department of Physics
Sponsor: Air Force Office of Scientific Research

OBJECTIVE: To purchase a carbon nanotube furnace system for research on novel field emitter arrays using actively-controlled carbon nanotubes as emitters. Such field emitter arrays will be investigated for application as the electron source inside high-power microwave devices.

MICRO-ELECTRO-MECHANICAL SYSTEMS (MEMS)-BASED MINIATURE MICROPHONE FOR DIRECTIONAL SOUND SENSING
Gamani Karunasiri, Associate Professor
Jose O. Sinibaldi, Research Assistant Professor
Department of Physics
Department of Mechanical and Astronautical Engineering
Sponsor: National Science Foundation

OBJECTIVE: To develop an integrated Micro-Electro-Mechanical Systems (MEMS)-based miniature microphone system for directional sensing of sound similar to that of the Ormia Ochracea fly. The fly employs a unique coupled mechanical bar system to extract the direction of sound with ears separated only
about 500 um. A set of such sensors can be used for pinpointing explosions by monitoring the direction of sound which can be deployed using micro air vehicles. In addition, a network of these sensors can be used for unattended movement monitoring.

KEYWORDS: Directional Sound Sensor, Micro-Electro-Mechanical-Systems

REAL TIME TERAHERTZ DETECTION USING MICROBOLOMETER FOCAL PLANE ARRAY
Gamani Karunasiri, Associate Professor
Department of Physics
Sponsor: Air Force Office of Scientific Research

OBJECTIVE: To develop a real-time terahertz (Thz) imaging system using microbolometer focal array technology originally developed for infrared imaging in the 8-12 µm band. Thz radiation is typically detected using either antenna-coupled semiconductor detectors or superconducting bolometers. Imaging of objects using these detection schemes requires either complex scanning mechanisms that slow down the data acquisition or expensive cryogenic cooling, which limits widespread use. The successful conclusion of the research project will lead to the incorporation of microbolometer technology for real-time imaging in Thz frequencies. Such imaging systems can be used in stand-off detection of concealed objects and in medical imaging with deeper penetration compared to infrared thermography.

SUMMARY: The aim of the proposed research is to develop a real-time terahertz imaging system using microbolometer focal array technology originally developed for infrared imaging in the 8-12 µm band. The successful conclusion of the research project will lead to the incorporation of microbolometer technology for real-time imaging at THz frequencies. Such imaging systems can be utilized in stand-off detection of concealed objects and medical imaging with deeper penetration compared to infrared thermography.

THESES DIRECTED:


KEYWORDS: Terahertz, Microbolometer, Spectroscopy
PHYSICS

THERMAL/SHOCK ISOLATION SYSTEM AND MATERIALS FOR COMMON AERO
VEHICLE PAYLOADS
Andres Larraza, Associate Professor
Department of Physics
Sponsor: Ocellus, Inc.

SUMMARY: Ocellus, Inc. was awarded a Phase II SBIR contract (FA9453-04-C-0162) by the Air Force for the development of TPS materials and systems for the Common Aero Vehicle. A portion of the technical activities involved acoustic evaluation and shock tube measurement of various test materials. The Naval Postgraduate School has suitable facilities and personnel to support Ocellus, Inc.

INFORMATION MECHANICS
James H. Luscombe, Professor
Department of Physics
Sponsor: National Security Agency

OBJECTIVE: To develop algorithms for characterizing the stochastical flow of information in computer networks.

INFORMATION MECHANICS
James H. Luscombe, Professor
Department of Physics
Sponsor: Defense Advanced Research Projects Agency

OBJECTIVE: To define system development requirements, test requirements, and program development materials for thermodynamically-based computer network models that quantitatively characterize the state of the network and indicate potentially malicious behavior.

NAVAL SEA SYSTEMS COMMAND, THESES, AND CURRICULUM SUPPORT
James H. Luscombe, Professor
Department of Physics
Sponsor: Naval Sea Systems Command

SUMMARY: Provided direct support between curriculum sponsor (NAVSEA), curriculum students, faculty, and their research.

NAVAL POSTGRADUATE SCHOOL RAILGUN TECHNOLOGY
William B. Maier, Senior Lecturer
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: To develop and improve railgun technology.

RAILGUN TECHNOLOGY
William B. Maier, Senior Lecturer
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: Naval Postgraduate School research focuses on innovative solutions to difficult technical problems in practical employment of railguns.
The monolithic barrel will improve performance, reduce manufacturing costs, and speed military implementation. (LT Forch and LT Caramico)

New projectile designs should reduce rail erosion and improve flight stability. (ENS Brown)

High-speed tests of rail, interface, and projectile materials and designs will improve bore life. (LT Brian Black and LCDR Clifford)

Power supply development. (LT Jesse Black and LT Mays)

Four students and the Principal Investigator (PI) attended the 13th Electromagnetic Launch Symposium in Potsdam, Germany, 22-25 May 2006.

Three students and the PI toured ARL facilities in Aberdeen, Picatinny, and Adelphi.

Four students visited the University of Texas, Institute for Advanced Studies, and Center for Electromechanics.

Four students and two staff visited the prototype Navy railgun facility at Dahlgren, Virginia.

The PI briefed NPS railgun research at two Office of Naval Research railgun reviews.

Visitors, other than NPS personnel, to the railgun facility included:

- Eugene Nolting (and CAPT David Kiel, PMS 405)
- Two ONR patent lawyers
- Dr. Bob Turman, Sandia National Laboratories
- Robin Keese, ARL

Classical field theory: Some progress on a difficult problem.

RR Contracts: Railgun work was funded by NPS EOY and POM grants and by Office of Naval Research reimbursable contracts.

**MICRO-ROBOT SWARM**

LT Antonio Matos, USN
Department of Physics

Sponsor: Space and Naval Warfare Systems Command Systems Center-San Diego

**OBJECTIVE:** To investigate the integration of four-level semiconductor structures into untethered micro-scale robots. These structures will facilitate true untethered locomotion, provide a high signal-to-noise optical sensor, and allow for randomization in decision logic, which is required for distributed swarm processing. These four-level structures have been characterized in earlier work as pulse-mode optical detectors, with pulse rate proportional to the incident optical intensity.

**BROWNOUT ALGORITHM (NRO MERIT)**

Richard C. Olsen, Professor
Department of Physics
Sponsor: National Reconnaissance Office

**OBJECTIVE:** To develop brown-out algorithms.

**CLASSIFICATION AND FUSION-BASED METHODS FOR THE ANALYSIS OF HYPERSPECTRAL AND POLARIMETRIC IMAGERY**

Richard C. Olsen, Professor
Department of Physics
Sponsor: National Reconnaissance Office

**OBJECTIVE:** To investigate techniques for the analysis of spectral and polarimetric imagery. Target detection and display techniques will be developed for application to high-spatial resolution imagery.
SUMMARY: Supported the Defense Intelligence Agency.

MEASUREMENT AND SIGNATURE INTELLIGENCE OUTREACH/LIAISON PROJECT
 Richard C. Olsen, Professor
 Department of Physics
 Sponsor: Defense Intelligence Agency

SUMMARY: Supported the Defense Intelligence Agency. The Naval Postgraduate School Measurement and Signature Intelligence (MASINT) Chair supported the Defense Intelligence Agency in spectral and polarimetric imaging projects.

OFFICE OF THE SECRETARY OF DEFENSE SUPPORT FOR REMOTE SENSING RESEARCH
 Richard C. Olsen, Professor
 Department of Physics
 Sponsor: Secretary of the Air Force

SUMMARY: Supported the Office of the Secretary of Defense via remote sensing technology. Support was provided for the Remote Sensing Center.

RADIANT HELIUM/ALEXANDRITE
 Richard C. Olsen, Professor
 Department of Physics
 Sponsor: Navy Tactical Exploitation of National Capabilities

SUMMARY: Supported Navy Tactical Exploitation of National Capabilities efforts in the Radiant Alexandrite project.

RADIANT HELIUM/ALEXANDRITE PART 2
 Richard C. Olsen, Professor
 Department of Physics
 Sponsor: Navy Tactical Exploitation of National Capabilities

SUMMARY: Supported Navy Tactical Exploitation of National Capabilities efforts in the Radiant Alexandrite project.

SPECIAL CAPABILITIES SUPPORT TO THE OFFICE OF THE SECRETARY OF DEFENSE
 Richard C. Olsen, Professor
 Department of Physics
 Sponsor: Secretary of the Air Force

SUMMARY: Supported the Office of the Secretary of Defense.
PHYSICS

SPECIAL CAPABILITIES SUPPORT TO THE U.S. AIR FORCE
Richard C. Olsen, Professor
Department of Physics
Sponsor: Secretary of the Air Force

SUMMARY: Supported the U.S. Air Force.

SPECTRAL IMAGING APPLICATIONS IN REMOTE SENSING
Richard C. Olsen, Professor
Department of Physics
Sponsor: National Geospatial-Intelligence Agency

SUMMARY: Supported spectral research efforts at the National Geospatial-Intelligence Agency.

SPECTRAL TEST PLANNING AND GROUND TRUTH SUPPORT
Richard C. Olsen, Professor
Department of Physics
Sponsor: National Geospatial-Intelligence Agency

SUMMARY: Supported spectral research efforts at the National Geospatial-Intelligence Agency.

TECHNICAL SUPPORT TO THE OFFICE OF THE SECRETARY OF DEFENSE
Richard C. Olsen, Professor
Department of Physics
Sponsor: Office of the Secretary of Defense

SUMMARY: Supported the Deputy Under Secretary of Defense.

UV SPECTRAL IMAGING FOR GAS ID AND MATERIAL ID
Richard C. Olsen, Professor
Department of Physics
Sponsor: National Science Foundation

OBJECTIVE: The proposed activity is intended to study spectral imagery in the UV spectral range. The first objective is to develop methods of measuring the concentration as and flow rates of gas plumes, in particular SO2, which is found in both manmade and natural features (smoke plumes, volcanic plumes). Secondly it is proposed to study the spectral character of various target materials, plants, and general backgrounds.

SEAWEB TECHNOLOGY FOR NAVAL SPECIAL WARFARE
Joseph A. Rice, SSC San Diego Engineering Acoustics Chair
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: To develop state-of-the-art, undersea, acoustic-networked communication and navigation technology for application to Naval special warfare.
PHYSICS

MICRO-ELECTRO-MECHANICAL SYSTEMS (MEMS)-BASED DIRECTIONAL MICROPHONE
LT Timothy Shivok, USN
Department of Physics
Sponsor: Space and Naval Warfare Systems Command Systems Center-San Diego

OBJECTIVE: In the submarine community, contact tracking can be conducted via towed array technology. Existing towed array technology requires resolving bearing ambiguity by turning the submarine. This practice could be eliminated if an array of directional microphones could be developed and perfected. The goal of this research is to develop an integrated micro-electro-mechanical systems (MEMS)-based miniature microphone system for directional sensing of sound.

NUMERICAL STUDIES OF ACOUSTIC PARTICLE VELOCITY, ACOUSTIC VARIABILITY WITH A SPLIT-STEP FOURIER PARABOLIC EQUATION MODEL, AND 3D EFFECTS OF AN IMPROVED 2D ACOUSTIC RAY ALGORITHM
Kevin B. Smith, Associate Professor
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: 1) To incorporate calculations of acoustic particle velocity into existing propagation code to investigate unique features applicable to Naval applications; 2) to investigate a new, efficient algorithm for computing acoustic variability using a Split-Step Fourier Parabolic Equation model; and 3) to complete the analysis, begun by the Principal Investigator and Fred Tappert of 3D Effects, computed using an improved 2D acoustic ray model.

SABBATICAL SUPPORT
Kevin B. Smith, Associate Professor
Department of Physics
Sponsor: Naval Undersea Warfare Center-Newport Division

SUMMARY: Acoustic vector fields are defined by the simultaneous, local evaluation of acoustic pressure and the associated particle motion of the medium in response to the passing acoustic field.

TRAVEL EXPENSES FOR SABBATICAL WORK
Kevin B. Smith, Associate Professor
Department of Physics
Sponsor: Naval Undersea Warfare Center-Newport Division

OBJECTIVE: To cover project expenditures for travel undertaken on behest of NUWC-Newport.

ATMOSPHERIC OPTICAL TURBULENCE MODELING AND MEASUREMENTS
Donald L. Walters, Professor
Department of Physics
Sponsor: SAF/FMBMB-AFOY

OBJECTIVE: To provide funding for a contractor to move a precision millimeter wave antenna from the top of building B-120 at the U.S. Air Force Station, Los Angeles, to U.S. Naval Weapons Station Seal Beach; and to continue development of a reference sensor for atmospheric optical measurements.

SUMMARY: The objective of removing the antenna was initiated, contracted, and executed within three weeks during June 2006, and the antenna was moved to the U.S. Naval Weapons Station Seal Beach. This was accomplished with the assistance of two U.S. congressmen. The task was initiated quickly because the
building was being demolished as a part of a complex U.S. Government, development contractor land swap in Los Angeles to build new facilities for the U.S. Air Force Station, Los Angeles. The second phase involved assessing the cost of replacing the original hydraulic drive with a computer controlled electric drive. General Dynamics VertexRSI performed this estimate in August 2006. The estimated $1 to 1.5M cost exceeds the level that the sponsor was willing to commit and the task was terminated.

The atmospheric sensor CMOS camera device driver was adapted through a C program interface to allow acquisition and control from a user-written MATLAB™ program. This allowed us to acquire high frame rate (278 frame/sec) stellar images to measure the dynamic flare and distortion introduced by the atmosphere. This sensor provides the basis for a government reference system needed to measure the magnitude of the atmospheric phase distortions introduced along optical paths of interest.

PRESENTATIONS:


ATMOSPHERIC OPTICAL TURBULENCE MODELING AND MEASUREMENTS

Donald L. Walters, Professor
Department of Physics
Sponsor: Office of the Secretary of the Air Force

OBJECTIVE: To provide modeling and assessment of the effects of atmospherics on optical communications and RF communications systems of national interest.

ATMOSPHERIC OPTICAL TURBULENCE MODELING AND MEASUREMENTS

Donald L. Walters, Professor
Department of Physics
Sponsor: Office of the Secretary of the Air Force

OBJECTIVE: To utilize the Naval Postgraduate School acoustic sonars, coupled with optical sensors, to measure the spatial scales of convective thermal plumes.

ATMOSPHERIC OPTICAL TURBULENCE SENSOR

Donald L. Walters, Professor
Department of Physics
Sponsor: U.S. Air Force Research Laboratories, Kirtland, New Mexico

OBJECTIVE: To develop the algorithms to control, acquire, and process a MICRON CMOS camera, which is a critical element in a reference sensor for atmospheric optical measurements.

SUMMARY: The atmospheric sensor CMOS camera device driver was adapted through a C program interface to allow acquisition and control from a user-written MATLAB™ program under Windows. This allowed us to acquire high frame rate (278 frame/sec) stellar images to measure the dynamic flare and distortion introduced by the atmosphere. A separate effort, with University of California-Berkeley ECE Professor Steve Butner, developed a Linux version of the device driver to control and acquire a burst of camera frames at twice the rate as the Windows device drivers. This sensor provides the basis for a government reference system needed to measure the magnitude of the atmospheric phase distortions introduced along optical paths of interest. Wave optical simulations of electric fields propagated through the atmosphere and processed by the Naval Postgraduate School algorithms showed that the NPS algorithms were functioning as well as or better than the best algorithms used by previous Department of Defense sensor systems that had much more complex and expensive implementations.
PRESENTATION:


ATMOSPHERIC OPTICAL TURBULENCE SENSOR DEVELOPMENT
Donald L. Walters, Professor
Department of Physics
Sponsor: Air Force Research Laboratory

OBJECTIVE: To provide modeling and assessment of the effects of atmospherics on optical communications and Rf communications systems of national interest.
DEPARTMENT OF PHYSICS

2006
Faculty Publications and Presentations
PHYSICS

PUBLICATIONS


**CONFERENCE PUBLICATIONS**


OVERVIEW:

Systems engineering focuses on the development of large and complex systems: how do the parts work together in an integrated system, given the precise specification of the structure and behavior?

CURRICULA SERVED:

The Naval Postgraduate School Department of Systems Engineering has fifteen faculty members with primary appointments, ten with joint appointments, and two administrative staff. We offer master’s degrees and will soon be offering a doctorate in systems engineering. We have about 60 resident students and about 200 non-resident students. We work closely with the Wayne E. Meyer Institute of Systems Engineering at NPS, especially for student research programs. Our website is http://www.nps.navy.mil/se/.

RESIDENT PROGRAMS OF STUDY:

Curriculum 580, the resident master of science in systems engineering (MSSE), is a seven-quarter degree program intended for technically oriented military officers, federal government civilians, and qualified international applicants. Students enrolling in the MSSE program may choose from one of three tracks:

- Combat Systems Engineering
- Network-Centric Systems Engineering
- Ship Systems Engineering

Curriculum 308, the resident Master of Science in Systems Engineering and Analysis (MSSEA), is a six-quarter degree program intended primarily for Navy unrestricted line officers.

NON-RESIDENT PROGRAMS OF STUDY:

- Curriculum 311, the master of science in systems engineering via distance learning (MSSE DL), is an eight-quarter, distance-learning degree program intended primarily for federal government civilian scientists and engineers at Navy field activities.
- Curriculum 721, the master of science in systems engineering management (MSSEM), is a distance-learning program intended for qualified military officers, senior enlisted, federal government civilians, and defense contractor civilians.
- The systems engineering certificate program provides the fundamentals of systems engineering to engineering duty officers and other officer communities without requiring the student to enroll in an NPS degree program.

RESEARCH THRUSTS:

Our research seeks to understand: 1) engineering methods and their application to problem solving; and 2) the spectrums of systems engineering - lifecycle, analyses, and integration of systems - balancing resources to ensure timely completion through hands-on research with Navy sponsors. Our mission is to

- Prepare graduates to ensure national security by providing technical education in designing, building, operating, maintaining, and improving reliable, capable, effective, affordable, complex systems of systems that meet the user’s needs when the user needs them.
- Perform research to improve and develop new systems engineering techniques and methods.
- Apply systems engineering techniques and methods to develop cost-effective, timely solutions to urgent national security problems.
RESEARCH PROGRAM (Research and Academic)-FY2006:

The Department of Systems Engineering delivered $1.3M in reimbursable education, $0.4M in reimbursable research, and about $.3M in other externally funded activities. Funded research included work by Senior Lecturer Mike Green in maximizing the utility of shipboard systems; Associate Professor Tom Huynh in systems engineering of a maritime domain protection system; Senior Lecturer Gene Paulo in systems engineering methods for the rapid equipping force initiative; Assistant Professor Ravi Vaidyanathan in robotics; and Associate Professor Cliff Whitcomb in systems engineering of the joint maritime assault connector.

The Naval Postgraduate School’s sponsored program exceeded $81 million in FY2006. Sponsored programs included both research and educational activities funded from an external source. A profile of the sponsored program for the Department of Systems Engineering is provided below:

Size of Program: $2.2M
<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Phone</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Olwell, David H.</td>
<td>Professor and Chairman</td>
<td>656-3583</td>
<td><a href="mailto:dholwell@nps.edu">dholwell@nps.edu</a></td>
</tr>
<tr>
<td>Harney, Robert</td>
<td>Associate Professor and Associate</td>
<td>656-2685</td>
<td><a href="mailto:harney@nps.edu">harney@nps.edu</a></td>
</tr>
<tr>
<td>Boensel, Matt</td>
<td>Lecturer and Associate Chairman for</td>
<td>656-3489</td>
<td><a href="mailto:mgboense@nps.edu">mgboense@nps.edu</a></td>
</tr>
<tr>
<td>Huynh, Thomas V.</td>
<td>Associate Professor</td>
<td>656-7568</td>
<td><a href="mailto:thuynh@nps.edu">thuynh@nps.edu</a></td>
</tr>
<tr>
<td>Rhoades, Mark</td>
<td>Senior lecturer</td>
<td>656-2321</td>
<td><a href="mailto:mmrhoade@nps.edu">mmrhoade@nps.edu</a></td>
</tr>
<tr>
<td>Catalano, Jean</td>
<td>Research Assistant</td>
<td>656-2956</td>
<td><a href="mailto:ekujawsk@nps.edu">ekujawsk@nps.edu</a></td>
</tr>
<tr>
<td>Kujawski, Edouard</td>
<td>Associate Professor</td>
<td>656-3324</td>
<td><a href="mailto:ekujawsk@nps.edu">ekujawsk@nps.edu</a></td>
</tr>
<tr>
<td>Shebalin, Paul V.</td>
<td>Senior Lecturer</td>
<td>656-1047</td>
<td><a href="mailto:pshebali@nps.edu">pshebali@nps.edu</a></td>
</tr>
<tr>
<td>Goshorn, Rachel</td>
<td>Assistant Professor</td>
<td>656-3835</td>
<td><a href="mailto:goshorn@nps.edu">goshorn@nps.edu</a></td>
</tr>
<tr>
<td>Langford, Gary</td>
<td>Senior Lecturer</td>
<td>656-1069</td>
<td><a href="mailto:golangfo@nps.edu">golangfo@nps.edu</a></td>
</tr>
<tr>
<td>Stevens, Mark R.</td>
<td>Lecturer</td>
<td>656-7545</td>
<td><a href="mailto:mstevens@nps.edu">mstevens@nps.edu</a></td>
</tr>
<tr>
<td>Green, John M.</td>
<td>Senior Lecturer</td>
<td>656-1084</td>
<td><a href="mailto:jmgreen@nps.edu">jmgreen@nps.edu</a></td>
</tr>
<tr>
<td>Miller, Greg</td>
<td>Lecturer</td>
<td>656-2957</td>
<td><a href="mailto:gamiller@nps.edu">gamiller@nps.edu</a></td>
</tr>
<tr>
<td>Vaidyanathan, Ravi</td>
<td>Assistant Professor</td>
<td>656-2960</td>
<td><a href="mailto:rvaidyan@nps.edu">rvaidyan@nps.edu</a></td>
</tr>
<tr>
<td>Hart, David A.</td>
<td>Professor of Practice</td>
<td>656-3839</td>
<td><a href="mailto:dahart@nps.edu">dahart@nps.edu</a></td>
</tr>
<tr>
<td>Paulo, Gene</td>
<td>Associate Chairman for Instruction</td>
<td>656-3452</td>
<td><a href="mailto:eppaulo@nps.edu">eppaulo@nps.edu</a></td>
</tr>
<tr>
<td>Whitcomb, Clifford</td>
<td>Associate Professor</td>
<td>656-3834</td>
<td><a href="mailto:cawhitco@nps.edu">cawhitco@nps.edu</a></td>
</tr>
<tr>
<td>Hart, David A.</td>
<td>Professor of Practice</td>
<td>656-3839</td>
<td><a href="mailto:dahart@nps.edu">dahart@nps.edu</a></td>
</tr>
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<td>Associate Chairman for Instruction</td>
<td>656-3452</td>
<td><a href="mailto:eppaulo@nps.edu">eppaulo@nps.edu</a></td>
</tr>
<tr>
<td>Whitcomb, Clifford</td>
<td>Associate Professor</td>
<td>656-3834</td>
<td><a href="mailto:cawhitco@nps.edu">cawhitco@nps.edu</a></td>
</tr>
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</table>
MAXIMIZING THE UTILITY OF SHIPBOARD SYSTEMS: SHIPBOARD MISSILE RELOADING AND INTEGRATION STUDY
John M. Green, Senior Lecturer
Department of Systems Engineering
Sponsor: Raytheon Company

SUMMARY: The Naval Postgraduate School desires to work with industry and apply its knowledge base and expertise to an understanding of problems associated with and finding solutions for integrating new weapon systems onto currently deployed Navy ships.

SYSTEM OF SYSTEMS ENGINEERING FOR MARITIME DOMAIN PROTECTION
Thomas V. Huynh, Associate Professor
Gene Paulo, Associate Chairman for Instruction
Department of Systems Engineering
John S. Osmundson, Associate Professor
Department of Information Sciences
Sponsor: Office of the Under Secretary of Defense

OBJECTIVE: To develop a systems engineering methodology that provides a framework and tool for designing maritime domain protection (MDP) system of systems (SOS) or complex systems; to develop an ontology specification for maritime domain coalition operations; to conduct a case study of an MDP SOS for a Singapore-U.S. coalition; and to extend the MDP Singapore-U.S. SOS to the following coalitions involving nations around the Malacca Straits and the U.S.: 1) Indonesia and the U.S., 2) the Philippines and the U.S., 3) Singapore, Indonesia, and the Philippines, and 4) Singapore, Indonesia, the Philippines, and the U.S.

RESEARCH IN NON-EXPECTED UTILITY MODELS FOR TRADEOFF STUDIES IN A MULTI-STATE WORLD
Edouard Kujawski, Associate Professor
Department of Systems Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: To develop and implement a quantitative approach to aid the Navy's decision-making capability for the selection and deployment of robust systems that best balance cost, performance, and risk for the multi-state world that it faces. This approach will 1) integrate systems thinking, valid mathematical models, and behavioral psychology, and 2) provide adequate information and visibility into the alternatives, rather than automatic decision-making based on a single number.

IMPROVISED EXPLOSIVE DEVICES STUDY
Gary O. Langford, Lecturer
Department of Systems Engineering
Sponsor: Naval Postgraduate School

SHORT COURSE ON DEPARTMENT OF DEFENSE ARCHITECTURE FRAMEWORK, V 1.0
Greg Miller, Lecturer
Department of Systems Engineering
Sponsor: Naval Air Warfare Center - Weapons Division

OBJECTIVE: To provide instruction on fundamentals of Department of Defense architecture framework products as artifacts of systems engineering processes in the defense acquisition environment.
APPLYING SYSTEMS ENGINEERING TO THE RAPID EQUIPPING FORCE
Gene Paulo, Associate Chairman for Instruction
David H. Olwell, Professor
Department of Systems Engineering
Sponsor: TRADOC Analysis Center-Monterey

OBJECTIVE: The Rapid Equipping Force (REF) works directly with operational commanders to rapidly find promising material solutions to their identified operational requirements. This research will develop, implement, and assess a set of systems engineering methods for the improvement of REF. For fiscal year 2006, REF capability will be addressed by the implementation of specialized systems engineering analysis concepts. Specifically, the purpose of this research will be to develop a tailorable REF analysis and implementation methodology, and to provide analysis, modeling, and simulation support to the REF for systems under consideration.

EXPLORATORY RESEARCH IN BIOLOGICALLY INSPIRED SYSTEMS
Ravi Vaidyanathan, Assistant Professor
Department of Systems Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: A two-year study is planned to perform exploratory research aimed at the development of a human-interface command and control package applicable for soldier-command of semi-autonomous military robots. This work will lay the foundation for an efficient, flexible, and robust human-machine command system, capable of directing robotics units performing military missions, without debilitating, hampering, or interfering with a warfighter's field operations.

THINK-A-MOVE
Ravi Vaidyanathan, Assistant Professor
Department of Systems Engineering
Sponsor: Think-a-Move, Ltd.

U.S. SPECIAL OPERATIONS COMMAND - THE NAVAL POSTGRADUATE SCHOOL
COOPERATIVE FIELD EXPERIMENTATION PROGRAM
Ravi Vaidyanathan, Assistant Professor
Department of Systems Engineering
Sponsor: Naval Postgraduate School

ALTERNATIVE ELECTRICAL POWER DISTRIBUTION SYSTEM ARCHITECTURES STUDY FOR PEO-SHIPS (PMS 377K) JOINT MARITIME ASSAULT CONNECTOR PROGRAM
Clifford Whitcomb, Associate Professor
Department of Systems Engineering
Sponsor: Naval Surface Warfare Center-Carderock Division

OBJECTIVE: To perform an analysis of advanced electric power system technologies that will determine the best options for several electrical distribution architectures that will enhance mission requirements for a given set of desired Joint Maritime Assault Connector mission profiles.
OBJECTIVE: To develop a framework to allow exploring the feasibility of the design space of solutions using decomposition-based design principles to define an efficient way to structure the system design and engineering process through a system architecting approach. The objective of the proposed research is to create an architecting methodology for conducting and prioritizing AOA studies in the context of complex warfighting systems development. The final formulation of an architecting process is expected to be a scientifically-based framework that uses functional allocation of requirements to physical form as the basis for creating feasible architectures for trade-offs.


CONTRIBUTION TO BOOK


TECHNICAL REPORTS


ADD Red Cell
SPACE SYSTEMS
ACADEMIC GROUP

RUDOLF PANHOLZER
CHAIRMAN
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, the SSAG 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 lifecycle, 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. 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 and Astronautical 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 Exploitation of National Capabilities (TENCAP) Space Chair
- Space-Systems Academic Chair
- NASA Michael J. Smith Space-Systems Chair
- National Reconnaissance Office Chair
- MASINT 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 and 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)-FY2006:

The Naval Postgraduate School’s sponsored program exceeded $81 million in FY2006. Sponsored programs included both research and educational activities funded from an external source.

Size of Program: $1.1M
SPACE SYSTEMS ACADEMIC GROUP

Panholzer, Rudolf
Chairman
656-2154/2278
rpanholzer@nps.edu

Olsen, Richard C.
Associate Professor and
Associate Chairman for Research
656-2019
olsen@nps.edu

Agrawal, Brij
Distinguished Professor
656-3338
agrawal@nps.edu

Danielson, Donald A.
Professor
656-2622
dad@nps.edu

Neta, Beny
Associate Chairman for
Instruction and Academic
Associate
656-2235
bneta@nps.edu

Alfriend, Terry
Visiting Professor
656-3939
ktalfr@nps.edu

Durkee, Phil
Professor
656-3465
durkee@nps.edu

Newman, James H.
NASA Chair Professor
656-2487
jhn@nps.edu

Betterton, T., RADM, USN (Ret.)
Naval Space Technology Chair and Professor
656-3765
tcbetter@nps.edu

Fouts, Douglas J.
Associate Professor
656-2852
dfouts@nps.edu

Olsen, Richard C.
Professor and Associate Chair for Research
656-2019
olsen@nps.edu

Boger, Dan
Professor
656-3617/2607
dboger@nps.edu

Gopinath, Ashok
Associate Professor
656-3400
gopinath@nps.edu

Panholzer, Rudolf
Chairman
656-2154/2278
rpanholzer@nps.edu

Bonometti, Joseph
Michael J. Smith NASA Chair Professor
656-3453
jabonome@nps.edu

Horning, James
Research Associate
656-3199
jahornin@nps.edu

Powers, John P.
Distinguished Professor
656-2679
jpowers@nps.edu

Bordetsky, Alex
Associate Professor
656-2287
abordets@nps.edu

Leonard, Barry
Visiting Associate Professor
656-3012
bal@allera.net

Racoosin, Charles M.
Visiting Assistant Professor and Naval Space Systems Chair Professor
656-2231
cm@nps.edu

Budden, Nancy Ann
Director Defense Counter Terrorism Technology
656-3332
nbudden@nps.edu

Loomis, Herschel H.
Professor
656-3214
hloomis@nps.edu

Rhoades, Mark
Program Officer
656-2492
mmr@nps.edu

Bursch, Daniel, CAPT USN
NRO Aerospace Chair Professor
656-2764
dwbursch@nps.edu

Michael, Sherif N.
Associate Professor
656-2252
michael@nps.edu

Romano, Marcello
Assistant Professor
656-2885
mromano@nps.edu
<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Phone</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ross, Alan</td>
<td>TENCAP Chair Professor</td>
<td>656-3769</td>
<td><a href="mailto:Aross@nps.edu">Aross@nps.edu</a></td>
</tr>
<tr>
<td>Tackett, Stephen</td>
<td>Military Instructor</td>
<td>656-2944</td>
<td><a href="mailto:shtacket@nps.edu">shtacket@nps.edu</a></td>
</tr>
<tr>
<td>Weatherford, Todd R.</td>
<td>Associate Professor</td>
<td>656-3044</td>
<td><a href="mailto:trweathe@nps.edu">trweathe@nps.edu</a></td>
</tr>
<tr>
<td>Ross, Isaac M.</td>
<td>Associate Professor</td>
<td>656-2074</td>
<td><a href="mailto:imross@nps.edu">imross@nps.edu</a></td>
</tr>
<tr>
<td>Trask, David</td>
<td>MASINT Chair Professor</td>
<td>656-2219</td>
<td><a href="mailto:dmtrask@nps.edu">dmtrask@nps.edu</a></td>
</tr>
<tr>
<td>Welch, Joe</td>
<td>Lecturer</td>
<td>656-3009</td>
<td><a href="mailto:wwelch@nps.edu">wwelch@nps.edu</a></td>
</tr>
<tr>
<td>Sakoda, Dan</td>
<td>Research Associate</td>
<td>656-3198</td>
<td><a href="mailto:dsakoda@nps.edu">dsakoda@nps.edu</a></td>
</tr>
<tr>
<td>Wadsworth, v. Donald</td>
<td>Senior Lecturer</td>
<td>656-3456</td>
<td><a href="mailto:Dwadsworth@nps.edu">Dwadsworth@nps.edu</a></td>
</tr>
<tr>
<td>Wilson, Lonnie</td>
<td>Research Associate Professor</td>
<td>656-2838</td>
<td><a href="mailto:wilson@nps.edu">wilson@nps.edu</a></td>
</tr>
<tr>
<td>Scott, Alan, CAPT, USN</td>
<td>Military Instructor</td>
<td>656-2453</td>
<td><a href="mailto:adscott@nps.edu">adscott@nps.edu</a></td>
</tr>
<tr>
<td>Walters, Donald L.</td>
<td>Professor</td>
<td>656-2267</td>
<td><a href="mailto:Walters@nps.edu">Walters@nps.edu</a></td>
</tr>
</tbody>
</table>

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CFD SIMULATION OF THE BASICS OF UNDERWATER LAUNCH FLOW
Ashok Gopinath, Associate Professor
Donald v. Z. Wadsworth, Senior Lecturer
Jose O. Sinibaldi, Research Assistant Professor
Department of Mechanical and Astronautical Engineering
Space-Systems Academic Group
Sponsor: Strategic Systems Programs

SUMMARY: The current proposal for fiscal year 2006 covers the second year of a multiple-year research effort at the Naval Postgraduate School. This project is sponsored by Strategic Systems Programs. The goal is to continue the development (started in fiscal year 2005) of the basic numerical simulation capability to predict the essential fluid dynamic characteristics associated with an underwater missile launch.

CARBON NANOTUBE DEVICE RADIATION SUSCEPTIBILITY AND MITIGATION TECHNIQUES
Herschel H. Loomis, Jr., Professor
Department of Electrical and Computer Engineering
Space-Systems Academic Group
Sponsor: National Reconnaissance Office

OBJECTIVE: To demonstrate the value of the remote configurability of the field-programmable gate array (FPGA) to space computing. To develop an SEA-tolerant, space-based computer using commercial, off-the-shelf FPGAs to demonstrate the feasibility of using triple modular redundancy to correct errors without resort to system reset. To build and fly a configurable, fault-tolerant mission computer on the NPSat, Midstar, and a satellite in a high-radiation orbit.

CONFIGURABLE FAULT-TOLERANT ARCHITECTURES FOR RELIABLE SPACE-BASED COMPUTING
Herschel H. Loomis, Jr., Professor
Department of Electrical and Computer Engineering
Space-Systems Academic Group
Sponsor: Secretary of the Air Force

OBJECTIVE: To demonstrate the value of the remote configurability of the field-programmable gate array (FPGA) to space computing. To develop a single-event-upset tolerant space-based computer using commercial, off-the-shelf FPGAs to demonstrate the feasibility of using triple modular redundancy to correct errors without resort to system reset. To build and fly a configurable, fault-tolerant mission computer on the NPSat, Midstar, and a satellite in a high-radiation orbit.

MARITIME DOMAIN AWARENESS EVALUATION
Herschel H. Loomis, Jr., Professor
Department of Electrical and Computer Engineering
Space-Systems Academic Group
Sponsor: Naval Engineering Logistics Office

OBJECTIVE: To evaluate various toolsets for fusion and display of data for maritime domain awareness.
IN SEARCH OF FORTY-PERCENT EFFICIENT, SPACE-BASED, MULTI-JUNCTION SOLAR CELLS: OPTIMIZATION AND DESIGN USING SILVACO VIRTUAL-WAFER-FABRICATION SOFTWARE
Sherif Michael, Professor
Department of Electrical and Computer Engineering
Space-Systems Academic Group
Sponsor: National Reconnaissance Office

OBJECTIVE: To use a new method for developing a realistic model of any type of solar cell using Silvaco/Atlas virtual wafer fabrication software.

MODELING, DESIGN, AND OPTIMIZATION OF MULTI-JUNCTION SOLAR CELLS USING SILVACO VIRTUAL-WAFER-FABRICATION SOFTWARE
Sherif Michael, Professor
Department of Electrical and Computer Engineering
Space-Systems Academic Group
Sponsor: National Reconnaissance Office

OBJECTIVE: To use a new method for developing a realistic model of any type of solar cell using Silvaco/Atlas virtual-wafer-fabrication software.

LITHIUM-ION-BATTERY TECHNOLOGY DEVELOPMENT FOR THE NPSAT1
Rudolf Panholzer, Chairman
Space-Systems Academic Group
Sponsor: National Reconnaissance Office

OBJECTIVE: To design, test, and construct (from commercial lithium-ion cells) a flight-worthy battery for use aboard the NPSat1 satellite.

NAVAL SPACE-SYSTEMS ACADEMIC CHAIR
Rudolf Panholzer, Chairman
Charles M. Racoosin, Visiting Assistant Professor and Naval Space Command Academic Chair Professor
Space-Systems Academic Group
Sponsor: Naval Network Space Operations Command

OBJECTIVE: Incumbents of the Space-Systems Academic Chair will engage in instruction and research as consultants in the area of specialization to students and faculty of the Naval Postgraduate School.

NPSAT1 SATELLITE SUPPORT
Rudolf Panholzer, Chairman
Space-Systems Academic Group
Sponsor: Secretary of the Air Force

OBJECTIVE: To fund instructional thesis research related to the NPSat1 micro-satellite and the development of the space vehicle. NPSat1 is part of the small satellite design program under the Naval Postgraduate School’s Space-Systems Academic Group.
SPACE SYSTEMS ACADEMIC GROUP

NPSAT1 SATELLITE SUPPORT
Rudolf Panholzer, Chairman
Space-Systems Academic Group
Sponsor: Department of Defense Space Test Program

OBJECTIVE: To fund system-level testing of the NPSat1 micro-satellite and the development of the space vehicle. NPSat1 is part of the small satellite design program under NPS’s Space-Systems Academic Group.

SPACE-SYSTEMS OPERATIONS STUDENT THESIS RESEARCH/EXPERIENCE TOUR
Rudolf Panholzer, Chairman
Space-Systems Academic Group
Sponsor: Naval Network Space Operations Command

OBJECTIVE: To fund Space-Systems Academic Group’s student-research-related travel and experience-tour travel pertaining to space-systems operations.

AEROASSISTED MANEUVERS AND MISSION DESIGN
Isaac Michael Ross, Professor
Department of Mechanical and Astronautical Engineering
Sponsor: NASA-Jet Propulsion Laboratory

SUMMARY: Principal Investigators will access and combine aircraft maintenance data with personnel and usage data for technical representatives. This will permit the development of a model for technical representative service levels in E2 squadrons at Pt. Mugu, California, and Norfolk, Virginia.

IOT&E FOR RADIANT GARNETT II
Alan Ross, TENCAP Chair Professor
Space-Systems Academic Group
Sponsor: Naval Engineering Logistics Office

OBJECTIVE: To develop a tool set for data manipulation, fusion, and display, and thus, to demonstrate improved maritime domain awareness.

MARITIME DOMAIN AWARENESS-EVALUATION OF THE MASTER DATA PROCESSING SYSTEM
Alan Ross, TENCAP Chair Professor
Space-Systems Academic Group
Sponsor: Naval Research Laboratory

SUMMARY: Evaluated the master data processing system using additional data sources in the Naval Postgraduate School maritime domain awareness fusion environment.

NAVY TACTICAL EXPLOITATION OF NATIONAL CAPABILITIES PROGRAM
Alan Ross, TENCAP Chair Professor
Space-Systems Academic Group
Sponsor: Naval Engineering Logistics Office

SUMMARY: Supported Naval Postgraduate School research in technology areas of interest to the Navy Tactical Exploitation of National Capabilities Program Office.
SPACE SYSTEMS
ACADEMIC GROUP

2006
Faculty Publications
and Presentations
PUBLICATIONS


GRADUATE SCHOOL OF BUSINESS AND PUBLIC POLICY

ROBERT N. BECK
DEAN
MISSION:

The mission of the Graduate School of Business and Public Policy is to serve the nation by educating military officers and DoD civilians in defense-focused business and public policy, by conducting scholarly research in defense management and public policy, by providing intellectual resources for leaders and organizations concerned with national-defense management practice and policies.

- In Education: Through graduate and non-degree programs, to develop students’ abilities to analyze, think critically, and take intelligent action so they can more effectively carry out their future professional responsibilities to manage organizations, resources, people, and programs in complex and sometimes life threatening environments.
- In Research: To conduct scholarly, technical, and applied research that supports military decision-making, problem solving, and policy setting; improves management processes and organizational effectiveness; contributes knowledge to academic disciplines, and advances graduate education.
- In Professional Service: To provide professional expertise that advances knowledge and business management within NPS, the Department of the Navy, the Department of Defense, and other government agencies; as well as in 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 incorporated in classroom instruction. The school’s research program goals are specified as follows on the Graduate School of Business and Public Policy “web” page: (http://www.nps.navy.mil/gsbpp/research.htm):

- Increase the quality and quantity of relevant defense-oriented research
- Catalyze a broad and robust research program
- Involve top researchers, practitioners and graduate students in defense-oriented research useful to DoD policy/decision making processes
- Augment and complement cooperative, interdisciplinary research activities
- Disseminate relevant, important results to researchers, sponsors, policy makers and practitioners
- Integrate defense-oriented research with education, DoD workforce training and standardize policy practices
- Establish and maintain a community of academic and professional scholars engaged in exploratory and applied research to address complicated defense issues from a number of perspectives, while integrating defense applications into familiar business disciplines

CURRICULA SERVED:

The Graduate School of Business and Public Policy has primary responsibility for seven 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. A third resident degree, the master of executive management (MEM) will start July 2006.

Distance learning graduate programs offered by the Graduate School of Business and Public Policy include: an executive-master-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:

Research in the Graduate School of Business and Public Policy is multidisciplinary and often widely diverse, but this research is directed toward a common set of goals. As stated in the school’s mission statement, the faculty conducts a variety of research to:

- Support military decision-making, problem-solving, and policy-setting
- Improve administrative processes and organizational effectiveness
- Contribute knowledge to academic disciplines
- Advance the mission of graduate education

The primary goal of the school’s research program is to provide the Navy and DoD with the capability of managing defense systems efficiently and effectively. This includes the efficient and effective utilization of resources, which derive from an existing base of knowledge or may require the development of new concepts and theory. Thus, the school recognizes the importance of both basic and applied research to the Navy and DoD, and it seeks to balance both types of research.

Concepts, theory, and existing knowledge can generally be identified with a particular functional area or discipline. Actual defense policy and management decisions or policies often require information or perspectives drawn from a variety of functional areas and professional expertise. Consequently, in addition to pursuing functional area research with a critical mass of faculty, the school actively seeks to engage in cooperative, interdisciplinary research. Such research 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 and professional experience 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. This is the case because many acquisition policy makers and executives have little or no benefit of theory for practice.

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 Departments of Defense 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 Greene, USN, (Ret.), this research program initiated fifteen research projects in 2003, with the number increasing to well over 20 in 2004, and over 35 in 2005. These projects include several collaborative efforts with Dr. Jacques Gansler (former Undersecretary of Defense for Acquisition, Technology and Logistics) and other faculty members at the University of Maryland. Primary research sponsors include: Assistant Secretary of the Navy (Research, Development and Acquisition), Naval Sea Systems Command, Program Executive Office (Ships), Program Executive Office (Integrated Warfare Systems) and the Defense Contract Management Agency (International).

A significant portion of this research funding is open-ended, restricted only to research topics involving acquisition issues broadly defined. The Graduate School of Business and Public Policy has established a competitive internal proposal process to allocate these funds; the call for proposals is distributed to faculty from across the Naval Postgraduate School. Priority is given to proposals that involve collaboration between tenure-track and non-tenure-track faculty members and to proposals involving thesis students and MBA project teams. The objective is to encourage collaboration that exploits the school’s academic as well as professional expertise, a collaboration that provides the Graduate School of Business and Public Policy a strong comparative advantage for defense acquisition policy research. This program has been growing rapidly, with four of five proposals funded in AY2004, nine of 11 proposals funded in AY2005 and 27 proposals submitted for AY2007; funding decisions are pending.

The Acquisition Research Program also hosts an annual Acquisition Research Symposium in Monterey. The third symposium, in May 2006, involved well over 100 people, including researchers and acquisition policy and decision makers from across the United States. The Honorable Kenneth J. Krieg – Under Secretary of Defense (Acquisition, Technology and Logistics) delivered the keynote address. Symposium details are on the symposium website (http://www.researchsymposium.org/ocs/).

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).
Professor Keith Snider, Senior Lecturers Mike Boudreau, John Dillard, Marshall Engelbeck, Raymond Franck, and Dave Matthews, and Lecturers Jeff Cuskey, Brad Naegle, Rene Rendon, and Don Summers are involved in this research area. The Acquisition Research Program also draws on faculty from all of the other discipline areas.

**Logistics and Transportation:** The primary mission of the Logistics and Transportation group is to educate military officers and DoD civilians in state-of-the-art concepts of logistics, transportation and supply chain 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 areas include:

- DoD inventory policy
- Cross-docking, inventory management and cycle time reduction
- Defense transportation and distribution systems
- Total Asset Visibility (TAV) and real-time logistics
- Metrics and Performance Based Logistics
- Spiral Development
- Modeling and simulation for logistics decision support
- Supply chain management and lean manufacturing and
- Sea-based logistics for the Navy and the Marine Corps

Much of this work has been supported through the acquisition-research program and its associated sponsors. Additional sponsors include the Office of Naval Research, NAVAIR, the Military Sealift Command, the U.S. Transportation Command and the Naval Surface Warfare Center.

Professors Aruna Apte, Uday M. Apte, Kenneth Doerr, Geraldo Ferrer, Keebom Kang, Ira Lewis, and Senior Lecturer Don Eaton are involved in this research area.

**Financial Management:** Research in the area of financial management has become increasingly important since the end of the Cold War and the events of 9-11. The financial-management (FM) group has identified three major functional areas as targets of opportunity for future research. These are:

- Financial resource policy formulation, analysis and management
- Financial management and budgeting
- Organizational efficiency, managerial control and performance metrics

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 and execution system; and relationships between financial management, contracting, acquisition and other policy fields. Financial management and budgeting includes the following: federal, DoD and Navy budget formulation and execution; impacts of budget allocation, reallocation and reduction; implementation of Defense Resource Management Systems; and the Chief Financial Officer Act and federal financial management reforms. The research area of organizational efficiency, managerial control and performance metrics, in turn, covers the following: mapping, goals, and objectives to a defense organization’s strategic themes using a balanced scorecard, examining the efficiency of defense sector consolidation and the cost – effectiveness of lease versus buy programs.

Sponsors for this research include: Assistant Secretary of the Navy (Research, Development and Acquisition), Program Executive Office (Ships); Program Executive Office (Integrated Warfare Systems); the Office of the Comptroller, COMNAVAIRPAC (CNAP); U.S. Department of Justice; and the Personnel Security Research Center (Department of Defense).

Professors Richard Doyle, Kenneth J. Euske, Nayantara Hensel, Lawrence Jones, Jerry McCaffery, Joe San Miguel, Nicole Thibodeau, Carmelita Troy, Senior Lecturer John Mutty, Commander Phil Cundreva (USN) and Colonel Randy Howard (USAF) are involved in this research area.

**Manpower Systems Analysis:** As noted above, the primary goal of the department’s research programs is to provide defense policy makers with the capability of utilizing resources with maximum efficiency and effectiveness. This includes *human* resources, the focus of research in the Manpower
Defense manpower policy makers have been faced with many challenges since the end of the Cold War and the events of 9-11. Key among these challenges include an over 30 percent reduction of the active-duty force, budget reductions in recruiting and advertising, a steady, high operational tempo and deployment schedule with fewer people, new missions, increasing pressure to change the “culture” of military service, renewed efforts toward population representation of women and racial/ethnic minorities throughout the force, a 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:

- Manpower supply and force requirements
- Improvements in selection and classification of enlisted personnel
- Innovations in recruiting and the application of new technologies
- Improvements in selection of officers and pre-commissioning programs
- Effectiveness of equal opportunity and diversity management programs
- Training effectiveness and efficiency
- Innovations in instructional technologies
- Innovations in enlisted assignments and auctions for assignment incentive pay
- Personnel retention in critical fields, including auction based approaches
- Reduction of first-term attrition rates among enlisted personnel
- Force management programs and planning
- Force structure and cost analysis
- Auction-based approaches to force shaping
- Career-force modeling
- Officer promotion and performance
- Civil-military relations and the All-Volunteer Force
- Manpower management in Reserve components

Sponsors for this research include: Office of the Chief of Naval Operations (N-1, N-1H, N-1Z, N-12, N-13, and N-14), Navy Personnel Research, Studies and Technology and the Office of the Assistant Secretary of Defense.

Professors Pete Coughlan, Mark Eitelberg, William Gates, Stephen Mehay, Elda Pema, Yu-Chu Shen, Senior Lecturer Alice Crawford, and Lecturer Bill Hatch are involved in this research area.

Organization, Management, and Policy Analysis: Faculty members in this functional area pursue basic and applied research on key management issues at a variety of organizational levels. Faculty members bring a strategic perspective to this work, seeking to identify courses of action that will best achieve organizational goals in a given setting. Individual faculty members are acknowledged experts who publish leading-edge research on a variety of issues. Top management issues include strategy and entrepreneurship, appreciative inquiry and positive change, organizational design (including the use of self-managing groups), social network analysis, ethics, collaboration in teams, managerial communications and the development of culture.

There is a strong expertise in leadership at all organizational levels. Leadership issues studied by faculty include leadership development, the identification of key leadership skills, innovation and change, motivational strategies, empowerment, coaching, communications strategies, conflict management and constructive uses of power. Faculty members are also experts in a variety of research methodologies—from highly sophisticated quantitative to in-depth qualitative analyses.

In addition to their subject area and methodological expertise, faculty members have developed considerable knowledge of current military organizations through their research. Most of this work has been with Navy organizations, such as the NAVSUP, NAVAIR, CNET, NETWARCOM, Naval Reserves and CINCLANTFLEET. However, faculty members have also worked with organizations in other service branches, including extensive work with the U.S. Army Reserve Command and Coast Guard Headquarters. Recent DoD-wide research includes work for the Office of Force Transformation. Individual faculty have
also conducted research for other U.S. government agencies, including the Office of Personnel Management, the Department of Homeland Security and the Center for Disease Control, and consulted with state government agencies, the United Nations, and private-sector organizations. Supervising student theses has broadened this knowledge even more. This organizational expertise increases the value of faculty as applied researchers for DoN and DoD organizations.

Professors Frank Barrett, Doug Brook, Nick Dew, Deborah Gibbons, Susan Hocevar, Cindy King, Leslie Sekerka, Jim Sucahn, Gail Fann Thomas, and Roxanne Zolin are involved in this research.

**RESEARCH PROGRAM (Research and Academic)-FY2006:**

The Naval Postgraduate School’s sponsored program exceeded $81 million in FY2006. 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.

![Pie chart showing distribution of sponsored programs](image)

Size of Program: $5.2M
# Faculty Listing

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<tr>
<th>Beck, Robert N.</th>
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<tr>
<td><strong>Dean</strong></td>
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<tr>
<td>656-2471</td>
<td><strong>Associate Dean for Research</strong></td>
</tr>
<tr>
<td><a href="mailto:rnbeck@nps.edu">rnbeck@nps.edu</a></td>
<td>656-2754</td>
</tr>
<tr>
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<td><a href="mailto:brgates@nps.edu">brgates@nps.edu</a></td>
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<td>656-2884</td>
</tr>
<tr>
<td><a href="mailto:auapte@nps.edu">auapte@nps.edu</a></td>
<td><a href="mailto:pjcandre@nps.edu">pjcandre@nps.edu</a></td>
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<tr>
<td><a href="mailto:umapte@nps.edu">umapte@nps.edu</a></td>
<td><a href="mailto:pcoughl@nps.edu">pcoughl@nps.edu</a></td>
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<td>656-2481</td>
</tr>
<tr>
<td><a href="mailto:fbarrett@nps.edu">fbarrett@nps.edu</a></td>
<td><a href="mailto:acrawford@nps.edu">acrawford@nps.edu</a></td>
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<td><a href="mailto:skbosque@nps.edu">skbosque@nps.edu</a></td>
<td><a href="mailto:twcrouch@nps.edu">twcrouch@nps.edu</a></td>
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<td><a href="mailto:mboudreau@nps.edu">mboudreau@nps.edu</a></td>
<td><a href="mailto:jcuskey@nps.edu">jcuskey@nps.edu</a></td>
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<tr>
<td><a href="mailto:dbrinkle@nps.edu">dbrinkle@nps.edu</a></td>
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<tr>
<td><a href="mailto:khdoerr@nps.edu">khdoerr@nps.edu</a></td>
<td><a href="mailto:ddoyle@nps.edu">ddoyle@nps.edu</a></td>
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<td><a href="mailto:meitelberg@nps.edu">meitelberg@nps.edu</a></td>
<td><a href="mailto:kjeuske@nps.edu">kjeuske@nps.edu</a></td>
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<td><a href="mailto:rmengelb@nps.edu">rmengelb@nps.edu</a></td>
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<td>Zolin, Roxanne</td>
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NAVAL EXPEDITIONARY LOGISTICS: A BLUEPRINT FOR COMPLEMENTING AND SUPPORTING LAND FORCES
LCDR Keith Applegate, USN
Graduate School of Business and Public Policy
Sponsor: Navy Operational Logistics Support Center-Norfolk

OBJECTIVE: To provide a portfolio for U.S. Navy logistics professionals who are members of, or whose function is to support, U.S. Navy expeditionary forces. The report will consolidate and deconflict existing logistics guidance, publications, instructions, and deployment procedures; and add elements of the aforementioned from other armed services and government agencies that are lacking in current U.S. Navy documents.

A DIAGNOSTIC APPROACH TO ANALYZING WEAPON SYSTEM LIFE-CYCLE SUPPORT: THE PHALANX CLOSE-IN WEAPON SYSTEM
Aruna Apte, Assistant Professor
Rene Rendon, Lecturer
Graduate School of Business and Public Policy
Sponsor: Naval Postgraduate School

SUMMARY: This study used a diagnostic approach to examine all aspects of the Phalanx Close-In Weapon System (CIWS) life-cycle support program. The study gauged the status of current conditions, analyzed the cost structures, identified the initiatives in place, and suggested areas that need further investigation.

FOCUSING ON CUSTOMER'S TIME IN FIELD SERVICE DELIVERY: A NORMATIVE APPROACH
Aruna Apte, Assistant Professor
Uday M. Apte, Professor
Graduate School of Business and Public Policy
Nandgopal Venugopal
Network Planning and Engineering Systems, Verizon Business
Sponsor: Naval Postgraduate School

SUMMARY: Although customer convenience should be rightfully considered as a central element in field services, the customer experience suggests that service enterprises rarely take customer’s preferred time into account in making the operational and scheduling decisions. This research combined the results of exploratory research into two interrelated topics: the explicit inclusion of customer time in non-emergency field service delivery decisions, and the analysis of tradeoff between the customer’s convenience and field service provider’s cost.

A MODEL FOCUSING ON CUSTOMER TIME IN FIELD SERVICE DELIVERY
Aruna Apte, Assistant Professor
Graduate School of Business and Public Policy
Sponsor: Naval Postgraduate School

OBJECTIVE: To develop a research design that, given the customer’s preference, minimizes collective costs to field service providers and customers by explicitly considering the customer's time and costs in making operational and scheduling decisions in field services.
MANAGING THE SERVICE SUPPLY IN THE DEPARTMENT OF DEFENSE: OPPORTUNITIES AND CHALLENGES
Uday M. Apte, Professor
Graduate School of Business and Public Policy
Sponsor: Naval Postgraduate School

OBJECTIVE: To conduct an initial exploratory analysis of Department of Defense (DoD) services acquisition so as to frame the totality of the DoD’s services acquisition environment. Specifically, researchers plan to identify the size of the DoD’s services acquisition sector in terms of dollars and scope, its structure in terms of in-sourcing versus outsourcing of different services, and the current emerging trends in service acquisition policies and practices. This analysis of size, structure, and trends in the DoD’s service supply chain will be followed by the identification of challenges faced by contracting officers, program managers, and end users in services acquisition.

MANAGING THE SERVICE SUPPLY CHAIN IN THE DEPARTMENT OF DEFENSE: OPPORTUNITIES AND CHALLENGES
Uday M. Apte, Professor
Geraldo Ferrer, Associate Professor
Ira Lewis, Associate Professor
Rene Rendon, Lecturer
Graduate School of Business and Public Policy
Sponsors: Naval Postgraduate School and PEO Ships

SUMMARY: This research conducted an initial exploratory analysis of Department of Defense (DoD) services acquisition so as to frame the totality of the DoD’s services acquisition environment. In each of the last five years, DoD has spent more dollars on services than on supplies, equipment, and goods, which includes weapon systems and other military items. As DoD’s services acquisition volume continues to increase in scope and dollars, the agency must provide greater attention to such issues as proper acquisition planning, adequate requirements definition, sufficient price evaluation, and proper contractor oversight.

STRATEGIC PLAN TRAINING FOR ENTERPRISE INTEGRATION/TOTAL OWNERSHIP COST PROGRAM
Frank J. Barrett, Professor
Graduate School of Business and Public Policy
Sponsor: Naval Supply Systems Command

SUMMARY: Training support under Enterprise Integration/Total Ownership Cost for OPNAV N40.

THIN CLIENT COMPUTER USABILITY STUDY
Douglas E. Brinkley, Senior Lecturer
Graduate School of Business and Public Policy
Sponsor: Sun Microsystems and the Naval Postgraduate School Foundation

SUMMARY: This is a multi-year multi-phase research effort. The first phase focuses on the ability of existing software programs being used at the Naval Postgraduate School (NPS) to operate in a thin client environment. This is facilitated by setting up a small network of six thin client devices and two network servers. The second phase will add six more thin clients to the network to allow limited performance data collection. The final phase will move from the prototype environment to a full working network by replacing all of the stand-alone personal computers (PCs) in an existing computer lab with thin client devices.
GRADUATE SCHOOL OF BUSINESS AND PUBLIC POLICY

CASE STUDY: CREATION OF THE DEPARTMENT OF HOMELAND SECURITY FOCUSING ON HUMAN RESOURCE MANAGEMENT POLICY AS A CENTRAL ELEMENT IN ORGANIZATIONAL DESIGN
Douglas A. Brook, Professor
Graduate School of Business and Public Policy
Sponsor: Office of Personnel Management

SUMMARY: Prepared a case study capturing the history of the design and enactment of the Department of Homeland Security personnel management system.

Douglas A. Brook, Professor
Cindy King, Assistant Professor
Graduate School of Business and Public Policy

SUMMARY: This research produced a case study on the formulation, policies, politics, and legislative and communications strategies that resulted in enactment of the new flexible personnel management provisions in the law that created the Department of Homeland Security. It included an exhaustive review of documentary evidence and interviews with key players in the White House, Congress, Office of Personnel Management, Office of Management and Budget, labor unions, and other observers and participants.

DEFENSE MANAGEMENT REFORM AND HOMELAND SECURITY MANAGEMENT
Douglas A. Brook, Professor
Graduate School of Business and Public Policy
Sponsor: Naval Postgraduate School

OBJECTIVE: To address the initiation and continuation of two research streams. First, in collaboration with the Center for Defense Management Reform, the objective is to build a baseline of research data on the history, major themes, and outcomes of defense management reform agendas. The second stream represents a continuation of research into the enactment, design, and deployment of new personnel management systems in the Department of Homeland Security and the Department of Defense.

TRANSFORMATION IN NAVY BUSINESS MANAGEMENT
Douglas A. Brook, Professor
LtCol. Bryan A. Hudgens, USAF, Lecturer
Graduate School of Business and Public Policy
Sponsor: Chief of Naval Operations

SUMMARY: Conducted research on benchmarking best practices in transformation.

TRANSFORMATION IN NAVY BUSINESS MANAGEMENT
Douglas A. Brook, Professor
Cindy King, Assistant Professor
Graduate School of Business and Public Policy
Sponsor: Chief of Naval Operations

SUMMARY: This project was conducted in response to a request from the Office of the Deputy Chief of Naval Operations (Material Readiness and Logistics) for extended research into benchmarking best practices in transformation, specifically in the areas of organizational, management, and strategic communication.
EFFICIENT MECHANISMS FOR IMPLEMENTING PUBLIC INVESTMENT DECISIONS IN THE PRESENCE OF EXCLUDABILITY AND CONSUMPTION EXTERNALITIES
Peter J. Coughlan, Associate Professor
Graduate School of Business and Public Policy
Sponsor: Naval Postgraduate School

SUMMARY: A fundamental and long-standing question in the area of public choice concerns mechanisms for making decisions about whether or not to invest in a given public project and how to allocate the cost of the project among relevant stakeholders. Theoretical analysis of this problem in the pure public good context (no excludability, no consumption externalities) has been both broad and thorough. This research project applied economic theory to characterize optimal allocation mechanisms for the broader class of public goods that may be excludable and/or congestible (or more broadly, exhibit consumption externalities).

MECHANISM DESIGN FOR PUBLIC DECISION-MAKING
Peter J. Coughlan, Associate Professor
Graduate School of Business and Public Policy
Sponsor: Naval Postgraduate School

SUMMARY: Investigated the design of auctions and other choice mechanisms for the purpose of government and/or public decision-making in such areas as investment, procurement, and manpower management.

ANALYSIS OF DECISIONS OF FEMALE SURFACE WARFARE OFFICERS TO STAY IN THE COMMUNITY
Alice Crawford, Senior Lecturer
Graduate School of Business and Public Policy
Sponsor: Office of the Chief of Naval Operations

OBJECTIVE: To identify the reasons that female Surface Warfare Officers decide to remain past the minimum service requirement.

DEFENSE WORKING CAPITAL FUND MANAGEMENT PROCESS AND FINANCIAL MANAGEMENT REFORM EFFECTIVENESS
Richard L. Dawe, Assistant Professor
Graduate School of Business and Public Policy
Sponsor: Naval Postgraduate School

SUMMARY: This research continued in two areas. The first area was Department of Defense (DoD) and Department of the Navy Working Capital Fund management. The second area continued with transformation of the highly documented and problematic “legacy” business systems within the DoD.

THE DEVELOPMENT AND ADOPTION OF RADIO FREQUENCY IDENTIFICATION (RFID) TECHNOLOGY IN THE DEPARTMENT OF DEFENSE (DOD)
Nicholas Dew, Assistant Professor
Graduate School of Business and Public Policy
Sponsor: Naval Postgraduate School

SUMMARY: This research investigated the development and adoption processes for Radio Frequency Identification (RFID) within the Department of Defense (DoD) environment. RFID technology appears to be an increasingly important technology in the 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.

WHAT IS THE RIGHT RADIO FREQUENCY IDENTIFICATION (RFID) FOR YOUR PROCESS?
Nicholas Dew, Assistant Professor
Geraldo Ferrer, Associate Professor
Uday M. Apte, Professor
Graduate School of Business and Public Policy
Sponsor: Program Executive Office Integrated Warfare Systems

SUMMARY: Radio Frequency Identification (RFID) has found several applications in both military and civilian organizations. Several configurations are possible, and multiple new applications are envisioned in the near future. This research used case method to study several RFID applications in multiple industries and to understand how this technology can be used to strengthen the process capabilities of an organization.

GOALS AND STANDARDS FOR DEFENSE LOGISTICS AGENCY WAREHOUSE OPERATIONS
Kenneth Doerr, Associate Professor
Douglas A. Brook, Professor
Graduate School of Business and Public Policy
Sponsor: Defense Logistics Agency

SUMMARY: Conducted research in goals and standards to reduce customer lead times in outbound operations at Defense Logistics Agency warehouses.

PERFORMANCE METRICS PROJECT
Kenneth J. Euske, Professor
Mary A. Malina, Assistant Professor
Graduate School of Business and Public Policy
Sponsors: Assistant Secretary of the Navy (RDA), Program Executive Office Integrated Warfare Systems, Naval Warfare Center, Port Hueneme Division

SUMMARY: This research evaluated the current Department of the Navy procurement performance metrics being collected from the major Naval systems commands. Metrics are intended to map to the strategic themes, goals, and objectives using a balanced scorecard approach incorporating five focus areas. The goal of the current research was to analyze the validity of the 21 metrics currently being collected from the major Naval systems commands. Do the metrics align with strategy? Can the metrics be measured effectively? Are the metrics linked to value?

PERFORMANCE METRIC PROJECT
Kenneth J. Euske, Professor
Mary A. Malina, Assistant Professor
Graduate School of Business and Public Policy
Sponsor: Naval Sea Systems Command

OBJECTIVE: The Program Executive Officer for Integrated Warfare Systems is in the midst of a performance measurement project. An output of the project will be a consolidated portfolio of metrics that represents progress and performance in each of the seven major program areas. The Graduate School of
Business and Public Policy of the Naval Postgraduate School will support the project by evaluating and augmenting the substantial work that has already been performed on this project.

**PERFORMANCE METRIC PROJECT**

Kenneth J. Euske, Professor  
Mary A. Malina, Assistant Professor  
Graduate School of Business and Public Policy  
Sponsor: Naval Surface Warfare Center-Port Hueneme Division

**OBJECTIVE:** The Naval Surface Warfare Center-Port Hueneme Division (NSWC-PHD) is in the midst of a performance measurement project. An output of the project will be a consolidated portfolio of metrics that represents progress and performance for all NSWC-PHD offices and departments. The Graduate School of Business and Public Policy of the Naval Postgraduate School will support the project by evaluating and augmenting the substantial work that has already been performed on this project.

**INVENTORY MANAGEMENT AT REMANUFACTURING FACILITIES**

Geraldo Ferrer, Associate Professor  
Graduate School of Business and Public Policy  
Sponsor: Naval Postgraduate School

**OBJECTIVE:** To develop inventory policies for remanufacturing operations, and to examine how these policies might be useful to military facilities.

**INVENTORY POLICIES IN MULTI-ECHelon REMANUFACTURING SITES**

Geraldo Ferrer, Associate Professor  
Aruna Apte, Assistant Professor  
Graduate School of Business and Public Policy  
Sponsor: Naval Postgraduate School

**SUMMARY:** This research presented a two-echelon remanufacturing site subject to constant demand, where the disassembly process and the repair process observed stochastic yield. Intuitive scheduling policies were compared and their robustness in the remanufacturing environment was checked. This was done by providing a simple policy involving two variables: the lot size in the upstream operation and the echelon factor. Conditions under which the remanufacturing shop would not hold inventory between two processes were identified. Conditions under which the remanufacturing shop would avoid holding finished goods inventory were determined.

**EFFICIENCY OF ALTERNATIVE ASSIGNMENT AUCTION FORMATS**

William R. Gates, Associate Professor  
Peter J. Coughlan, Associate Professor  
Graduate School of Business and Public Policy  
Sponsor: Naval Personnel Research Studies and Technology/PERS-12
ASSESSING AND BUILDING SYSTEM-LEVEL NETWORKS IN THE PUBLIC SECTOR
Deborah E. Gibbons, Assistant Professor
Graduate School of Business and Public Policy
Sponsor: Naval Postgraduate School

SUMMARY: Assessed system-level networks among public, volunteer, and non-profit organizations, established benchmarks for effective networks, and determined cultural effects on network formation and structure.

THE ECONOMICS OF NETWORK-BASED INDUSTRIES
Nayantara Hensel, Assistant Professor
Graduate School of Business and Public Policy
Sponsor: Naval Postgraduate School

SUMMARY: Developed and estimated cost efficiency models for network-based industries and determined the type of network-specific factors that can impact the ability of a firm or network to achieve economies of scale and economics of density. Examples of network-specific factors potentially impacting the achievement of network efficiencies include the effects of government regulatory policies, the effects of firm-specific characteristics (firm size), the effects of market-specific characteristics (type of competition), the effects of the type of financial architecture linking a given network together, and the impact of various firm decisions.

ANALYSIS OF FLIGHT HOUR PROGRAM MANAGEMENT, BUDGET EXECUTION, COST-AVOIDANCE, AND FINANCIAL MANAGEMENT INITIATIVES IN COMMANDER, NAVAL AIR FORCE, U.S. PACIFIC FLEET
Lawrence R. Jones, Professor
Richard L. Dawe, Assistant Professor
Graduate School of Business and Public Policy
Sponsor: Naval Air Force U.S. Pacific Fleet

OBJECTIVE: To provide analytical assistance to the Office of the Comptroller, Commander, Naval Air Force, U.S. Pacific Fleet, in the comptroller function; and in the analysis of budget execution and other initiatives for improving command management and management control, achieving cost-reduction and avoidance in the Flight Hour Program, and accommodating budget reduction in fiscal years 2005, 2006, and beyond. In addition, the project will include analysis of improvements in management systems and systems support to provide better data to enable management of the command in conformance with sound business management principles and practices.

WAGNER CHAIR
Lawrence R. Jones, Professor
Graduate School of Business and Public Policy
Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: To further develop and enhance the relationship between the Naval Postgraduate School and COMSPAWARSYS/COM/Program Executive Officer C4I and Space in the area of Defense C4I and IT systems acquisition and management. The Chair shall act as a coordination mechanism across the NPS faculty and student body to provide research, analytical, and other services devoted to addressing and resolving C4I issues, including technical, acquisition, financial, and program management issues.
ADVISORY BOARD OF BUSINESS AND PUBLIC POLICY

ADMIRAL STANLEY R. ARTHUR CHAIR OF LOGISTICS
Keebom Kang, Associate Professor
Graduate School of Business and Public Policy
Sponsor: U.S. Transportation Command

SUMMARY: In accordance with the Memorandum of Agreement that established the Admiral Stanley R. Arthur Chair of Logistics (formerly known as the Admiral Jeremy Boorda Chair of Management and Analysis, referred to as “Chair”), this project delineates those duties, responsibilities, and appropriate deliverables associated with USTRANSCOM's funding of the Chair for fiscal year 2006. The Admiral Stanley R. Arthur Chair of Logistics was established in 2003 and now serves as the advising Chair for the three logistics management curricula in which USTRANSCOM's primary interests lie.

EXPLORING RELATIONSHIP BETWEEN LANGUAGE, PERCEPTION, AND PERSUASION
Cynthia L. King, Assistant Professor
Graduate School of Business and Public Policy
Sponsor: Naval Postgraduate School

OBJECTIVE: To investigate two cases in which communicative events are explored in order to examine the relationship between language and perception. The objective of the study is to make explicit, through empirically-based discourse analysis, the perspective of participants in cases where misunderstanding appears to have occurred.

RESEARCH ON RETURN ON INVESTMENT TO IMMEDIATE GRADUATE EDUCATION PROGRAMS
Stephen L. Mehay, Professor
Graduate School of Business and Public Policy
Sponsor: Office of the Chief of Naval Personnel

OBJECTIVE: To apply accepted economic principles, statistical techniques, and methods of cost-benefit analysis to assess the return of investment (ROI) for immediate graduate education programs, and to assess the relative ROI on programs that deliver graduate education immediately versus programs that deliver advanced education later in an officer's career.

RETURN ON INVESTMENT ON IMMEDIATE GRADUATE EDUCATION PROGRAM
Stephen L. Mehay, Professor
Graduate School of Business and Public Policy
Sponsor: Chief of Naval Operations, N14

SUMMARY: Return on investment on immediate graduate education programs.

THESIS DAY TRAVEL
Stephen L. Mehay, Professor
Graduate School of Business and Public Policy
Sponsor: Office of Naval Operations

OBJECTIVE: To support research by faculty and students in the MSA curriculum who support the research objectives of the Chief of Naval Personnel and the N-1 (SPA) organization. In particular, these funds will support the presentation of student thesis research results at the annual “Thesis Day” in Washington, D.C., and Millington, Tennessee. The funds will be used to support travel for six student presenters and at least two faculty to travel to Washington, D.C., and Millington, Tennessee.
WORKFORCE AGING AND RETENTION MODEL
Stephen L. Mehay, Professor
Graduate School of Business and Public Policy
Sponsor: Naval Sea Logistics Center Detachment, Fairfield

SUMMARY: The area of workforce planning in which NLSCPAC currently needs analytical support is in prediction of changes in workforce size due to separation and retirement. An aging workforce presents serious challenges to the Department of Defense. When government workers retire, important and sometimes critical information and expertise can be lost. Forecasting and formulating policies to deal with the resulting workforce gaps require a set of analyses and models to assist manpower planners and managers. To begin to answer these questions, a workforce aging model was developed that will predict the probabilities of retirement and separation for current civilian Navy and Army employees. The data and models produced by this research will be input to the Navy and Army workforce planning system.

ETHICS IN ACTION: PREPARING NAVY SUPPLY CORPS OFFICERS FOR EXERCISING MORAL COURAGE ASSESSMENT AND BEST PRACTICES STUDY PHASE I-III
Leslie E. Sekerka, Assistant Professor
Graduate School of Business and Public Policy
Sponsor: Naval Supply Systems Command

OBJECTIVE: To conduct additional education and research to edify ethical behavior in the military workplace, amplifying current efforts for sponsored efforts with the USNSC.

EFFECT OF ORGANIZATIONAL AND MARKET CHANGES ON HOSPITAL BEHAVIOR
Yu-Chu Shen, Assistant Professor
Graduate School of Business and Public Policy
Sponsor: Naval Postgraduate School

SUMMARY: The U.S. health care system has undergone significant structural change over the past decade, including changes in hospital ownership, formation of large hospital systems and large medical groups, and an overall increased concentration in many sectors. Although each merger and for-profit acquisition drew a lot of media attention, there is very little empirical evidence on how these organizational changes affect provider behavior, especially among the Veterans Affairs (VA) hospitals. This research investigated the effects of hospital mergers on provider behavior; the effects of for-profit health plan expansions on hospital performance; and the issue of whether VA hospitals respond differently to market changes than general hospitals.
CHAIR OF ACQUISITION AND ACQUISITION RESEARCH
Keith F. Snider, Associate Professor
Graduate School of Business and Public Policy
Sponsor: Deputy Assistant Secretary of the Navy

OBJECTIVE: To determine the extent to which Department of Defense (DoD) activities are capitalizing on the legislative provisions of FARA, FASA, and SARA; and to make specific recommendations for improving the full utilization of the commercial item designation provisions. This objective is critical to contracting and acquisition commands (as well as those they support) to achieve reduced acquisition lead times, reduce transactional costs, and generally, garner efficiencies and effectiveness not possible without the legislative provisions. The research would provide an overview of the legislation; investigate current business practices within the DoD related to the legislative provisions; analyze and determine the extent to which the DoD is capitalizing on the provisions; and make specific recommendations for better utilizing the legislation to the benefit of the DoD.

CHAIR OF ACQUISITION AND ACQUISITION RESEARCH PROGRAM
Keith F. Snider, Associate Professor
Graduate School of Business and Public Policy
Sponsor: Marine Corps Systems Command-PM (ICE)

OBJECTIVE: To perform studies and analyses in acquisition topics of immediate concern to PM ICE through the acquisition research program, as well as to stimulate and supervise studies and analyses conducted by Naval Postgraduate School faculty and students. Proposal topics will be agreed upon by the sponsor and the Acquisition Research Chair.

CHAIR OF ACQUISITION MANAGEMENT AND ACQUISITION PROGRAM
Keith F. Snider, Associate Professor
Graduate School of Business and Public Policy
Sponsor: Program Executive Officer for Littoral/Mine Warfare

OBJECTIVE: Pursuant to the proposed Memorandum of Understanding between Program Executive Officer (PEO) for Littoral/Mine Warfare and the Naval Postgraduate School (NPS) President, NPS proposes to perform studies and analyses in acquisition topics of immediate concern to the PEO, as well as to stimulate and supervise studies and analyses conducted by NPS faculty and students. Proposed topics will be agreed upon by the sponsor and the Acquisition Research Chair.

CHAIR OF ACQUISITION MANAGEMENT AND ACQUISITION RESEARCH
Keith F. Snider, Associate Professor
Graduate School of Business and Public Policy
Sponsor: Naval Sea Systems Command

OBJECTIVE: Pursuant to the Memorandum of Understanding between Commander, Naval Sea Systems Command, and the Naval Postgraduate School (NPS) Superintendent, dated 18 July 2003, NPS proposes to perform studies and analysis in acquisition topics of immediate concern to the Commander, as well as to stimulate and supervise studies and analyses conducted by NPS faculty and students. Proposed topics include studies related to performance-based logistics, ramifications of spiral development on weapon systems total ownership cost, and case(s) of successful total ownership cost reduction efforts.
OBJECTIVE: Pursuant to the Memorandum of Understanding between Program Executive Officer (PEO) for Integrated Warfare Systems (IWS) and the Naval Postgraduate School (NPS) Superintendent, dated 11 June 2003, NPS proposes to perform studies and analyses in acquisition topics of immediate concern to the PEO, as well as to stimulate and supervise studies and analyses conducted by NPS faculty and students. This proposal is an addendum to the fiscal year 2005 PEO IWS proposal of 1 October 2004, and amplifies on the open architecture research to be accomplished thereunder.

SUMMARY: The Chair of Acquisition Management is responsible for executing the functions set forth in the Memorandum of Understanding.

OBJECTIVE: Pursuant to the Memorandum of Understanding between Program Executive Officer (PEO) Ships and the Naval Postgraduate School (NPS) Superintendent, dated 22 April 2004, NPS proposes to perform studies and analysis on acquisition topics of immediate concern to the PEO, as well as to stimulate and supervise studies and analyses conducted by NPS faculty and students.

OBJECTIVE: To establish accounts and procedures for the development, delivery, and maintenance of the annual Acquisition Research Symposium of the Naval Postgraduate School, to support revenues and expenses.

OBJECTIVE: Changing major acquisition organization to adopt the best loci of knowledge, responsibilities, and decision rights/collaboration readiness assessment.
TERMINATION LIABILITY RESEARCH THROUGH ACQUISITION RESEARCH PROGRAM
Keith F. Snider, Associate Professor
Graduate School of Business and Public Policy
Sponsor: Office of Under Secretary of Defense (AT&L)

OBJECTIVE: To perform termination liability research through the acquisition research program at the Graduate School of Business and Public Policy.

Nicole Thibodeau, Assistant Professor
Graduate School of Business and Public Policy
Sponsor: Naval Postgraduate School

SUMMARY: Studied the relationship between organizational architecture (performance measurement, performance incentives, and decision rights) and performance in government through the Veterans' Hospital system and an extension to the Department of Defense.

DEVELOP TECHNOLOGY AND SOFTWARE ON A MODULE BASIS FOR BUILDING THE RAPID-ORDERING SYSTEM AND ASSOCIATED TECHNOLOGIES
Ron Tudor, Lecturer
Graduate School of Business and Public Policy
Sponsors: United States Military Academy
     Marine Corps Systems Command

OBJECTIVE: To develop technology and software on a module basis for building the rapid-ordering system and other associated technologies; to create data-access layers, TUIs, etc., and testing. NPS will research and develop modular technology for the ROS and create data-assess layers, a task-oriented user interface, data-object models, directory subsyst4ms, and digital-asset structures and provide all testing.

KANSAS CITY DISTRICT INTEGRATION
Ron Tudor, Lecturer
Graduate School of Business and Public Policy
Sponsor: Marine Corps Systems Command

SUMMARY: The Naval Postgraduate School (NPS) is researching and developing a Rapid Ordering System (ROS) for the Kansas City District (KCD), Army Corps of Engineers. NPS will research and develop a user interface for the PM to access the KCD ROS. The ROS is controlled by the KCD and under the operational restrictions and conditions as imposed by the Federal Acquisition Regulation, the Defense Federal Acquisition Regulation Supplement, and the KCD Chief of Contracting.

RAPID EQUIPPING FORCE
Ron Tudor, Lecturer
Graduate School of Business and Public Policy
Sponsor: TRADOC Analysis Center-Monterey

OBJECTIVE: To develop and demonstrate a methodology for rapidly analyzing a wide spectrum of potential products from a value analysis perspective, to be utilized by the Army Rapid Equipping Force office.
OBJECTIVE: To identify state-of-the-art commercial processes in the commercial internet world, and to adapt and develop methods by which the Department of Defense and the federal government can incorporate these efficiencies to transform current ordering, billing, and disposal systems.
GRADUATE SCHOOL OF BUSINESS AND PUBLIC POLICY

2006
Faculty Publications and Presentations
PUBLICATIONS


CONFERENCE PUBLICATIONS


TECHNICAL REPORT


MISCELLANEOUS

INSTITUTES AND CENTERS

THE CEBROWSKI INSTITUTE FOR INFORMATION INNOVATION AND SUPERIORITY

WAYNE E. MEYER INSTITUTE OF SYSTEMS ENGINEERING

MOVES INSTITUTE (MODELING, VIRTUAL ENVIRONMENTS AND SIMULATION)

CENTER FOR INTERDISCIPLINARY REMOTELY PILOTED AIRCRAFT STUDIES

CENTER FOR DEFENSE TECHNOLOGY AND EDUCATION FOR THE MILITARY SERVICES
THE CEBROWSKI INSTITUTE
FOR INFORMATION INNOVATION
AND SUPERIORITY

PETER J. DENNING
DIRECTOR
OVERVIEW:

The Cebrowski Institute for Innovation and Information Superiority sponsors cross-discipline investigations into ways that information processes and technologies, organizational development, and personal skills can strengthen stability, transition operations, crisis response, warfighting, and defense in support of national and global security.

Areas of focus include hastily formed networks, indicators of impending crisis, architectures for network centric operations, World Wide Consortium for the Grid (W2COG), mobile devices and communications, information operations, counterterrorism and irregular warfare, energy and sustainability, information assurance and security, and innovation process.

CURRICULA SERVED:

The Institute operates as a federation of research centers and projects, serving a broad community of students and faculty. The Institute does not manage its own curriculum.

RESEARCH:

The Cebrowski Institute's annual theme projects create focal points for faculty from diverse academic areas to connect and share related research. These theme projects are selected as reflections of issues relevant to national security, with both technical and social dimensions. Around these themes, the Cebrowski Institute organizes research symposia, hosts visiting speakers and collaborators, and facilitates a brown bag lunch series, all of which serve as hubs for our cross-discipline studies.

In 2005, the Cebrowski Institute's theme project was W2COG. This research initiative established a consortium to accelerate DoD's Global Information Grid (GIG) development. Researchers explored the world of “open” e-business and the world wide web, and applied appropriate lessons to the GIG. W2COG delivered successful process pilots for:

- Rapid, low cost, objective, expert, industry analysis of net-ready issues Community of Practice (COP) for “semantic data strategy.”
- Rapid demonstration, validation, and fielding of bundled interoperable “net-ready” components designed for the “edge-of-the-GIG” network. These pilots, performed by the members of the functioning consortium, proved the hypothesis that an “open” e-business approach enacted by motivated government, academia, and industry partners can find paths to GIG functionality.

The Cebrowski Institute's 2006-2007 theme project, Hastily Formed Networks (HFN), was created during the fall of 2005. The HFN project helps to understand DoD's emerging, non-traditional new work, whether in stability operations environments, like Iraq; or in humanitarian assistance and disaster relief work, such as the Indonesian Tsunami, Hurricane Katrina, or the Pakistani earthquake; or during the response efforts that occurred during and after 9/11. This project specifically addresses our overall understanding of this critical area, most notably at the intersection of social organization, and technical aspects of networking.

CENTERS AND PROJECTS:

- Center for Excellence in Information Operations
- Center for Information Security Research
- Center for Mobile Devices and Communications
- Center for Terrorism and Irregular Warfare
- Cryptologic Research Center
- Hastily Formed Networks Project (Humanitarian Assistance and Disaster Relief; Improvisation; Operational Analyses; Real Options; Swift Trust)
- Autonomous Coordination Lab
RESEARCH PROGRAM (Research and Academic)-FY2006:

The Naval Postgraduate School's sponsored program exceeded $81 million in FY2006. Sponsored programs include both research and educational activities funded from an external source. A profile of the sponsored program for the Cebrowski Institute is provided below.

Size of Program: $779K
Denning, Peter J.  
Director and Professor  
831-656-3603  
pjd@nps.edu

Higgins, Susan  
Deputy Director and Lecturer  
831-656-3596  
shiggins@nps.edu

**Executive Committee**

Boger, Dan  
Dean of Research and Professor  
831-656-3671 or 3411  
dboger@nps.edu

Hayes-Roth, Rick  
Professor  
831-656-3983  
fahayesr@nps.edu

Steckler, Brian D.  
Lecturer  
831-656-3837  
steckler@nps.edu

Brutzman, Don  
Associate Professor  
831-656-2149  
brutzman@nps.edu

Hughes, Wayne  
Professor  
831-656-2484  
whughes@nps.edu

**Affiliated Center and Research Project Directors**

Arquilla, John  
Professor  
831-656-3450  
jarquilla@nps.edu

Irvine, Cynthia  
Professor  
831-656-2461  
irvine@nps.edu

Singh, Gurminder  
Professor  
831-656-3041  
gsingh@nps.edu

Barrett, Frank  
Professor  
831-656-2328  
fbarrett@nps.edu

Martell, Craig  
Assistant Professor  
831-656-2110  
smartell@nps.edu

Steckler, Brian D.  
Lecturer  
831-656-3837  
steckler@nps.edu

Gaver, Don  
Distinguished Professor  
831-656-2605  
dgaver@nps.edu

Robertson, R. Clark  
Professor  
831-656-2383  
crobertson@nps.edu

Tucker, David  
Associate Professor  
831-656-3754  
dctucker@nps.edu

Gunderson, Chris  
Research Associate Professor  
831-224-5182  
cgunderson@nps.edu

Robinson, Glenn E.  
Associate Professor  
831-656-2710  
grobinson@nps.edu
<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baer, Wolfgang</td>
<td>Research Associate Professor</td>
<td><a href="mailto:baer@nps.edu">baer@nps.edu</a></td>
</tr>
<tr>
<td>Bergman, Mark</td>
<td>Assistant Professor</td>
<td><a href="mailto:mbergman@nps.edu">mbergman@nps.edu</a></td>
</tr>
<tr>
<td>Bordetsky, Alexander</td>
<td>Associate Professor</td>
<td><a href="mailto:abordets@nps.edu">abordets@nps.edu</a></td>
</tr>
<tr>
<td>Budden, Nancy Ann</td>
<td>Director for Defense Counter Terrorism Technology</td>
<td><a href="mailto:nbudden@nps.edu">nbudden@nps.edu</a></td>
</tr>
<tr>
<td>Buddenberg, Rex A.</td>
<td>Senior Lecturer</td>
<td><a href="mailto:buddenberg@nps.edu">buddenberg@nps.edu</a></td>
</tr>
<tr>
<td>Burke, Karen</td>
<td>Research Associate Professor</td>
<td><a href="mailto:klburke@nps.edu">klburke@nps.edu</a></td>
</tr>
<tr>
<td>Das, Arijit</td>
<td>Research Associate</td>
<td><a href="mailto:adas@nps.edu">adas@nps.edu</a></td>
</tr>
<tr>
<td>Denning, Dorothy</td>
<td>Professor</td>
<td><a href="mailto:dedennin@nps.edu">dedennin@nps.edu</a></td>
</tr>
<tr>
<td>Dinolt, George W.</td>
<td>Associate Professor</td>
<td><a href="mailto:gwdinolt@nps.edu">gwdinolt@nps.edu</a></td>
</tr>
<tr>
<td>Gallup, Shelley</td>
<td>Research Associate Professor</td>
<td><a href="mailto:gpgallup@nps.edu">gpgallup@nps.edu</a></td>
</tr>
<tr>
<td>Giob, John</td>
<td>Research Associate</td>
<td><a href="mailto:jhgiobson@nps.edu">jhgiobson@nps.edu</a></td>
</tr>
<tr>
<td>Hatch, William</td>
<td>Lecturer</td>
<td><a href="mailto:whatch@nps.edu">whatch@nps.edu</a></td>
</tr>
<tr>
<td>Hocevar, Susan</td>
<td>Associate Professor</td>
<td><a href="mailto:shocevar@nps.edu">shocevar@nps.edu</a></td>
</tr>
<tr>
<td>Housei, Thomas J.</td>
<td>Professor</td>
<td><a href="mailto:tjhousei@nps.edu">tjhousei@nps.edu</a></td>
</tr>
<tr>
<td>Jacobs, Patricia</td>
<td>Professor</td>
<td><a href="mailto:pjacobs@nps.edu">pjacobs@nps.edu</a></td>
</tr>
<tr>
<td>Jones, Carl</td>
<td>Professor Emeritus</td>
<td><a href="mailto:crijones@nps.edu">crijones@nps.edu</a></td>
</tr>
<tr>
<td>Kress, Moshe</td>
<td>Professor</td>
<td><a href="mailto:mkress@nps.edu">mkress@nps.edu</a></td>
</tr>
<tr>
<td>Marvel, Orin E.</td>
<td>Visiting Associate Professor</td>
<td><a href="mailto:omarvel@nps.edu">omarvel@nps.edu</a></td>
</tr>
<tr>
<td>McGregor, Don</td>
<td>Research Associate</td>
<td><a href="mailto:mcgregor@nps.edu">mcgregor@nps.edu</a></td>
</tr>
<tr>
<td>Mcgregor, Don</td>
<td>Research Associate</td>
<td><a href="mailto:mcgreged@nps.edu">mcgreged@nps.edu</a></td>
</tr>
<tr>
<td>Nissen, Mark E.</td>
<td>Assistant Professor</td>
<td><a href="mailto:mnissen@nps.edu">mnissen@nps.edu</a></td>
</tr>
<tr>
<td>Pilnick, Steve</td>
<td>Research Associate Professor</td>
<td><a href="mailto:spilnick@nps.edu">spilnick@nps.edu</a></td>
</tr>
<tr>
<td>Roberts, Nancy C.</td>
<td>Professor</td>
<td><a href="mailto:nroberts@nps.edu">nroberts@nps.edu</a></td>
</tr>
<tr>
<td>Rowe, Neil C.</td>
<td>Assistant Professor</td>
<td><a href="mailto:ncrwwe@nps.edu">ncrwwe@nps.edu</a></td>
</tr>
<tr>
<td>Su, Wen</td>
<td>Assistant Professor</td>
<td><a href="mailto:wsu@nps.edu">wsu@nps.edu</a></td>
</tr>
<tr>
<td>Szechto, Roberto</td>
<td>Assistant Professor</td>
<td><a href="mailto:rszechto@nps.edu">rszechto@nps.edu</a></td>
</tr>
<tr>
<td>Volpano, Dennis</td>
<td>Associate Professor</td>
<td><a href="mailto:volpano@nps.edu">volpano@nps.edu</a></td>
</tr>
<tr>
<td>Xie, Geoffrey</td>
<td>Professor</td>
<td><a href="mailto:xie@nps.edu">xie@nps.edu</a></td>
</tr>
<tr>
<td>Zolin, Roxanne</td>
<td>Assistant Professor</td>
<td><a href="mailto:ryzolin@nps.edu">ryzolin@nps.edu</a></td>
</tr>
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CONSORTIUM FOR THE GRID
Peter J. Denning, Professor
Christopher Gunderson, Research Associate Professor
Department of Information Sciences
Cebrowski Institute for Innovation and Information Superiority
Sponsor: Office of the Assistant Secretary of Defense

SUMMARY: The Consortium for the Grid (COG) is a consortium of government, industry, and academic engineers working on the continuing goal of advancing networking technology to support the Global Information Grid. The COG aims to accelerate systems interoperability agreements between units and agencies in a highly complex environment where technical guidance can never be complete, there is no central authority, and both technology and situation are constantly changing.

SUPPORT FOR INSTITUTE DIRECTOR
Peter J. Denning, Professor
Department of Information Sciences
Cebrowski Institute for Innovation and Information Superiority
Sponsor: Naval Postgraduate School

JOINT INTEROPERABILITY TEST COMMAND NETCENTRIC CERTIFICATION OFFICE
Christopher Gunderson, Research Associate Professor
Department of Information Sciences
Cebrowski Institute for Innovation and Information Superiority
Sponsor: Defense Information Systems Agency

SUMMARY: The Naval Postgraduate School (NPS) Cebrowski Institute leveraged lessons learned in its World Wide Consortium for the Grid (W2COG) research initiative and applied expertise resident among NPS faculty and students to assist JITC create the Netcentric Certification Office, and thereby accelerate incremental fielding of NCES and JC2.

ENERGY CONSENSUS COMMUNITY WEBSITE
Susan Higgins, Deputy Director and Lecturer
Department of Information Sciences
Cebrowski Institute for Innovation and Information Superiority
Sponsor: Office of Force Transformation

SUMMARY: The Naval Postgraduate School developed an online community environment (website) that fosters information sharing on the topic of energy and sustainability across Department of Defense (DoD) organizations. The site created a key hub for exploring, learning, and sharing about energy and sustainability issues in the DoD, with the underlying assumption that energy is a national security imperative. The site showcases existing “energy-smart” efforts in the DoD. It provides a resource for decision makers in the DoD to make sense of complex energy issues. The site will serve as a learning resource - helping increase the learning rates of DoD members on this important topic by creating connections among people via emerging collaboration technologies.
TRANFORMATION CHAIR AT THE NAVAL POSTGRADUATE SCHOOL
Susan Higgins, Deputy Director and Lecturer
Department of Information Sciences
Cebrowski Institute for Innovation and Information Superiority
Sponsor: Office of Force Transformation

SUMMARY: Established the Naval Postgraduate School Transformation Chair and defined the terms of the selection, activities, and support of the Chair.

SYSTEM DYNAMICS/REAL OPTIONS ANALYSIS OF THE GLOBAL EARTH OBSERVATION SYSTEM OF SYSTEMS
Thomas J. Housel, Professor
Department of Information Sciences
Cebrowski Institute for Innovation and Information Superiority
Sponsor: Boeing

SUMMARY: A Global Earth Observation System of Systems case study was written describing the extent to which a system dynamics/real options integrated analysis approach demonstrated innovative advancements in valuing real options. Further, generalization of this initial work was explored.
THE CEBROWSKI INSTITUTE
FOR INFORMATION INNOVATION
AND SUPERIORITY

2006
Faculty Publications
and Presentations

WAYNE E. MEYER INSTITUTE
OF SYSTEMS ENGINEERING
(MISE)

FRANK SHOUP
DIRECTOR
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, systems analysis, technology, and joint professional education.

A major feature of the institute’s program of studies is capstone projects, which replace the usual individual theses. The capstone projects are large studies addressing issues of significant Navy, joint, and national interest, conducted by groups of students from all services, civilians, and many foreign national officers. Capstone projects completed in 2006 include:

- **Maritime Threat Response** – Examined the response options potentially available in a variety of maritime threat scenarios.
- **Joint Battle Management Command and Control** - A joint project with the Air Force Institute of Technology and sponsored by JFCOM. This project addressed joint close air support, time sensitive targeting, and joint fires aspects of JBMC2.
- **Shipboard Theater Ballistic Missile Defense** – Addressed the potential roles and capabilities of future seaborne theater ballistic missile defense systems.
- **Riverine Warfare** – Addressed the requirements and capabilities necessary for the execution of the riverine warfare missions of the newly created Navy Expeditionary Warfare Command. This project focused on new technology sensors, unmanned vehicles, and weapons.
- **Joint Fires** – A study conducted in collaboration with the Air Force Institute of Technology. This project addressed emerging concepts and organizations for reconnaissance, surveillance, target identification, and weapons assignment from all sources of fire support.

The research program currently conducted in the Meyer Institute includes a series of projects related to maritime security in its broadest sense, focusing on systems concepts and concepts of operations for maritime defense. These are sponsored by the Office of the Secretary of Defense (HD) as a continuing program funded at $6.2M over the FYDP.

Other reimbursable research projects include a digital array radar design project for ballistic missile defense (sponsored by the Missile Defense Agency), and a rapid-response, command-and-control project (sponsored by Joint Forces Command).

CURRICULA SERVED:

The Systems Engineering and Analysis curriculum does not have a dedicated faculty, but rather draws on the teaching resources of other curricula.

RESEARCH THRUSTS:

- Maritime Security
- Joint Battle Management C2
- Undersea Warfare
- Mine Warfare
RESEARCH CHAIRS:

- Military Chair of Undersea Warfare
- Military Chair of Mine Warfare

RESEARCH FACILITIES:

- Three integrated student design labs

RESEARCH PROGRAM (Research and Academic):

The sponsored research programs for the Wayne E. Meyer Institute Systems Engineering are:

- OSD-sponsored Maritime Domain Awareness $6.2M over the FYDP
- Undersea Warfare $250K
- Mine Warfare $250K
- Low Energy Nuclear Reactions $190K

RESEARCH PROGRAM (Research and Academic)-FY2006:

The Naval Postgraduate School’s sponsored program exceeded $81 million in FY2006. Sponsored programs include both research and educational activities funded from an external source. A profile of the sponsored program for the Wayne E. Meyer Institute of Systems Engineering is provided below.

Size of Program: $10.9M
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<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Phone</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoup, Frank</td>
<td>Director</td>
<td>656-7639</td>
<td><a href="mailto:feshoup@nps.edu">feshoup@nps.edu</a></td>
</tr>
<tr>
<td>Ehlert, James F.</td>
<td>Associate Director for Education</td>
<td></td>
<td><a href="mailto:sfk@nps.edu">sfk@nps.edu</a></td>
</tr>
<tr>
<td></td>
<td>Vacant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fisher, Ed</td>
<td>Senior Lecturer</td>
<td>656-3000</td>
<td><a href="mailto:elfisher@nps.edu">elfisher@nps.edu</a></td>
</tr>
<tr>
<td>King, Sharon</td>
<td>Executive Assistant</td>
<td>656-7847</td>
<td><a href="mailto:sfking@nps.edu">sfking@nps.edu</a></td>
</tr>
<tr>
<td>Hoang, Trinh</td>
<td>Program Manager</td>
<td>656-2545</td>
<td><a href="mailto:hoa@nps.edu">hoa@nps.edu</a></td>
</tr>
<tr>
<td>Melich, Michael E.</td>
<td>Research Professor</td>
<td>656-3776</td>
<td><a href="mailto:mmelich@nps.edu">mmelich@nps.edu</a></td>
</tr>
<tr>
<td>Johnson, Rodney W.</td>
<td>Visiting Professor</td>
<td>656-7959</td>
<td><a href="mailto:rwjonso@nps.edu">rwjonso@nps.edu</a></td>
</tr>
<tr>
<td>Philbin, Paula</td>
<td>Senior Lecturer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Williams, Rick</td>
<td>RADM, USN (Ret.)</td>
<td>656-7702</td>
<td><a href="mailto:rdwilla@nps.edu">rdwilla@nps.edu</a></td>
</tr>
<tr>
<td>Jones, Raymond</td>
<td>RADM, USN (Ret.)</td>
<td>656-2488</td>
<td><a href="mailto:rjones@nps.edu">rjones@nps.edu</a></td>
</tr>
<tr>
<td>Pierce, Terry</td>
<td>Research Associate Professor</td>
<td></td>
<td><a href="mailto:tcpierce@nps.edu">tcpierce@nps.edu</a></td>
</tr>
<tr>
<td></td>
<td>Vacant</td>
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DEVELOPMENT AND VERIFICATION OF THE NAVY'S 3D MINE IMPACT BURIAL PREDICTION MODEL (IMPACT35)
Peter C. Chu, Professor
Department of Oceanography
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Office of Naval Research

SUMMARY: With Office of Naval Research support, a 3D hydrodynamic model (IMPACT35) was developed to replace the existing model (IMPACT28) to predict the mine impact burial.

LITTORAL OCEANOGRAPHY FOR MINE WARFARE
Peter C. Chu, Professor
Department of Oceanography
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Naval Oceanographic Office

OBJECTIVE: This is a continuation of the long-term effort of the Principal Investigator and his students (Naval officers) on the oceanographic effect on mine warfare. The proposal includes three elements: 1) development of the Navy's 3D Impact Burial Prediction Model (IMPACT35), 2) investigation of the effects of the mephitic layer on mine acoustic detection, and 3) littoral ocean modeling for mine warfare. Five Naval Postgraduate School students will be working on these elements for their Master of Science degree, and will be co-supervised by Naval Oceanographic Office scientists (Steve Haeger, Peter Fleischer, and Mel Wagstaff) and Peter C. Chu at the Naval Postgraduate School. Such an effort enhances both operations and education in the Navy.

OCEANOGRAPHY FOR CAMPAIGN ANALYSIS ON UNDERSEA WARFARE
Peter C. Chu, Professor
Department of Oceanography
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Naval Oceanographic Office

SUMMARY: This is a multi-year effort of the Peter C. Chu, the Principal Investigator, and his students, U.S. Naval officers, to determine the impact of environmental data and ocean model products on Navy systems and missions for Naval Undersea Warfare, Naval Special Warfare, and Expeditionary Warfare. Future decisions to fund the development of new or upgraded capabilities will depend on the outcome of such analyses.

SATELLITE ALTIMETRY DATA ANALYSIS FOR NAVAL WARFARE
Peter C. Chu, Professor
Department of Oceanography
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Space and Naval Warfare Systems Command

SAFETY AND RISK-INFORMED DECISION-MAKING
Carson Eoyang, Professor Emeritus
Wayne E. Meyer Institute of Systems Engineering
Sponsor: National Aeronautics and Space Administration

SUMMARY: The planned workshop on safety and risk-informed decision making represents collaboration between the Naval Postgraduate School (NPS) and the National Aeronautics and Space Administration (NASA). The workshop material was prepared especially for NASA management, including program and project managers, and was presented by safety experts in the field. The workshop presentations were
structured to promote an effective safety culture, integration of safety and decision processes, and implementation of a risk-informed decision-making framework.

CRITICAL EXPERIMENTS IN CONDENSED MATTER NUCLEAR SCIENCE, PHASE 1: DESIGN AND PLAN
Michael E. Melich, Research Professor
Rodney W. Johnson, Visiting Professor
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Defense Threat Reduction Agency

SUMMARY: The existence of effects of the condensed matter state on the state of nuclei has been established in a continuing series of experiments begun nearly 20 years ago.

TECHNOLOGICAL SURPRISE IN NUCLEAR PHYSICS: AN ANALYSIS OF CERTAIN EXPERIMENTAL RESULTS
Michael E. Melich, Research Professor
Rodney W. Johnson, Visiting Professor
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Office of the Secretary of Defense

SUMMARY: Using the extraordinarily accurate results of previous OSD/NA-sponsored measurements at NRL and a subset of the collection of other quality experimental results on Low Energy Nuclear Reactions (LENR), the methods developed by E.T. Jaynes in “Theory of Probability: The Logic of Science,” were used to estimate the probability of technological surprise in nuclear physics. These estimates were used to analyze the question: Is continuing concern by Department of Defense warranted?

UNCONVENTIONAL WEAPONS OF MASS DESTRUCTION: DETAILED INVESTIGATION OF NOVEL NUCLEAR PHYSICS AND ITS IMPLICATIONS. PROJECT NUMONKI II - 2005
Michael E. Melich, Research Professor
Wayne E. Meyer Institute of Systems Engineering
Robert C. Harney, Associate Professor
Department of Systems Engineering
Sponsor: Defense Advanced Research Projects Agency

SUMMARY: Continued measurements and analyses of novel methods and nuclear effects begun under Defense Advanced Research Projects Agency-sponsored Project Numonki I.

NAVY SHIP DESIGN
Fotis A. Papoulias, Associate Professor
Department of Mechanical and Astronautical Engineering
Sponsor: Northrop Grumman Ship Systems, Inc.

DEPLOYABLE JOINT COMMAND CONTROL
Frank Shoup, Director
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Naval Surface Warfare Center-Panama City

SUMMARY: The SEA-9 Rapid Response Command and Control team developed and analyzed architectures for a rapidly-deployable command and control system to provide Regional Combatant Commanders with initial situational awareness and communication capabilities. This analysis will be
provided to the Deployable Joint Command and Control Joint Program Office to aid in the development of a Rapid Response Kit.

NAVAL POSTGRADUATE SCHOOL CHAIR OF MINE WARFARE PROGRAM
Frank Shoup, Director
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Program Executive Officer for Littoral/Mine Warfare

SUMMARY: The Chair of Mine Warfare was established in 1996 with a Memorandum of Understanding between the Director, Expeditionary Warfare, on the Chief of Naval Operations’ staff, the Program Executive Office for Mine Warfare, and the Naval Postgraduate School (NPS). The Chair is intended to enhance the academic and research content in several curricula with mine warfare-related materials, and to establish NPS as a major center for instruction, research, and analysis in mine warfare subjects. To that end, the Chair serves on the Undersea Warfare Academic Committee and as the Assistant Director, NPS Undersea Warfare Research Center. Both functions are under the NPS Wayne E. Meyer Institute of Systems Engineering. Parties to the Chair of Mine Warfare MOU agreed that the position be established on a continuing basis to support mine warfare acquisition and life cycle management.

NAVAL POSTGRADUATE SCHOOL CHAIR OF UNDERSEA WARFARE PROGRAM
Frank Shoup, Director
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Naval Undersea Warfare Center-Newport Division

SUMMARY: The Chair of Undersea Warfare was established with a Memorandum of Understanding between the President of the Naval Postgraduate School (NPS) and the Naval Undersea Warfare Center commander. The chair program is intended to enhance the academic and research content in several curricula with undersea warfare-related material, and to establish NPS as a major center for instruction, research, and analysis in undersea warfare subjects. To that end, the chairman serves as the director of the Naval Postgraduate School’s Undersea-Warfare Research Center under the Wayne E. Meyer Institute of Systems Engineering. The position is established on a continuing basis to support undersea warfare acquisition and life cycle management.

RED TEAM SUPPORT FOR MARITIME SECURITY OPERATIONS
Frank Shoup, Director
Wayne E. Meyer Institute of Systems Engineering
CAPT Jeffrey E. Kline, USN (Ret.), Senior Lecturer
Department of Operations Research
Sponsor: Office of the Under Secretary of Defense

OBJECTIVE: To conduct research based on unclassified sources to explore a potential course of action available to terrorists for attacking U.S. Navy ships in foreign ports. The payoff will be a series of maritime vulnerability assessments derived from unclassified sources available to terrorist cells. Products were evaluated through wargames manned by Naval Postgraduate School Red Teams operating against experienced fleet AT/AP planners.
WAYNE E. MEYER INSTITUTE
OF SYSTEMS ENGINEERING
(MISE)

2006
Faculty Publications
and Presentations


NPS Red Cell
THE MOVES INSTITUTE
(MODELING, VIRTUAL
ENVIRONMENTS, AND
SIMULATION)

RUDOLPH P. DARKEN
DIRECTOR
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 C. Chu, Research Assistant Professor Michael Capps, and Associate Professor Donald P. 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 E. Irvine

- Communications/Networks:
  Assistant Professor Geoffrey Xie and Professor Nancy Roberts

RESEARCH THRUSTS:

3D VISUAL SIMULATION


- **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.

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.
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

- **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)-FY2006:

The Naval Postgraduate School’s sponsored program exceeded $81 million in FY2006. 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: $3.2M**
Darken, Rudolph P.
Chairman
656-4072
darken@nps.edu

Baer, Wolfgang
Research Associate
656-2209
baer@nps.edu

Chu, Peter
Professor
656-3688
pcchu@nps.edu

Kolsch, Matthias
Assistant Professor
656-3402
mnkolsch@nps.edu

Becker, Bill
Research Faculty
656-3963
wibecher@nps.edu

Ciavarelli, Tony
Research Professor
656-1073
aciavarelli@nps.edu

Kress, Moshe
Professor
656-3927
mkress@nps.edu

Blais, Curtis L.
Research Associate
656-2488
cblais@nps.edu

Falby, John
Senior Lecturer
656-3390
falby@nps.edu

Lewis, Ted
Professor
656-2830
tlewis@nps.edu

Bradley, Gordon H.
Professor
656-2359
Rgbright@nps.edu

Gaver, Donald P., Jr.
Distinguished Professor
656-2605
dgaver@nps.edu

Lucas, Thomas W.
Associate Professor
656-3039
tlwllucas@nps.edu

Brutzman, Donald P.
Associate Professor
656-2149
brutzman@nps.edu

Hiles, John E.
Research Professor
656-2988
hiles@nps.edu

Martell, Craig
Assistant Professor
656-2210
cmartell@nps.edu

Buss, Arnie
Research Assistant Professor
656-3259
abuss@nps.edu

Hutchins, Sue
Research Assistant Professor
656-3768
shutchins@nps.edu

McCauley, Michael
Research Professor
656-2191
memccaul@nps.edu

Buttrey, Sam
Associate Professor
656-3035
buttrey@nps.edu

Jacobs, Patricia A.
Professor
656-2258
pajacobs@nps.edu

McGhee, Robert B.
Professor
656-2026
mcghee@nps.edu
<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Phone</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miller, Nita</td>
<td>Associate Professor</td>
<td>656-2281</td>
<td><a href="mailto:nlmiller@nps.edu">nlmiller@nps.edu</a></td>
</tr>
<tr>
<td>Sadagic, Amela</td>
<td>Research Associate Professor</td>
<td>656-3819</td>
<td><a href="mailto:asadagic@nps.edu">asadagic@nps.edu</a></td>
</tr>
<tr>
<td>Sullivan, Joe, CDR, USN</td>
<td>Military Instructor</td>
<td>656-7582</td>
<td><a href="mailto:jasullivan@nps.edu">jasullivan@nps.edu</a></td>
</tr>
<tr>
<td>Paulo, Eugene</td>
<td>Senior Lecturer</td>
<td>656-3452</td>
<td><a href="mailto:eppaulo@nps.edu">eppaulo@nps.edu</a></td>
</tr>
<tr>
<td>Sanchez, Paul</td>
<td>Senior Lecturer</td>
<td>656-30353</td>
<td><a href="mailto:pjsanche@nps.edu">pjsanche@nps.edu</a></td>
</tr>
<tr>
<td>Yun, Xiaoping</td>
<td>Associate Professor</td>
<td>656-2629</td>
<td><a href="mailto:yun@nps.edu">yun@nps.edu</a></td>
</tr>
<tr>
<td>Rowe, Neil C.</td>
<td>Associate Professor</td>
<td>656-2462</td>
<td><a href="mailto:ncrowe@nps.edu">ncrowe@nps.edu</a></td>
</tr>
<tr>
<td>Sanchez, Susan</td>
<td>Professor</td>
<td>656-2780</td>
<td><a href="mailto:smsanche@nps.edu">smsanche@nps.edu</a></td>
</tr>
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</table>
ASSAULT BREACHER VEHICLE SIMULATION TRAINING SYSTEM
William J. Becker, Research Assistant Professor
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: Program Manager for Training Systems

SUMMARY: Developed a prototype software simulation of the Assault Breacher Vehicle remote control system interface.

PROVIDE SUBJECT MATTER EXPERTS FOR VIRTUAL TECHNOLOGIES AND ENVIRONMENTS, EXTREME ENVIRONMENTS URBAN WARFIGHTER RESEARCH SUPPORT FOR THE OFFICE OF NAVAL RESEARCH
William J. Becker, Research Assistant Professor
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: Office of Naval Research

SUMMARY: The Naval Postgraduate School is currently funded to support the Office of Naval Research Virtual Technologies and Environments program and its Extreme Environments Urban Warfighter Research (EEUWR) plan. This project provided travel for subject matter experts in support of the EEUWR effort.

VIRTUAL TECHNOLOGIES AND ENVIRONMENTS: COMBINED ARMS TEAM TRAINING RESEARCH AND SUPPORT
William J. Becker, Research Assistant Professor
Rudolph P. Darken, Associate Professor
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Department of Computer Science
Sponsor: Office of Naval Research

SUMMARY: This project is in its second of three planned years. The primary target of these investigations is in the area of combined arms operations where teams of marines, soldiers, sailors, aviators, and commanders must communicate and coordinate their efforts toward a single goal. Most often, while members of the individual teams (within aviation, within artillery, etc.) have trained together, cross-team training likely has not occurred. This is the challenge.

APPLICATION OF WEB-BASED TECHNOLOGIES TO COMMON MANEUVER NETWORKS FOR EMBEDDED TRAINING, MISSION PLANNING, AND REHEARSAL
Curtis L. Blais, Research Associate
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: TRADOC Analysis Center-Monterey

SUMMARY: The Army's Future Combat System, a system of systems, must have the capability to transition seamlessly between C4ISR and models and simulations that are at the core of embedded training.

COMMON MANEUVER NETWORKS AND MOBILITY COMMON OPERATIONAL PICTURE
Curtis L. Blais, Research Associate
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: TRADOC Analysis Center-Monterey

SUMMARY: Designed and developed an ontological foundation for formal description of information required to support C4I and modeling and simulation system interoperability related to maneuver networks and a mobility common operational picture.
MOVES INSTITUTE

JOINT BATTLE MANAGEMENT LANGUAGE
Curtis L. Blais, Research Associate
Donald P. Brutzman, Associate Professor
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: U.S. Army Engineer Research and Development Center

SUMMARY: Developed a Joint Battle Management Language (JBML) for unambiguous orders and reports intelligible and actionable to live, constructive, and robotic forces. Specifically, provided U.S. Navy expertise for specification and demonstration of Naval components of JBML.

MILITARY OPERATIONS OTHER THAN WAR FLEXIBLE ASYMMETRIC SIMULATION TECHNOLOGIES TOOLBOX PROTOTYPE TOOLBOX REFINEMENT
Curtis L. Blais, Research Associate
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: Dynamic Research Corporation

SUMMARY: Developed course materials for instruction and training on Military Operations Other Than War Flexible Asymmetric Simulation Technologies toolbox/tools in support of operational planning and analysis.

NAVAL REPRESENTATION IN GIG MODELING AND SIMULATION COI FOCUS GROUP MEETINGS
Curtis L. Blais, Research Associate
Donald P. Brutzman, Associate Professor
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: Chief of Naval Operations, N708MI

SUMMARY: The Naval Postgraduate School, in conjunction with N708M, has established a degree program, the Modeling, Virtual Environments and Simulation (MOVES) curriculum, and a research institute, the MOVES Institute. The degree program generates officers capable of filling 6202 P-coded billets upon graduation. The program is roughly half computer science and half operations analysis, to produce officers with an understanding of modern modeling, virtual environments and simulation. This proposal seeks to provide faculty support on mid- and long-term issues of interest to the N708M sponsor and to couple student theses to N708M programs.

NAVY MODELING AND SIMULATION FUNCTIONAL NAMESPACE COORDINATOR
Curtis L. Blais, Research Associate
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: Office of Naval Research

SUMMARY: Served as the Navy Modeling and Simulation Functional Namespace Coordinator, managed emerging Extensible Markup Language namespaces to enable developers and other users access, and employed the defined information models without having to create customized structures for each application and to facilitate data interchange across numerous applications.
VERIFICATION, VALIDATION, AND ACCREDITATION ONTOLOGY FOR MODELING AND SIMULATION SYSTEMS
Curtis L. Blais, Research Associate
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: Chief of Naval Operations, N798MI

SUMMARY: The Naval Postgraduate School, in conjunction with N708M, has established a degree program, the Modeling, Virtual Environments, and Simulations (MOVES) curriculum, and a research institute, the MOVES Institute. The degree program is roughly half computer science and half operations analysis, to produce officers with an understanding of modern modeling, virtual environments, and simulation. This proposal seeks to provide faculty support on mid- and long-term issues of interest to the N708M sponsor and to couple student theses to N708M programs.

ADVANCED X3D TECHNIQUES (INCLUDING OPEN-SOURCE SHADER SUPPORT)
Donald P. Brutzman, Associate Professor
Jeffrey Weekley, Research Professor
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: Chief of Naval Operations, N708MI

SUMMARY: The Naval Postgraduate School, in conjunction with N708M, has established a degree program, the Modeling, Virtual Environments, and Simulations (MOVES) curriculum, and a research institute, the MOVES Institute. The degree program generates officers capable of filling 6202 P-coded billets upon graduation. The degree program is roughly half computer science and half operations analysis, to produce officers with an understanding of modern modeling, virtual environments, and simulation. This proposal seeks to provide faculty support on mid- and long-term issues of interest to the N708M sponsor and to couple student theses to N708M programs.

BATTLESPACE VIDEO ARCHIVE AND RETRIEVAL SYSTEM
Donald P. Brutzman, Associate Professor
Rex A. Buddenberg, Senior Lecturer
Department of Information Sciences
Sponsor: Marine Corps Systems Command

OBJECTIVE: To produce a software interface designed specifically to exploit tactical motion imagery already being gathered in the field. This interface will provide users with fast access to imagery of a given site obtained over multiple flights and days (already archived), and provide that imagery from a common user controlled perspective (view direction and resolution) in order to facilitate easy assessment of changes in the scene.

MODELING AND 3D VISUALIZATION FOR EVALUATION OF ANTI-TERRORISM/FORCE PROTECTION ALTERNATIVES PHASE II
Donald P. Brutzman, Associate Professor
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: Naval Facilities Engineering Command

SUMMARY: Performed directed research for design and development of simulation models and 3D visualization in support of waterside security installation planning and evaluation initiatives.
SUMMARY: Performed directed research for design and development of simulation models and 3D visualization in support of Anti-Terrorism/Force Protection (AT/FP) installation planning and initiatives. The work was directed by specific sub-task requirements identified by the AT/FP sponsor during the period of performance.

SUMMARY: Performed directed research for design and development of simulation models and 3D visualization in support of waterside security installation planning and evaluation initiatives. The work was directed by specific sub-task requirements delineated by the waterside security sponsor at the outset and during the period of performance. Initial technical requirements included expansion of current modeling and visualization of Pearl Harbor to extend the geospatial area of coverage and physics-based models, and to add details for planning of barrier emplacements, assessing benefits of the employment of different systems (sensors, barriers, patrol craft) in various combinations against possible threats.

SUMMARY: To present a modeling and simulation briefing covering the functionality of the Naval Postgraduate School Autonomous Unmanned Vehicle workbench tactical decision aid software to NSCT1 under funding provided by Mr. Simmons.

SUMMARY: The project built on GMU/Naval Postgraduate School existing, open-source capabilities for in-the-clear multicasting that runs over standard Internet connections, using an overlay network with one relay agent per subnet (LAN).
MOVES INSTITUTE

SAVAGE MODELING AND ANALYSIS LANGUAGE
Donald P. Brutzman, Associate Professor
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: Chief of Naval Operations, N708MI

SUMMARY: The Naval Postgraduate School, in conjunction with N708M, has established a degree program, the Modeling, Virtual Environments, and Simulation (MOVES) curriculum, and a research institute, the MOVES Institute. The degree program is roughly half computer science and half operations analysis, to produce officers with an understanding of modern modeling, virtual environments, and simulation. This proposal seeks to provide faculty support on mid- and long-term issues of interest to the N708M sponsor and to couple student theses to N708M programs.

UNDERSEA WARFARE EXTENSIBLE MARKUP LANGUAGE WORKING GROUP FOR UNDERSEA WARFARE DECISION SUPPORT SYSTEM TACTICAL DATA INTERCHANGE
Donald P. Brutzman, Associate Professor
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: Naval Sea Systems Command

OBJECTIVE: To enable distribution of properly documented, classified when necessary, working group recommendations, exemplars, and results to Navy and Department of Defense XML registries for long-term community of interest use and improvement.

WEB-BASED GRID-ENHANCED DISCRETE EVENT SIMULATION
Donald P. Brutzman, Associate Professor
Arnold H. Buss, Research Assistant Professor
Don McGregor, Research Associate
Department of Computer Science
Sponsor: Chief of Naval Operations, N708MI

SUMMARY: The Naval Postgraduate School, in conjunction with N708M, has established a degree program, the Modeling, Virtual Environments, and Simulation (MOVES) curriculum, and a research institute, the MOVES Institute. The degree program generates officers capable of filling 6202 P-coded billets upon graduation. The program is roughly half computer science and half operations analysis, to produce officers with an understanding of modern modeling, virtual environments, and simulation. This proposal seeks to provide faculty support on mid- and long-term issues of interest to the N708M sponsor and to couple student theses to N708M programs.

WEB-BASED TECHNOLOGIES TOOLKIT AND SUPPORT FOR THE COALITION SECURE MANAGEMENT AND OPERATIONS SYSTEM ADVANCED CONCEPT TECHNOLOGY DEMONSTRATION
Donald P. Brutzman, Associate Professor
Curtis L. Blais, Research Associate
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: Office of the Deputy Under Secretary of Defense

SUMMARY: The Coalition Secure Management and Operations System Advanced Concept Technology Demonstration demonstrated critically needed capabilities to share command and control data with multiple coalition partners on a single, multinational, information-sharing network.
XML-BASED TACTICAL CHAT
Donald P. Brutzman, Associate Professor
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: Chief of Naval Operations, N708MI

SUMMARY: The Naval Postgraduate School, in conjunction with N708M, has established a degree program, the Modeling, Virtual Environments, and Simulation (MOVES) curriculum, and a research institute, the MOVES Institute. The degree program generates officers capable of filling 6202 P-coded billets upon graduation. The program is roughly half computer science and half operations analysis, to produce officers with an understanding of modern modeling, virtual environments, and simulation. This proposal seeks to provide faculty support on mid- and long-term issues of interest to the N708M sponsor and to couple student theses to N708M programs.

XML, XSBC, AND X3D WEB-BASED TECHNOLOGIES SUPPORT FOR THE ANTI-SUBMARINE WARFARE TACTICAL ASSESSMENT SYSTEM
Donald P. Brutzman, Associate Professor
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: Naval Undersea Warfare Center-Newport Division

OBJECTIVE: To provide software support for XJ3D and X3D technology integration with the Anti-Submarine Warfare Tactical Assessment System. A secondary goal is to develop and demonstrate emergent USW-XML technologies.

X3D-EARTH: ARCHIVABLE COMPOSED COLLABORATIVE WEB-BASED 3D VISUALIZATION WITH GLOBAL GEOSPATIAL CONTEXT FOR COMPLEX ANALYSIS/EVALUATION OF INTELLIGENCE PRODUCTS
Donald P. Brutzman, Associate Professor
Amela Sadagic, Research Associate Professor
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: Naval Air Systems Command

OBJECTIVE: The Extensible 3D (X3D) earth project will create a standards-based 3D visualization infrastructure for visualizing all manner of real-world objects and information constructs in a geospatial context.

DYNAMIC ALLOCATION OF FIRES AND SENSORS UNMANNED AERIAL VEHICLE ANALYSIS
Arnold H. Buss, Research Assistant Professor
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: TRADOC Analysis Center-Monterey

OBJECTIVE: To enhance the usability of Dynamic Allocation of Fires and Sensors, spiraling in improvements to ASC-U; to provide documentation in the form of a user manual; and to perform analysis on scenarios to help determine quantities and allocations of unmanned aerial vehicles (UAV) as part of the UAV mix study.
INTEGRATION OF THE NAVAL POSTGRADUATE SCHOOL MULTI-AGENT SIMULATION ARCHITECTURE AND SIMKIT/VISKIT
Arnold H. Buss, Research Assistant Professor
John Hiles, Research Professor
Donald P. Brutzman, Associate Professor
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: Chief of Naval Operations, N708MI

SUMMARY: The Naval Postgraduate School, in conjunction with N708M, has established a degree program, the Modeling, Virtual Environments, and Simulation (MOVES) curriculum, and a research institute, the MOVES Institute. The degree program generates officers capable of filling 6202 P-coded billets upon graduation. The program is roughly half computer science and half operations analysis, to produce officers with an understanding of modern modeling, virtual environments, and simulation. This proposal seeks to provide faculty support on mid- and long-term issues of interest to the N708M sponsor and to couple student theses to N708M programs.

LOGISTIC BATTLE COMMAND
Arnold H. Buss, Research Assistant Professor
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: TRADOC Analysis Center-Monterey

OBJECTIVE: To provide a preliminary requirement analysis and design effort, and to document the Logistics Battle Command simulation.

DEVELOPMENT, VALIDATION, AND APPLICATION OF A SAFETY CLIMATE SURVEY FOR AIR TRAFFIC CONTROL FACILITIES
Anthony P. Ciavarelli, Professor
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: Federal Aviation Administration

SUMMARY: Developed an online (web-based) safety survey for use by Federal Aviation Administration air traffic control facilities. The survey was based upon previous research and development of a comparable U.S. Navy and Marine Corps system.

ANNUAL I/ITSEC SPONSORSHIP
Rudolph P. Darken, Associate Professor
Department of Computer Science
Sponsor: Chief of Naval Operations, N708MI

SUMMARY: The Naval Postgraduate School, in conjunction with N708M, has established a degree program, the Modeling, Virtual Environments, and Simulation (MOVES) curriculum, and a research institute, the MOVES Institute. The degree program generates officers capable of filling 6202 P-coded billets upon graduation. The program is roughly half computer science and half operations analysis, to produce officers with an understanding of modern modeling, virtual environments, and simulation. This proposal seeks to provide faculty support on mid- and long-term issues of interest to the N708M sponsor and to couple student theses to N708M programs.
FACILITATING ORGANIZATIONAL LEARNING AND CHANGE THROUGH THE NATIONAL EXERCISE PROGRAM
Rudolph P. Darken, Associate Professor
Department of Computer Science
Perry McDowell, Lecturer
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: Department of Homeland Security

OBJECTIVE: To study how organizations learn from exercises and how this learning can be brought to bear on improved capacity for readiness in homeland security.

SUMMARY: This program was a collaboration between the MOVES Institute, the Center for Homeland Defense and Security, and the Center for International Security and Cooperation at Stanford University. The program involved a basic research component to determine how organizational learning applies to this domain and an applied research component where a prototype for simulations for exercises was built and tested.

INVESTIGATING ATC PROCEDURES FOR SIMULTANEOUS NON-INTERFERING FLIGHT WITHIN THE NATIONAL AIRSPACE SYSTEM
Rudolph P. Darken, Associate Professor
Department of Computer Science
CDR Joseph A. Sullivan, USN, Military Faculty
Perry McDowell, Lecturer
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: Federal Aviation Administration

THE MOVES INSTITUTE – FISCAL YEAR 2006
Rudolph P. Darken, Associate Professor
Department of Computer Science
Sponsor: Chief of Naval Operations, N61F22

SUMMARY: The Naval Postgraduate School, in conjunction with N61, has established a degree program, the Modeling, Virtual Environments, and Simulation (MOVES) curriculum, and a research institute, the MOVES Institute. The degree program generates officers capable of filling XX99-P/6202 P-coded billets upon graduation. The program is roughly half computer science and half operations research analysis, to produce officers with an understanding of modern modeling, virtual environments, and simulation. Faculty provided support on mid- and long-term issues of interest to the N61 sponsor and to couple student theses to N61 programs.

MOVES INSTITUTE OUTREACH/ALUMNI SUPPORT
Rudolph P. Darken, Associate Professor
Department of Computer Science
Sponsor: Chief of Naval Operations, N708MI

SUMMARY: The Naval Postgraduate School, in conjunction with N708M, has established a degree program, the Modeling, Virtual Environments, and Simulation (MOVES) curriculum, and a research institute, the MOVES Institute. The degree program generates officers capable of filling 6202 P-coded billets upon graduation. The program is roughly half computer science and half operations analysis, to produce officers with an understanding of modern modeling, virtual environments, and simulation. This proposal seeks to provide faculty support on mid- and long-term issues of interest to the N708M sponsor and to couple student theses to N708M programs.
SUMMARY: This project, in its second of three years, was modified after the initial year. VIRTE Demo 3 is about training distributed teams of teams. Questions include, how virtual environments can enhance the way teams train with other teams when communication and coordination are key, what are the advantages and disadvantages of such training, where should it be used and where avoided, what to virtual environments contribute that conventional method cannot, and how can new possibilities overcome practical barriers and limitations. In short, the research asks how virtual environments assist in training distributed teams and how they can have an immediate impact where needed most. The primary target will be in combined arms operations, in which teams of marines, soldiers, sailors, aviators, and commanders must communicate and coordinate toward a single goal. Usually individual teams (within aviation, artillery, etc.) have only trained together and cross-team training is not likely to have occurred. This is the challenge.

ATTENDANCE AT THE INTERSERVICE/INDUSTRY TRAINING, EDUCATION, AND SIMULATION CONFERENCE
Perry McDowell, Lecturer
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: Naval Air Systems Command

SUMMARY: Supported travel and labor for Perry McDowell to attend the Interservice/Industry Training, Simulation, and Education Conference in Orlando, Florida.

DISPLAY AND VISUALIZATION OF MOVEMENT PREDICTIONS FOR GROUND VEHICLES
Perry McDowell, Lecturer
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: Applied Visions, Inc.

OBJECTIVE: The primary objective for the area of collaboration is that of adding specific artificial intelligence to the DELTA3D open source game engine developed by the Naval Postgraduate School MOVES Institute from a number of pre-existing open source projects. A second area of collaboration is to develop embedded training capabilities in the Small Business Innovation Research Phase II prototype.

A FULLY INTEROPERABLE OPEN SOURCE VISUAL SIMULATION CAPABILITY: COMBINING THE DELTA3D OPEN SOURCE GAME ENGINE WITH THE EXTENSIBLE MODELING AND SIMULATION FRAMEWORK
Perry McDowell, Lecturer
Donald P. Brutzman, Associate Professor
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: Chief of Naval Operations, N708MI

SUMMARY: The Naval Postgraduate School, in conjunction with N708M, has established a degree program, the Modeling, Virtual Environments, and Simulation (MOVES) curriculum, and a research institute, the MOVES Institute. The degree program generates officers capable of filling 6202 P-coded billets upon graduation. The program is roughly half computer science and half operations analysis, to produce officers with an understanding of modern modeling, virtual environments, and simulation. This
proposal seeks to provide faculty support on mid- and long-term issues of interest to the N708M sponsor and to couple student theses to N708M programs.

MULTI-PURPOSE ENTERPRISE SIMULATION SUITE
Perry McDowell, Lecturer
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: TRADOC Analysis Center-Monterey

OBJECTIVE: To support the Army's MPESS project by providing expert consultation, development of alternative concepts for future army modeling and simulation strategy, and requirements for conceptual and data exchange models.

AN OPEN SOURCE SIMULATION ENGINE WITH SCENARIO EDITING AND AAR FOR JNTC TRAINING AND EDUCATION APPLICATIONS
Perry McDowell, Lecturer
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: Naval Air Systems Command Training Systems Division-Orlando

OBJECTIVE: To add scenario generation and after action review capability to the DELTA3D open source game engine so that it can be used to create joint training. An additional objective is to build a prototype training application demonstrating this capability.

EVALUATION OF THE TRAINING EFFECTIVENESS OF VIRTUAL SIMULATIONS IN SUPPORT OF TEAM PERFORMANCE AND COLLECTIVE TRAINING STANDARDS
Amela Sadagic, Research Associate Professor
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: Chief of Naval Operations, N708MI

SUMMARY: The Naval Postgraduate School, in conjunction with N708M, has established a degree program, the Modeling, Virtual Environments, and Simulation (MOVES) curriculum, and a research institute, the MOVES Institute. The degree program generates officers capable of filling 6202 P-coded billets upon graduation. The program is roughly half computer science and half operations analysis, to produce officers with an understanding of modern modeling, virtual environments, and simulation. This proposal seeks to provide faculty support on mid- and long-term issues of interest to the N708M sponsor and to couple student theses to N708M programs.

VIRTUAL TECHNOLOGIES AND ENVIRONMENTS: EVALUATION OF THE TRAINING EFFECTIVENESS OF VIRTUAL SIMULATIONS IN SUPPORT OF COLLECTIVE TRAINING STANDARDS
Amela Sadagic, Research Associate Professor
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: Office of Naval Research

OBJECTIVE: To evaluate the effectiveness of the use of virtual training simulations as supplementary tools in raising the level of units' preparedness and their effect on collective training standards in combined arms training situations.
VIRTUAL TECHNOLOGIES AND ENVIRONMENTS: EVALUATION OF THE TRAINING EFFECTIVENESS OF VIRTUAL FOR TRAINING OF FIRE SUPPORT TEAMS-FIELD STUDY
Amela Sadagic, Research Associate Professor
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: Office of Naval Research

OBJECTIVE: To evaluate the effectiveness of the use of virtual training simulations as supplementary tools in training of the fire support team and the effects of that training on their performance in live fire exercise in combined arms training. This is an addendum to an earlier research effort titled “Virtual Technologies and Environments: Evaluation of the Training Effectiveness of Virtual Simulations in Support of Collective Training Standards” conducted by Dr. Amela Sadagic under the Virtual Technologies and Environments program.

INERTIAL MOTION TRACKING FOR INSERTING HUMANS INTO A NETWORKED SYNTHETIC ENVIRONMENT
Xiaoping Yun, Professor
Department of Electrical and Computer Engineering
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: U.S. Army Research Office

OBJECTIVE: To research techniques for realistic, “immersive” –quality inclusion of motion-tracked avatars into virtual environments.

SOURCELESS POSITION TRACKING USING SMALL INERTIAL/MAGNETIC SENSORS AND GAIT MEASUREMENTS
Xiaoping Yun, Professor
Department of Electrical and Computer Engineering
Eric Bachmann, Lecturer
Department of Computer Science
Sponsor: Chief of Naval Operations, N708MI

OBJECTIVE: To create a new technology for human body motion tracking in networked virtual environments. Unlike other existing body tracking technologies, this system does not depend on any external sources, thus creating a “sourceless” tracking system. The development of the new motion tracking system consists of two main components: i) design and prototype of a novel nine-axis MARG sensor, and ii) development and software implementation of a complimentary filter based on use of Quaternions rather than Euler angles. Other components of the system development include testing and evaluation of wireless communications for transmitting sensor data, development of a realistic avatar based on laser-scanned data, and creation of a simple yet effective sensor calibration procedure.

PLATFORM CAMERA AIRCRAFT DETECTION FOR APPROACH EVALUATION AND TRAINING
LT Yusko
MOVES Institute (Modeling, Virtual Environments, and Simulation)
Sponsor: SPAWAR Systems Center-San Diego

SUMMARY: Approach training currently relies solely on manual observation and verbal feedback to the pilot. The objective of this project is to provide both pilots and Landing Signal Officers (LSO) with valuable information about individual approaches in the carrier landing environment. The project investigated fully automatic data acquisition by means of computer vision-based analysis of platform camera video. The obtained data support enhanced LSO training, real-time approach analysis, and pilot self-improvement through advanced review capabilities.
THE MOVES INSTITUTE
(MODELING, VIRTUAL ENVIRONMENTS, AND SIMULATION)

2006
Faculty Publications and Presentations
CONFERENCE PUBLICATIONS


PRESENTATIONS

CENTER FOR
INTERDISCIPLINARY REMOTELY
PILOTED AIRCRAFT STUDIES

ROBERT BLUTH
DIRECTOR
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 (UAV). 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, including:

- 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 square foot hangar and maintenance and administrative spaces for CIRPAS staff. These include a fully outfitted machine shop, an 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 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 the 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 the DoE, CIRPAS provides the vehicle’s services during the remainder of the year to other users.

Characteristics of the 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-foot 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 a 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 suites. The basic meteorological and GPS suite consists of a Rosemount temperature probe, an Edgetech chilled mirror dew point sensor, a Rosemount flow angle probe with static ports, a Vaisala temperature and dewpoint 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 three-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)
- 3500 x 60 ft runway
- 2000 sq ft hangar
- Shared utilization of NRL
- Temporary office space

RESEARCH PROGRAM (Research and Academic)-FY2006:

The Naval Postgraduate School’s sponsored program exceeded $81 million in FY2006. Sponsored programs include 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 is provided below:

Size of Program: $5.3M
Bluth, Robert T.
Research Associate and Director
384-2776
rtbluth@nps.edu

Jones, Kevin
Research Associate Professor
656-5037
jones4@nps.edu

Knorr, Jeffrey B.
Professor and Chairman
656-2815
jknorr@nps.edu

Paduan, Jeffrey D.
Associate Professor
656-3350
paduan@nps.edu

Jonsson, Haflidi, H.
Research Assistant Professor
384-2776
hjonsson@nps.edu

Pace, Phillip E.
Professor
656-3286
pepace@nps.edu

Ramp, Steven R
Research Professor
656-2201
sramp@nps.edu
SUMMARY: Assisted NESDIS with Twin Otter flights to collect data for use in future instrument design, WINDSAT product validation, and validation of instrument performance models. Project used both Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) ground and airborne winds lidars to reverse engineer the specifications for lidar components. CIRPAS also prepared for additional experiments to explore the optimal deployment strategies for airborne doppler winds lidar in support of various field experiments.

SUMMARY: Assisted National Polar-Orbiting Environmental Satellite System 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 GSFC.

SUMMARY: The Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) provided pre-flight coordination, flight coordination, range management, flight safety, and facility management of Aerovironment, Inc.’s activities at the CIRPAS facility and ensured compliance with all CIRPAS and Caltech policies and procedures. The overall objective of this project was to conduct flight demonstrations of technologies that may be applicable to the next generation of surveillance unmanned aircraft. CIRPAS provided facility and personnel support.

SUMMARY: Supported U.S. Marine Corps Desert Talon activity with a Pelican configured as an unmanned aerial vehicle surrogate with a Predator EO-IR payload.

SUMMARY: Supported U.S. Marine Corps Desert Talon activity with a Pelican configured as an unmanned aerial vehicle surrogate with a Predator EO-IR payload.
DIVINE STRIKE PARTICLE MEASUREMENTS
Robert T. Bluth, Research Associate
Hafldi H. Jonsson, Research Associate Professor
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Defense Threat Reduction Agency

SUMMARY: Supported Divine Strike testing with airborne measurement of particles.

HURT CAMP ROBERTS PROJECT
Robert T. Bluth, Research Associate
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Air Force Research Laboratory

SUMMARY: The Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) supported the Air Force Research Laboratory/IFSC HURT flight testing at the CIRPAS unmanned aerial vehicle airfield at Camp Roberts, California.

INTELLIGENT AUTONOMY PROGRAM
Robert T. Bluth, Research Associate
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: University of California, Berkeley

SUMMARY: The Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS), through its primary contractor, Caltech, provided pre-flight coordination, flight coordination, range management, flight safety, and facility management of the University of California-Berkeley's Center for the Cooperative Control of Unmanned Vehicles Activities at the CIRPAS facility; and ensured compliance with all CIRPAS and Caltech policies and procedures.

LCLC DEMONSTRATOR FLIGHT TESTS
Robert T. Bluth, Research Associate
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: WTW, LLC

SUMMARY: The Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) provided pre-flight coordination, flight coordination, and range measurement of WTW, LLC activities while conducting flight testing of the LCLC unmanned aerial vehicle at the CIRPAS facility, and ensured compliance with all CIRPAS and Caltech policies and procedures.

LEAPP AT ROBERTS PROJECT
Robert T. Bluth, Research Associate
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Defense Advanced Research Projects Agency

SUMMARY: The Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) supported LEAPP flight testing at the CIRPAS unmanned aerial vehicle airfield at Camp Roberts, California. CIRPAS provided range safety support and access to office, hangar, and communications facilities.
LONG GUN TESTING AT CAMP ROBERTS PROJECT
Robert T. Bluth, Research Associate
Haflidi H. Jonsson, Research Associate Professor
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Defense Advanced Research Project Agency

SUMMARY: The Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) supported long-gun flight testing at the CIRPAS unmanned aerial vehicle airfield at Camp Roberts, California. CIRPAS provided range safety support and access to office, hangar, and communications facilities. More than fifty percent of the funds required to support this flight testing were sent to a contractor. The contractor provided logistics support for this project.

LR-3/COMPASS BRIGHT DEVELOPMENT
Robert T. Bluth, Research Associate
Haflidi H. Jonsson, Research Associate Professor
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Aeronautical Systems Center

SUMMARY: The Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) supported LR-3/Compass bright flight testing at the CIRPAS UAV airfield at Camp Roberts, California. Assumed a 10 day deployment. CIRPAS provided range safety support and access to office, hangar, and communications facilities. More than fifty percent of the funds required to support this flight testing were sent to a contractor. The contractor was required to provide logistics support for this project.

NAVAL POSTGRADUATE SCHOOL/CENTER FOR INTERDISCIPLINARY REMOTELY PILOTED AIRCRAFT STUDIES SUPPORT OF NATIONAL POLAR-ORBITING ENVIRONMENTAL SATELLITE SYSTEM CALIBRATION/VALIDATION OF SPACE-BASED WIND MEASUREMENTS
Robert T. Bluth, Research Associate
Haflidi H. Jonsson, Research Associate Professor
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: National Oceanic and Atmospheric Administration

SUMMARY: Naval Postgraduate School/Center for Interdisciplinary Remotely Piloted Aircraft Studies supported National Polar-Orbiting Environmental Satellite System-funded field campaigns.

SUMMARY: This research incorporated human systems integration (HSI) research efforts to support the Tactical Network Topology project. The project included research in two major areas: HSI assessments of field-portable devices, and a research center with both laboratory and field-based research capability to assess HSI efforts for warfighters.
SUMMARY: Supported Joint Forces Command, Joint Operational Testbed System (JOTBS) Mechanical and Astronautical Engineering (MAE) Unmanned Aerial Vehicles (UAV) test objectives with four Predator MAE UAV flight operations with Pelican and Predator P030, P035, and possibly R048 air vehicles, and one ground-control station/GDT.

SUMMARY: The Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS), through its primary contractor, Caltech, provided pre-flight coordination, flight coordination, range management, flight safety, and facility management of Nextgen aeronautics activities at the CIRPAS facilities. Nextgen flew an ROV/RC model (MFX-1) as part of the Defense Advanced Research Projects Agency Morphine Aircraft Structure Program. CIRPAS provided facility and personnel support.

SUMMARY: Provided Pelican support of various MEU training in an urban environment exercise.

SUMMARY: The Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) worked with NAVAIR Weapons Division in developing procedures to operate Predator unmanned aerial vehicles in support of Weapons Division research activities.

SUMMARY: Provided Predator support in fiscal year 2006, with 32 flight hours (30 mission hours and 2 hours flight testing).
CIRPAS

SKYTOTE CAMP ROBERTS PROJECT
Robert T. Bluth, Research Associate
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Air Force Research Laboratory

SUMMARY: The Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) supported ARFL/VAAA Skytote flight testing at the CIRPAS unmanned aerial vehicle airfield at Camp Roberts, California. CIRPAS provided range safety support and access to office, hanger, and communications facilities. More than fifty percent of the funds required to support this flight testing were sent to a contractor. The contractor provided logistics support for this project.

SMALL BUSINESS INNOVATIVE RESEARCH PROGRAM
Robert T. Bluth, Research Associate
Haflidi H. Jonsson, Research Associate Professor
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Office of Naval Research

OBJECTIVE: To support the Office of Naval Research Small Business Innovative Research (SBIR) program in the development and management of SBIR contracts.

TUAV TRAINING SUPPORT
Robert T. Bluth, Research Associate
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Unmanned Aircraft Systems

SUMMARY: The Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) provided U.S. Army TUAV training with Predators 30 and 35 at El Mirage, California, between 31 July 2006 and 15 February 2007 with (3) training schedules, (16) 10 flight hours each, along with 15 maintenance flights for a total of 525 total flight hours. All flight activity was conducted from the CIRPAS ground-control station and will be LOS. Flight crew must be away from the operations site for 12 hours of each 24-hour day. The contractor is required to provide logistics and ground support for this project, which requires more than 80% of funds to be sent to a contractor.

TYRA CAMP ROBERTS PROJECT
Robert T. Bluth, Research Associate
Haflidi H. Jonsson, Research Associate Professor
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: U.S. Special Operations Command

SUMMARY: The Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) supported U.S. Special Operations Command/Tyra flight testing at the CIRPAS UAV airfield at Camp Roberts, California. CIRPAS provided range safety support and access to office, hanger, and communications facilities. More than fifty percent of the funds required to support this flight testing were sent to a contractor. The contractor provided logistics support.

UK FPASS TRAINING
Robert T. Bluth, Research Associate
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Lockheed Martin Maritime Systems and Sensors-Tactical System

SUMMARY: The Naval Postgraduate School’s Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) provided pre-flight coordination, flight coordination, range management, flight safety,
and facility management of Lockheed Martin's activities at the CIRPAS facility, and ensured compliance with all CIRPAS and Caltech policies and procedures.

UK FPASS TRAINING
Robert T. Bluth, Research Associate
Haflidi H. Jonsson, Research Associate Professor
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Lockheed Martin Maritime and Sensors-Tactical System

SUMMARY: Specific tasks were performed by Caltech in support of the Center for Interdisciplinary Remotely Piloted Aircraft Studies’ activities in support of Lockheed Martin’s Desert Hawk UK training program. Lockheed Martin has been requested by the British MOD to train British soldiers to operate the Desert Hawk (FPASS) unmanned aerial vehicle. CIRPAS provided facility and personnel support.

CENTER FOR INTERDISCIPLINARY REMOTELY PILOTED AIRCRAFT STUDIES
RADIOMETER CALIBRATION SYSTEM
Haflidi H. Jonsson, Research Associate Professor
Robert T. Bluth, Research Associate
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Office of Naval Research

OBJECTIVE: To acquire research instruments and equipment for the development of a comprehensive system to calibrate airborne and surface radiometer instrumentation.

NAVAL POSTGRADUATE SCHOOL/CENTER FOR INTERDISCIPLINARY REMOTELY PILOTED AIRCRAFT STUDIES SUPPORT OF THE GOMACCS EXPERIMENT
Haflidi H. Jonsson, Research Associate Professor
Robert T. Bluth, Research Associate
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: National Oceanic and Atmospheric Administration

SUMMARY: The Naval Postgraduate School's (NPS) Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) participated in and supported the airborne research objectives of NOAA's GOMACCS project in Houston, Texas, during August and September 2006. GOMACCS is a large research project that involves four aircraft, research ships, and land-based observation sites. The objective was to understand the effect emissions from large oil refineries and chemical facilities have on air quality and cloud properties. The contractor provided logistics and ground support for this project, which required more than 50% of funds be sent to a contractor.

NAVAL POSTGRADUATE SCHOOL/CENTER FOR INTERDISCIPLINARY REMOTELY PILOTED AIRCRAFT STUDIES SUPPORT OF OFFICE OF NAVAL RESEARCH AIRBORNE OBJECTIVES-AMENDMENT 1
Haflidi H. Jonsson, Research Associate Professor
Robert T. Bluth, Research Associate
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Office of Naval Research

SUMMARY: Naval Postgraduate School/Center for Interdisciplinary Remotely Piloted Aircraft Studies supported Office of Naval Research-funded field campaigns.


OVERVIEW:

The NPS Field Experimentation Program began approximately two years ago with the purpose of providing the opportunity for students and faculty to evaluate some of their latest technologies in an operational environment and, when appropriate, to rapidly transition them to the warfighter.

CURRICULA SERVED:

The program relies heavily on the operational knowledge of our joint student body as well as a very close working relationship with USSOCOM. Congressional funding (CDTEMS) together with funding from USSOCOM and the Office of Force Transformation has permitted 1-2 week long quarterly field experiments to be conducted, using laboratories on the NPS campus, the NPS Beach Laboratory and CIRPAS (Marina Airport), Monterey Bay, the MOUT facility at Fort Ord, and an NPS CIRPAS UAV test facility at the California Army National Guard, Camp Roberts, CA. Twenty-eight thesis students and twenty-two faculty from across the campus participated in FY04 and several courses in different departments utilized the field experiments as class projects.

RESEARCH THRUSTS:

USSOCOM has funded several small companies with innovative new technologies to work with NPS and many other companies and government laboratories have participated using their own funds. Quantitative measures of performance for the technologies are obtained and Special Operations Forces are utilized in many of the experiments to obtain user input; e.g., there is a strong human systems integration component. In the past year this team developed a Surveillance and Target Acquisition Network (STAN) which can provide the soldier on the ground the ability to push-pull video, data, and text messages with other soldiers and with other ISR assets in the area in both rural and urban environments; e.g., it has both local and long-haul reach-back capabilities. It also provides situational awareness and blue force tracking. It utilizes air and ground based wireless networks, satellites, unmanned vehicles (UAVs, UGVs, AUVs, airships, tethered balloons), unattended ground sensors, and handheld PDAs to greatly enhance situational awareness and to enhance our ability to find, fix, and identify enemy personnel and equipment. The INTER-4 Tacticom was one of the primary end products of the FY04 program. The effort is also investigating leave-behind infrastructure that can be utilized during post-conflict reconstruction.

RESEARCH PROGRAM (Research and Academic)-FY2006:

The Naval Postgraduate School’s sponsored program exceeded $81 million in FY2006. Sponsored programs included both research and educational activities funded from an external source. CDTEMS’s program exceeded $1M in FY2006.
Netzer, David W.
Distinguished Professor
Code 09
656-2980
dnetzer@nps.edu
FIELD EXPERIMENTATION PROGRAM FOR SPECIAL OPERATIONS
David W. Netzer, Distinguished Professor
Center for Defense Technology and Education for the Military Services
Sponsor: U.S. Special Operations Command

SUMMARY: Enhanced Special Operations Forces technological capability and satisfied operational requirements by identifying key gaps and inefficiencies in capabilities, and by exploring viable solutions from emerging technologies through the use of quarterly field experiments.

INTEGRATION OF SPECIAL OPERATIONS FORCES UASS INTO SPECIAL OPERATIONS FORCES TACTICAL NETWORK
David W. Netzer, Distinguished Professor
Center for Defense Technology and Education for the Military Services
Sponsor: U.S. Special Operations Command

SUMMARY: Enhanced U.S. Special Operations Command - Naval Postgraduate School (NPS) Cooperative Field Experimentation Program through the use of NPS faculty and student research and infrastructure enhancements.

MULTIPLE UNMANNED AERIAL VEHICLES FOR SURVEILLANCE AND MENSURATION OF GROUND EMISSION SOURCES
David W. Netzer, Distinguished Professor
Center for Defense Technology and Education for the Military Services
Sponsor: Department of Energy, National Nuclear Security Administration

OBJECTIVE: To develop and demonstrate the capability for using multiple small unmanned aerial vehicles in cooperative behavior for surveillance and mensuration of ground emission sources.

U.S. SPECIAL OPERATIONS COMMAND - NAVAL POSTGRADUATE SCHOOL COOPERATIVE FIELD EXPERIMENTATION PROGRAM
David W. Netzer, Distinguished Professor
Center for Defense Technology and Education for the Military Services
Sponsor: U.S. Special Operations Command

SUMMARY: Provided flight, payload integration, and facilities support for unmanned air systems testing and evaluation at Camp Roberts, California.
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