

Naval Postgraduate School
Monterey, California 93943-5138



NPS-09-03-002

Summary of Research

2002



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

Summary of
Research
2002

Submitted by the Faculty
Compiled by the
Office of the Associate Provost and Dean of Research
Naval Postgraduate School
Monterey, CA 93943-5138

NAVAL POSTGRADUATE SCHOOL
Monterey, California

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REPORT DOCUMENTATION PAGEForm approved
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Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE January 2005	3. REPORT TYPE AND DATES COVERED Summary Report, 1 October 2001-30 September 2002
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4. TITLE AND SUBTITLE Summary of Research 2002	5. FUNDING
--	-------------------

6. AUTHOR(S) Faculty of the Naval Postgraduate School

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000	8. PERFORMING ORGANIZATION REPORT NUMBER NPS-09-05-001
---	--

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000	10. SPONSORING/MONITORING AGENCY REPORT NUMBER
--	---

11. SUPPLEMENTARY NOTES The views expressed in this report are those of the authors and do not reflect the official policy or position of the Department of Defense or U.S. Government.

12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited	12b. DISTRIBUTION CODE A
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13. ABSTRACT (Maximum 200 words.) This report contains project summaries of the research undertaken at the Naval Postgraduate School. A list of recent publications is also included which consists of conference presentations, books, contributions to books, published journal papers, and technical reports. The research was conducted in the areas of National Security Affairs, Computer Science, Defense Analysis, Information Science, Operations Research, Aeronautics and Astronautics, Electrical and Computer Engineering, Mathematics, Mechanical Engineering, Meteorology, Oceanography, Physics and Business and Public Policy. This also includes research by the Space Systems Academic Group, Institute for Information Innovation and Superiority (I2SI), The Wayne E. Meyer Institute, formerly the Institute for Defense Systems Engineering and Analysis (IDSEA), The Modeling, Virtual Environments and Simulation (MOVES) Institute, School of Aviation Safety and Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS).
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14. SUBJECT TERMS	15. NUMBER OF PAGES 605
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT Unlimited
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THE NAVAL POSTGRADUATE SCHOOL MISSION

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



PREFACE

Research at the Naval Postgraduate School is carried out by faculty in the four Graduate Schools, Research and Education Institutes, Research Centers and the School of Aviation Safety. This volume contains research summaries for the projects undertaken by faculty during 2002. 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/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 2002, the level of research effort overall at the Naval Postgraduate School was 195 faculty work years and exceeded \$60 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 FY2002, over 94% of the research program was externally supported. A profile of the sponsorship of the Naval Postgraduate School Research Program in FY2002 is provided in Figure 1.

INTRODUCTION

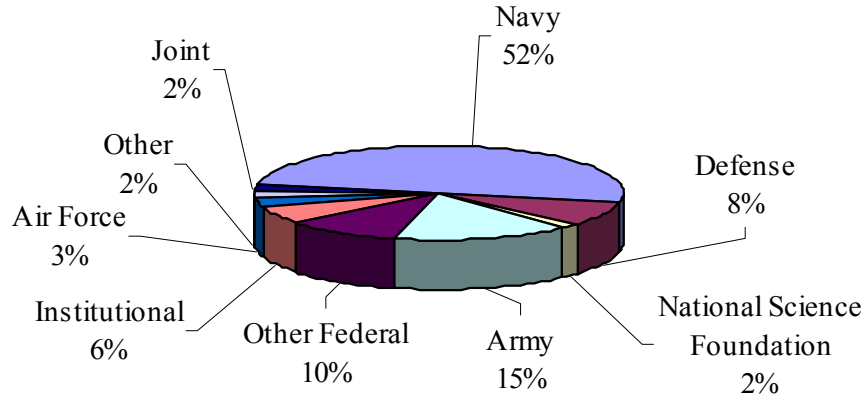


Figure 1. Profile of NPS Research and Sponsored Programs (\$61M)

The Office of Naval Research is the largest Navy external sponsor. The Naval Postgraduate School also supports the Systems Commands, Warfare Centers, Navy Labs and other Navy agencies. A profile of external Navy sponsorship for FY2002 is provided in Figure 2.

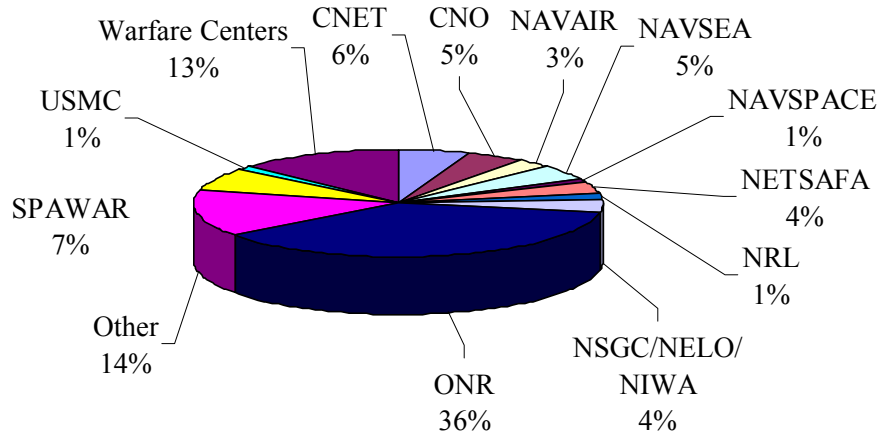


Figure 2. Navy External Sponsors of NPS Research and Sponsored Programs (\$31M)

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

January 2005

TABLE OF CONTENTS

PREFACE ix

INTRODUCTION xi

SCHOOL OF INTERNATIONAL GRADUATE STUDIES

DEPARTMENT OF NATIONAL SECURITY AFFAIRS

Department Overview 5

Faculty Listing 7

Research Summaries

 Iran’s Nuclear Weapons Program 9

 Policy and Strategy for Peace Support Operations 9

 Center for Contemporary Conflict/ Regional Security Education Program. Strategic Insights 9

 Command/Control Practices of New Military Powers 9

 NATO and Bio-defense 9

 Political-Military Analysis 10

 Regional Security Analysis 10

 Regional Security Education Program for Carl Vinson Battle Group 10

 Regional Security Education Program for the Lincoln Battle Group 10

 The Navy and Globalization 10

 Military Policies of Post-Soviet States: Sources and Conduct 11

 U.S.-Russian Workshop on Confidence-Building Measures In Strategic Command, Control and
 Communications 11

 Arms Control Compliance: Future Issues 11

 China’s Nuclear Future 12

 Naval Postgraduate School Outreach for Nuclear Strategy 12

 Analyzing New Strategic Concepts 12

 Europe and Information Warfare 13

 European Security and NATO Nuclear Policy 13

Faculty Publications and Presentations 15

GRADUATE SCHOOL OF OPERATIONAL AND INFORMATION SCIENCES

DEPARTMENT OF COMPUTER SCIENCE

Department Overview 23

Faculty Listing 25

Research Summaries

 Generative Decision Support Architecture Project 27

 Emergency Response for Cyber Infrastructure Management/Protecting Packet-Switched
 Communications Networks 27

 Applying Run-Time Monitoring to the Deep-Impact Fault Protection Engine 27

 Experiments with Test Case Generation and Runtime Analysis 28

 Integration of Rapid Prototyping and Runtime Verification 28

 FY02 Support for Computer Network Research Lab 29

 PKI Research and Training Laboratory 29

 CISR Information Assurance Scholarship Program 29

 CISR Information Assurance Studies and Research Program 30

 Critical Infrastructure Protection: An Interdisciplinary Course 31

 Emerging Technologies Impacting Information Assurance 32

 FAA Analyses 32

 IA Tutorials and Workshops for Educators 33

 Information Assurance Laboratory Development 34

 Information Ethics Development for the U.S. Navy 34

 Information System Certifier Education 35

 Monterey Security Enhanced Architecture Project 36

 Project Challenge Problems 37

TABLE OF CONTENTS

Security-Enhanced Windows CE	38
Secure Environments Research, Phase III (Project 107305).....	38
Sim Security.....	39
Sim Security Enhancements.....	40
Provide DL Architecture.....	41
Automated Software/Hardware Integration in DoD.....	42
Development of Software Engineering for NAVSEA Weapon System Software Safety Program	42
Dynamic Assembly for Systems Adaptability, Dependability, and Assurance (DASADA) Project	42
Engineering Automation for Reliable Software	44
Metcast Queries Development and Consulting	47
Metcast Software Integration	47
Software Risk Assessment	47
Testing of Large Software Intensive System	47
Weapon Software Safety Program in NPS Software Engineering Automation Center.....	48
Magma: A Liquid Software Approach for Fault Tolerance and Security for Server Agent-Based Active Networking Management (SAAM)	49
Computational Support for Testing and Evaluating Composed Heterogeneous Distributed Missile Systems	49
Engineering Technologies for the Warfighter 2002	50
Intelligent Software Decoys.....	51
Policies for Distributed Systems and Networks	52
Testing of Large Software-Intensive Systems.....	53
Fire Plan Sketch Manager for C2PC, Software Project	54
Automated Linguistic Analysis of Battlefield Intelligence Reports.....	54
Distance Learning Thesis Support for the Automated Policy Specification Research.....	55
Enhanced Sensor Formula for the Tactical Remote Sensor System (TRSS)	55
Basic Research in Information Privacy.....	56
A Networking Protocol for Underwater Acoustic Networks	56
SAAM: Network Management for Integrated Services	57
Integration of Heterogenous Software Systems Through Computer-Aided Resolution of Data Representation Differences	57
Faculty Publications and Presentations	59

DEPARTMENT OF DEFENSE ANALYSIS

Department Overview	67
Faculty Listing.....	69
Research Summaries	
Deceiving Terrorists.....	71
Research and Analysis of Terrorist Information Operations (RATIO): Phase One	71
Research and Analysis of Terrorist Information Operations (RATIO): Phase Three: 2001	71
Terrorist IO Analysis to Support Force Protection: Phase Two	71
Military Innovations: The Case of Special Operations Forces.....	72

DEPARTMENT OF INFORMATION SCIENCE

Department Overview	75
Faculty Listing.....	77
Research Summaries	
High Resolution Terrain Data Generation.....	79
Micro Terrain Tool Distribution Support.....	79
Terrain Database Toolkit.....	80
Adaptive Management of Wireless C4ISR Networks.....	80
Feedback Mechanisms for Agent-Based QOS Adaptive Management of Networking Resources	80
The Integrated Theater Assessment Profiling System (iTAPS)	81
Intelligent Agent Architectures to Support Aircraft Carrier Deck Operators.....	81

TABLE OF CONTENTS

Limited Objective Experiment on Peer-to-Peer Wireless Collaboration	82
Network Operation Center Collaborative Management	82
Development of Hf Radio-Wan	83
FY 02 IO/IW Research.....	83
Gun Weapons System Command and Control Project.....	84
Multi-Mission Maritime Aircraft (MMA) Simulation Project	84
Naval Simulation System (NSS) Course Development, OA/MV4655	84
Naval Simulation System (NSS) Development and Testing	85
Naval Surface Fire Support Project.....	85
FOSSAC: Study of Legacy Systems and Application Integration	85
Total Force Administration System (TFAS) Support	85
USAREC Recruiting Strategic Vision Program (RSVP) Wargame: An Operational Decision Making Agent-Based Simulation System.....	86
USAREC Recruiting Strategic Vision Program (RSVP)/ Recruiting Market Simulation (RMS) Wargame	86
Technical Support on the Command and Control Interface for the Expeditionary Sensor Grid (ESG) Enabling Experiment Program	86
Cognitive Task Analysis of Intelligence Information Managers.....	87
Adaptive Architectures for Command and Control.....	88
Center for Defense Technology and Education for Military Service	92
A Vulnerability Analysis of Cell Phones	96
Effects of EA-6B Jamming on Anti-Ship Missile Defense (ASMD).....	97
Jamming Tactics and Employment of EA-6B Against Advanced Radar and Tactical Data Link Systems	97
Jamming Tactics and Employment of UEU Against Advanced Radar and Communications Systems..	97
Missile IMU Model.....	98
Developing the Next Generation IEEE Dependability Standard: IEEE 982 Standard Dictionary of Measures of the Software Aspects of Dependability.....	99
Estimate and Control Software Fault Content More Effectively.....	99
Investigation of the Risk to Software Reliability of Requirements Changes	101
Naval Postgraduate School/HQ USPACOM Liaison Desk for Calendar Year 2002.....	102
United States Marine Corps Specific Software Integration Requirements of the Advanced Field Artillery Tactical Data System/Tactical Combat Operations Software Suites	104
Faculty Publications and Presentations	105

DEPARTMENT OF OPERATIONS RESEARCH

Department Overview	115
Faculty Listing.....	117
Research Summaries	
Chair of Applied Systems Analysis	119
Extensible Optimization Toolkit for Military Planning Systems	119
Large-Scale Optimization	121
Verification, Validation, and Accreditation of the Decision Support Toolbox, Version 2	123
Large-Scale Optimization	123
Munitions Investment Models.....	125
Optimizing Navy Program Planning.....	125
Applicability Assessment for Maritime Operations	126
Toolkit for Evaluating Algorithms for Internetting of Fires.....	127
Officer Candidate School Data Analysis Study	128
Officer Recruiting Structure II, Task 2	128
Sensor Mix Study.....	129
Lessons Learned from Infrastructure	129
Optimization Models for Installation Management	130
Nuclear Proliferation Assessment	130

TABLE OF CONTENTS

Analytical Decision-Supporting Research Using Synthesized Adaptive-Agent-Based Modeling and Mathematical Modeling	131
Joint Experimentation HIGH-Level-Low-Resolution Modeling.....	132
Modeling the Benefits and Risks of Mine Avoidance.....	132
Models for Liver Insult and Recovery	133
Training and Research Support for Director, Operational	133
Test and Evaluation.....	133
Development of Joint Experimentation Methodology, Courseware and Handbook	134
Data Quality Assurance to Support NAVSUP Logistics	135
Joint Interoperability Testing of Air and Space Surveillance Systems	135
CNET: Joint Combat Modeling	136
The Value of Information and Analysis of Combat Data.....	136
The Effects of Reversing Sleep-Wake Cycles on Sleep and Fatigue on the Crew of USS <i>JOHN C. STENNIS</i>	137
Fatigue Effects on Team Performance	137
Modeling Human Elements of Decision Making.....	138
NETFIRES Dynamic Allocation of Weapons Effects	138
Sleep Patterns in U.S. Navy Recruits: An Assessment of the Impact of Changing Sleep Regimens... ..	139
Sleep Patterns of U.S. Navy Submariners.....	139
Lines of Communication and Agent-Based Systems	140
Support for the Joint Staff Force Structure, Resources and Assessment Directorate	140
Dynamic Allocation of Strike Force Asset.....	141
Optimization Modeling for Planning Investments in Airlift Infrastructure and Tanker Fleet.....	141
Optimizing Tomahawk Land Attack Predesignation	142
Homeland Security Research and Technology Proposal (Optimizing Electric Grid Design Under Asymmetric Threat)	142
Adaptive Exploration of Agent-Based Command and Control Simulations	142
Ground Logistics Command and Control	144
Modeling and Simulation Analysis for Expeditionary Logistics	144
Research on Aggregated Combat Models II - Methodology for the Comparative Evaluation of Models	145
Linear Program/Partially Observable Markov Decision Processes Information Optimization Methodology	145
Targeting Optimization	145
A Comparison of Two Methods of Scoring Impact Locations	146
Naval Postgraduate School/Rand Mobility Optimizer Model Support.....	146
Summer Program in Operations Research Technology, Distinguished Visiting Professors	146
Large-Scale Mixed Integer Programming.....	147
Large-Scale Network Algorithms	147
Parallel Computing for the NPS Optimization Lab.....	147
Support for the Center for Operations Research, National Security Agency	147
Faculty Publications and Presentations	149

GRADUATE SCHOOL OF ENGINEERING AND APPLIED SCIENCES

DEPARTMENT OF AERONAUTICS AND ASTRONAUTICS

Department Overview	163
Faculty Listing.....	165
Research Summaries	
Active Launch Vibration Isolation	167
Angular Rate Estimation by Dynamic Gyro for Spacecraft Attitude Control.....	167
Bifocal Relay Mirror Technology Development.....	167
Dual Line of Sight Control.....	167
Multi-Body Flexible Dynamics and Control Models.....	168
Relay Mirror Testbed	168

TABLE OF CONTENTS

Satellite Servicing Laboratory.....	168
Spacecraft Systems	168
Swarm-Formation Satellite System Design	169
Vibration Suppression and Isolation in the Imaging Spacecraft	169
Advanced Material and Cooling Systems for Liquid Rocket Engine Components	169
A Diagnostically Enhanced Six DOF Thrust Stand for Pulse Detonation Engine Testing	169
The Effects of Rocket Motor Operating Conditions on Exhaust Plume Soot Concentrations and IR Signature	170
Identification and Characterization of Critical Issues for Pulse Detonation Engine Development.....	170
Liquid Rocket Engine Signature Studies.....	170
Pulse Detonation Technology Development.....	170
Unsteady Fuel Injection Studies.....	171
Experimental Studies of Compressible Dynamic Stall Control	171
A Fundamental Study of Compressible Dynamic Stall and Its Control Over a Variable Droop Leading Edge Airfoil.....	172
Steady and Unsteady Flow Control for Dynamic Stall and Hub-Drag Reduction	172
Support of FSU/FAMU Experimental Studies of Compressible Dynamic Stall Control.....	173
Aircraft Combat Survivability, Reliability and System Safety Engineering	173
F/A-18 C/D Avionics Architecture Study	174
UHF Electrically Scanned Array (UESA) Study	174
Cascade Vortex Shedding Study	174
Modeling and Instrumentation for Precision Airdrop Guidance, Navigation, and Control for Precision Airdrop	174
Continued Development of the Affordable Guided Airdrop System	175
Integration and Flight Test of UCLA's Navigation Computer on NPS's UAV Frog	175
Competency Education Package for Aircraft Structures.....	175
Finite Element Multi-Disciplinary Analysis of Flight Vehicles.....	175
Aeronautical Engineering Curriculum Support.....	176
An Experimental and Computational Investigation of Oscillating Airfoil Unsteady Aerodynamics at Large Mean Incidence.....	176
Cross-Flow Fan for VTOL Airplane.....	176
Development of Micro Air Vehicle	177
Improvement of IFLOW	177
NPS/CIRPAS Support of ONR Airborne Research Objectives	177
Evaluation of a New Approach to Efficient Trajectory Optimization.....	177
Evaluation of a Predictive Method for Near-Optimal Guidance	177
Advanced Fan and Compressor Development Studies	178
HCF/SPIN Test Research.....	178
Research in the Acoustic Detection of the RAH-66 Comanche Helicopter	178
Research in Damper Free Rotor Design Based on Maple Generated Non-Linear Simulation.....	179
Research in the Structural Dynamic Response of the RAH-66 Comanche Helicopter	179
Faculty Publications and Presentations	181
 DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING	
Department Overview	187
Faculty Listing.....	191
Research Summaries	
Arctic Antenna Site Evaluation.....	193
Noise and Interference Affecting the Performance of Existing and Proposed Communication Systems	193
Integrated Fight-Through Power and Advanced Power Converter Modules	193
Beowulf Systems Distributed Network Operations Research.....	194
FY02 Support for the Computer Network Research Laboratory and Thesis Research.....	194
Investigation in Disparate Sensor Integration for the Early Warning of Biological and Chemical Threats	194

TABLE OF CONTENTS

Detection, Classification, and Processing of Wireless Local Area Network Signals	194
NSA/ATD Cryptologic Research Lab and Thesis Research Support	195
Effectiveness of Broadband Antenna Designs	195
Feasibility Study on Applications of UV Filaments to Surface Wave Propagation	195
Vulnerability of Wireless Networks in Indoor and Urban Environments	196
Antenna Development for Man-pack Tactical Radios	196
Concealed Weapons Detection.....	196
Design and Prototype of Wideband USQ-113 Antennas for EA-6B	196
Ultrawideband Antenna for the USQ-146 Installation in the H-60 Helicopter	197
USQ-146 Low-profile Omni-directional Ultra-Wideband Antenna for Shipboard and Vehicular Use	197
USQ-146 Low-profile Quadrant-Switchable-Beam Ultra-Wideband Antenna for Shipboard and Vehicular Use.....	197
CNSG 04/05 Mid-Career Technical Update	197
Project Gusty Oriole.....	198
Triple-Modular-Redundant Architectures for Reliable Space-Based Computing.....	198
Timing-based Communication Channels	198
Wireless Networking Protocol Vulnerability Assessment	198
Radiation Tolerant ASIC and Photovoltaic Devices for Space-based Systems	199
Radiation Tolerant ASIC and VLSI Devices for Space-based Systems.....	199
Gusty Yearling, Task A.....	199
Magnetic Field Sensor Placement and Time-reversed EM Imaging Studies	199
Optimization of Magnetic Field Sensor Placements Using a Genetic Algorithm	200
System Vulnerability and Shielding Effectiveness Study: Task F1947	200
System Vulnerability Study: Task F1947	200
AEA Software Support Activity and SEAD Analysis	200
Digital Target Imaging Architecture for Multiple Large Target Generation.....	201
Navy Surface Anti-ship Cruise Missile Threat Simulator Validation Working Group.....	201
Open Loop Analysis and Cruise Simulation Studies of DTIB Results.....	201
Integrated Sensing and Processing.....	201
JSIPS-N Communications, Model and Simulation Research Project	202
Modeling and Simulation of JSIPS-N Communications Architecture (JCA)	202
SILVACO Tools Development.....	202
Advanced RF Receiver System Architectures	202
Electromagnetic Susceptibility and Analysis of Critical Infrastructure Systems	203
Green Acres Project	203
High Performance Deinterleaver Using MOP Parameters	203
Preliminary Investigation at Desert Facility.....	203
Reduced Crew Size Metrology Using Wireless LANs and Wearable PCs	203
Submarine Wireless Local Area Networking.....	204
Computer Aided Detection for Synthetic Aperture Sonar System	204

DEPARTMENT OF MATHEMATICS

Department Overview	207
Faculty Listing.....	209
Research Summaries	
Total Least Squares Fitting of Ordered Data with Polynomial Splines.....	211
Modeling the Spread of Biological Infections in a Functioning Military Unit	211
Thermocapillary Effects in Welding.....	212
Buckling of Ship Grillages with Bulb Flat Stiffeners	212
Guidance and Control Algorithms for Hypersonic and Reusable Launch Vehicles	213
Trajectory Guidance Using a Spectral Method	213
Visiting Professor at U. S. Military Academy.....	214
Aspects of the Statistical Theory of Shape.....	214
Convergence of the Shifted QR Algorithm for Unitary Hessenberg Matrices.....	215

TABLE OF CONTENTS

Convergence of the Unitary QR Algorithm with a Unimodular Wilkinson Shift	215
Information System Certifier Education	215
Analysis of Data from the Multi-center Validation Project	216
Integrated Cooperative Control of Satellite Formations	217
New Trends in Nonlinear Dynamics and Control and Their Applications.....	218
Galerkin Spectral Synthesis Methods	218
A Study of Lateral Boundary Conditions for the NRL's Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS).....	219
Models of Endogenous Formation of Coalitions	220
Stability in Situations of Shifting Balance of Power.....	220
Acoustic Radiation and Scattering from Submerged Structures	220
Fifth International Symposium	221
Finite Element Modeling of High Frequency Acoustics	221
NPS Mine and Undersea Warfare Program	222
Faculty Publications and Presentations	223

DEPARTMENT OF MECHANICAL ENGINEERING

Department Overview	229
Faculty Listing.....	231
Research Summaries	
Total Ship Systems Engineering (TSSE) in Support of NAVSEA Contract Design	233
The Acquire Model and Its Application to the MOUT Environment	233
JMEM Air to Surface Tasks 3,8,16.....	233
Development of Smart Microelectronic Solder Joints for Microelectronic Packaging.....	234
Interfacial Sliding in Multi-Component Systems.....	234
Thermo-Mechanical Behavior of Solder Joints for Electronic Packaging	235
Evaluation of Cooling Technologies for Magnetostrictive Actuators.....	236
Modeling of Heat Transfer in a Rocket Engine Combustion Chamber.....	237
Thermophotovoltaic (TPV) Power Conversion	237
Turbine Convective Cooling Concepts Evaluation	238
Sponsors: Naval Air Systems Command, Naval Air Warfare Center and Defense Advanced Research Projects Agency.....	238
Evaluation of Vendor-Proposed Concepts for Motion Compensation for Roll-on/Roll-off Stern Ramps	239
Center for Autonomous Underwater Vehicle Research DURIP Project	240
Center for Autonomous Underwater Vehicle Research	240
Tactical Decision Aids Using Modeling and Simulation	241
Development of Interactive Finite Element Method on the World Wide Web	242
Effects of Micro-Structural Variation on Local Damage Initiation and Growth of Specimen.....	242
Modeling in Nano-Mechanics.....	243
Ship Damping Studies for Energy Dissipation in Ship System.....	243
The Mechanical and Microstructural Characterization of Commercial AA5083 Materials.....	244
Microstructure Evolution and Control During Friction Stir Processing (FSP) of Cast Naval Bronze Materials.....	245
Ultra-Fine and Nano-Grain Microstructures by Severe Plastic Deformation.....	246
Low Observable Multi-Function Stack (LMS) Exhaust Enhanced Mixing Suppressor.....	247
Review of Advanced Technology Gas Turbine Research and Development Programs	248
Distance Learning Support for TS4001.....	249
Extended State Space Modeling of RRDF	249
Motion Minimization in High Speed Towing Operations.....	249
Robust Distributed Control of Shipboard Systems	250
Dynamics of Bow Waves/Spray Generation.....	251
Flow-Induced Vibrations	251
Mechanism of Spray Generation at the Free Surface of Liquid Jets.....	252
Model of Dynamics and Decay of Wake Vortices in Parallel Runways.....	253

TABLE OF CONTENTS

Review of Hydrodynamic Loads on Structures.....	253
Ship Damping Studies for Energy Dissipation in Ship Structure System.....	254
Shock and Vibration Analysis in Support of DDG-81 Class Shock Follow-On Actions.....	255
Faculty Publications and Presentations	257

DEPARTMENT OF METEOROLOGY

Department Overview	265
Faculty Listing.....	267
Research Summaries	
Dynamics of Northwest Pacific Tropical Disturbances and Monsoon.....	269
Forecast of Cloud Probability in Southeast Asia.....	270
Monsoon Disturbances Over the China Seas	270
Monsoon-Enso Interactions	271
An Integrated Model for Assessment of Rf/IR Detectability for Force Protection.....	272
Atmospheric Corrections for Geodetic Quality Radio Ranging Using Real Data	273
Buoy Power Generation: ONR Small Business Innovation Research Program.....	274
Demonstration of Linked UAV Observations and Atmospheric Model Predictions in Chem/Bio Attack Response.....	274
Evaluation of MBL Profile Estimations (TDrop and Bulk Methods)	275
Long-Term Flux-Buoy Measurements at Wallops Island: Mean METOC, Turbulence, Near-Surface Scalar Profiles, and Surface Waves.....	276
METOC Data Acquisition (MORIAH/SMOOS(R)).....	276
Refractivity Profile Collection During Vessel Signature Tests: Dam Neck, VA, and San Clemente Island, CA	277
Refractivity Profile Collection: RED and SCI'01	278
Scaling Near-Surface Atmospheric and Surface Wave Influences on Radar Propagation Over the Sea (RED)	279
The Application of Regional Aerosol Properties to AVHRR Aerosol Retrieval Algorithms	280
Satellite-Derived Marine Atmospheric Boundary Layer and EM/EO Properties	281
Target Area METOC Merit Support	281
Structure Changes of Tropical Cyclones.....	282
Support of U.S. Weather Research Project Hurricane Landfall Science Coordinator.....	283
Systematic Approach to Tropical Cyclone Forecasting	284
Transition of Dynamical Model Track Prediction Evaluation System.....	285
Tropical Cyclone Motion and Structure Studies	285
Using the SHEBA Flux Data to Improve Regional and Global Climate Models.....	286
Numerical Studies of the Physical Oceanography of the Mediterranean Sea	288
Evolution of Tropical Cyclone Characteristics	289
Predicting Tropical Cyclone Formation and Structure Change.....	290
NOWCAST for the Next Generation Navy	291
GLOBEC – Northeast Pacific Climate Change Mechanisms	291
Meteorology, Oceanography, and Military Operations.....	293
Development of Marine Forecaster Training Materials	294
Development of Mesoscale Training Materials	294
High Resolution Fire Weather Modeling.....	294
Practical Limits to Atmospheric Mesoscale Predictability.....	295
Analyses of Aircraft Measurements of Boundary Layers and Stratus Clouds in the Arctic	296
Evaluations of Surface Flux and Boundary Parameterizations in CoAmps Using Aircraft Measurements	296
Implementing and Testing Entrainment Parameterization for Stratocumulus-Topped Boundary Layers in CoAmps.....	297
Improving Surface Flux Parameterization in the Navy's CoAmps.....	297
Understanding the Evolution of Stratocumulus Clouds in the Coastal Zone	298
Collaborative Research Projects in Direct Support of FNMOC Operational Mission	299
METOC Support for Operationally Focused Thesis.....	300

TABLE OF CONTENTS

Boundary Layer Effects on Atmospheric Fronts.....	300
Boundary Layer Effects on Mesoscale Phenomenon.....	301
Faculty Publications and Presentations	303
 DEPARTMENT OF OCEANOGRAPHY	
Department Overview	315
Faculty Listing.....	317
Research Summaries	
ONR Chair in Artic Marine Science	319
Coupled Ocean Acoustics and Physical Oceanography Observations in the South China Sea: The NPS Acoustic Component	319
Determination of the Detection and Classification Probabilities and Range Limits of Inexpensive Acoustic Sensors and Data Processing Techniques for Monitoring Odontoceti Whales	320
Uncertainties and Interdisciplinary Transfers Through the End-to-End System (UNITES).....	321
Assessment and Reconstruct of Navy’s Mine Impact Burial Prediction Model	322
Littoral Zone Oceanography for Mine Warfare	324
Littoral Zone Oceanography for Mine Warfare	326
Value-Aided of Altimetry Data to Undersea Warfare.....	329
GPS Antarctic Landing System: Landing Systems Committee Studies.....	330
Student Experience Tour – Differential GPS at AUTEC	330
Central California Hydrographic Surveys.....	330
Ocean Current and Sediment Trap Measurements.....	331
Nonhydrostatic Modeling of West Florida Shelf Flow and Tracers.....	332
Collaborative Research: Nearshore Canyon Experiment	333
Nearshore Canyon Experiment	334
Arctic Ocean Model Intercomparison Project (AOMIP)	335
Carbon Cycling in the Chukchi and Beaufort Seas-Field and Modeling Studies.....	336
Coupled Biophysical Modeling of the Arctic Ocean	337
Interannual Variability of Biophysical Linkages Between the Gulf of Alaska and Bering Sea	338
Evaluation of the POP Model for Navy Forecasting Use.....	339
Mesoscale Variability and Processes in an Eddy-Resolving Global POP Simulation	340
Analysis of Hf Radar Data from the Northern Adriatic Sea.....	340
Diurnal to Seasonal Variability of Surface Ocean Currents from High Frequency Radar.....	341
GLOBEC Mapping the Evolution of Mesoscale Jets and Eddies in the Upwelling Ecosystem Off Cape Blanco, or Using Long-Range High Frequency Radar.....	341
An Innovative Coastal-Ocean Observing Network (ICON)-Renewal	342
Modeling the Central California Coastal Upwelling System: Physics, Ecosystems and Resource Management.....	343
Adriatic Mesoscale Experiment	344
Mediterranean Drifter Data Analysis	344
Aerial Surveys of the Ocean and Atmosphere Off Central California	344
GLOBEC: Moored Current Observations Along the Eureka LTOP Transect	345
Processes in Marginal Seas – and – Asiaex Project Management.....	346
A Relocatable Real-Time Coastal Ocean Observing System.....	348
Development of Training Materials for Users of Navy Operational Ocean Circulation and Tide Models	348
Investigation of Source of Huntington Beach Sewage Contamination	348
Sediment Transport in Monterey Canyon	349
Application of Parallel Ocean and Climate Models to Decade/Century Prediction	350
Development of a Geodesic Climate Model with Quasi-Lagrangian Vertical Coordinate	350
Collaborative Research: The Role of Ice-Ocean Exchange in Ice-Albedo Feedback	351
Modeling Thermobaric Effects in Antarctic Deep Ocean Convection.....	351
Observation of Velocity Fields Under Wind-Forced Waves.....	352
Upper Ocean Effects on the Surface Heat Budget of the Arctic Autonomous Ocean Flux Bouy.....	352
Evolution of Rip Currents and Morphology: Field Experiments and Numerical Modeling	353

TABLE OF CONTENTS

Modeling and Torrey Pines Beach Nourishment	354
Near Shore Wave Processes	354
Interannual to Decadal Ocean Variability and Predictability	355
Faculty Publications and Presentations	357

DEPARTMENT OF PHYSICS

Department Overview	373
Faculty Listing	375
Research Summaries	
ISAR Imaging of Targets in Low Signal-to-Clutter Environments	377
Radar Image Estimation and Model Assessment by Subspace Fitting	377
Underwater Warhead Technology	378
A 100KW Free Electron Laser Design	379
A 100KW Free Electron Laser Design	380
Computational Free Electron Laser Research	380
High Energy Laser Weapons: Modeling and Simulations	381
TJNAF High Power Free Electron Laser Research	382
UMD/NPS Free Electron Laser Research	383
Infra-Red Research - Thermal Imaging Models	383
Spectral Imagery in the Near-Ultraviolet	384
Active Mirror Alignment for Free-Electron Lasers on Ships	385
Nonradiating Wave Sources	385
Parametric Excitation	386
Development of Network Vulnerability Analysis Training System (VATS)	387
Laser Beacon Prototype	387
Laser Beacon Prototype for Missile Defense	387
Infrared Face Recognition System for Human Identification Using Uncooled Infrared Imager	388
Optical Sensors Operating Similar to Biological Vision Systems	388
Laser Plasma Radiation Source Development	389
Bilge Water Separation Column Using Sound	389
Laser Beacon Prototype F/Missile Defense	390
Ultra-Violet Filaments to Surface wave Propagation	390
Railgun Technology: Interface Between Rail and Projectile	390
Third Fleet-NPS Faculty Research Desk	391
Physics of Mine Detection in Surf Zone	391
Research F/Detection of Buried Mines	392
Study of Seismic Sonar Demonstrations	392
CMO R&D Technical Assistance	392
MASINT Support for the Army	392
OSD Liaison and Operation Noble Eagle	393
Research in Spectral Temporal Imaging	393
Spectral Polarimetric Imagery Support	394
Terrain Categorization via Sensor Fusion	394
Analysis of Acoustic Navigation Subsystem for Trident Submarines	394
Reverberation Modeling and Data Analysis in ASIAEX (FY02)	395
Study of Domestic Infrastructure Vulnerability to High Power Microwaves	396
Threshold Cathode Test Facility (TCTF)	397
Disparate Sensor Integration	398
Dual IR Collection and Calibration	398
Predicting Electro-Optical Performance from Space	398
Atmospheric Optical Turbulence Modeling	399
Mesoscale Modeling of Atmospheric Optical Turbulence	400
Faculty Publications and Presentations	401

TABLE OF CONTENTS

SPACE SYSTEMS ACADEMIC GROUP

Department Overview 409
Faculty Listing..... 411
Research Summaries
 Advanced Multi-Junction Solar Cells Measurement System for NPSAT1 Satellite 413
 Ferroelectricity Research Newsletter 413
 Lithium-Ion Polymer Battery Technology Development for NPSAT1 Satellite 413
 Naval Space Systems Academic Chair 413
 NPS NSAT1 Satellite Instructional Support 414
 Space Systems Operations Student Thesis Research/Experience Tour..... 414
 Space Systems Students Thesis Research Projects, Directed Studies and Space Engineering
 Experience Tour 414
 Aeroassisted Maneuvers and Mission Design..... 414
 Military Application of Space Research Project - Basic Funding for 2002-2003 414
 First Principles Prediction of X-Ray Impulse 415
Faculty Publications and Presentations 417

GRADUATE SCHOOL OF BUSINESS AND PUBLIC POLICY

School Overview 423
Faculty Listing..... 427
Research Summaries
 System Dynamics Decision Support Tool for Obesity Treatment Program..... 431
 Commander 3d Fleet Appreciative Inquiry Summit 431
 Information Professional (IP) Community ESC and Summit 431
 Service School Command Esc and Summit 431
 Establishment of Acquisition Chair 432
 Safe Schools Project..... 432
 Economic and Return-on-Investment Analysis for Advanced Technology Ordinance Surveillance... 432
 Intelligent Agents and Web-Based Markets for Detailing Naval Personnel 433
 Optimal Slotting of Forward Pick Areas for the Defense Distribution Center..... 435
 Sea Based Warehousing..... 435
 Analysis of Budget Reduction, Cost-Avoidance and Financial Management Initiatives in
 COMNAVAIRPAC 436
 Simulation Modeling Analysis of Sea Ports of Debarkation (SPODs) 437
 Comprehensive Study of Junior ROTC 438
 Description and Assessment of Personnel Security Process and Procedures for Military Personnel... 438
 Evaluation of Efficient Officer Commissioning Source Mixes..... 438
 Research Design and Methodological Support 438
 Building Causal Performance Models from Qualitative Data..... 439
 Corporate Equality Index: A Stock Market Reaction Study 439
 Management Control and Performance Measurement: An Empirical Test of Causal Relations..... 439
 Development of Aspen Data Base 440
 General Educational Development (GED) Screening Pilot Study - Part II..... 440
 Support to MSA Curriculum from Chief of Naval Personnel 440
 Intelligent Agents and Web-Based Markets for Detailing Naval Personnel 441
 Knowledge-Flow Theory for Very-Large Enterprises 441
 Application of Information Technology to Peace Operations and Complex Emergencies 442
 Financial Reporting and Analysis Research for the Department of Defense Personnel Security
 Research Center 443
 The Impact of Information Technology Investments..... 443
 Navy Senior Executive Managing Diversity Seminar..... 444
 Efficient Estimation of Population Proportions 444
 Multiple-Choice Tests in Classical and Modern Test Theory 445
 Part and Partial Correlations in Standardized Testing..... 445

TABLE OF CONTENTS

Quantile Logistic Models	446
Sequential Testing for Selection	446
Faculty Publications and Presentations	447

INSTITUTES AND CENTERS

INSTITUTE FOR INFORMATION SUPERIORITY AND INNOVATION (I2SI)

Institute Overview	459
Faculty Listing.....	461
Research Summaries	
Research Summary CDTEMS Support for I2SI	465
Research Summary NPS CISR Scholarship for Service	466
Faculty Publications and Presentations	467

WAYNE E. MEYER INSTITUTE OF SYSTEMS ENGINEERING (MISE)

Institute Overview	473
Faculty Listing.....	475
Research Summaries	
Navy’s Mine Impact Burial Predict Model	477
Data and Analysis Support for Fleet Battle Experiment-Juliet	477
Center for Defense Technology and Education for the Military Services (CDTEMS).....	478
Test of Design of Sparse Optical Array	478
Unconventional Weapons of Mass Destruction	479
A Strategy for Dealing with Islamic Terrorists	480
Directional Transducer Measurement Facility	480
NPS Mine and Undersea Warfare Program	481
Anti-Terrorism Information System.....	481
Force Protection Experimentation, Non-Lethal Weapons Testing.....	481
Force Protection Limited Objective Experiment.....	482
NPN Fleet Implementation, Systems and Process Analysis.....	483
Faculty Publications and Presentations	485

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

Institute Overview	493
Faculty Listing.....	497
Research Summaries	
Modeling and Simulation Technical Support.....	499
Extensible Modeling and Simulation (XMSF): Establish Requirements, Develop Exemplars.....	499
Generic Hub: XML-Based Information Interchange for Defense Messaging, Shipboard/Theatre	
Command and Control, Distributed 3D Battlespace Visualization	499
NPSNET-V - Semantic Interoperability for Large-scale Networked Virtual Environments	500
Rendering Dynamic Structures Using Web-Capable 3D Models for Military Simulations.....	500
Streaming 3D Graphic Using VRTP for Distributed Simulation	500
Naval Surface Support for Joint Land Warrior	500
Adaptive Monitoring and Validation of Agent-based systems	500
Synthetic Ocean for Modeling, Virtual Environments, and Simulation (MOVES) Using the	
Arcview Geographic Information System (GIS).....	500
ATC Procedures for Simultaneous Non-Interfering Flight Within the National Airspace System.....	501
Explanations Used in Tutoring.....	501
MV-22 Crew Training for Deployed Expeditionary Forces: Marine Corps Air to Ground Operations	502
Virtual At-Sea Trainer.....	503
Analytical Decision-Supporting Research Using Synthesized Adaptive-Agent-Based Modeling	
and Mathematical Modeling.....	503

TABLE OF CONTENTS

NPS-MOVES Agent Architecture	504
Center for the Study of Potential Outcomes.....	504
DC Trainer Experiment.....	504
Hybrid Inertial Motion Tracking for Inserting Humans into Networked Synthetic Environments.....	504
Counterplanning in Simulation of Information Warfare	505
Audio Design Principles From the Entertainment Industry and High End Audio Servers Applied to Navy and Marine Corps Training.....	506
Audio Technology and Management in Modern Navy Systems.....	506
Developing an Audiometric Measure to Assess Localization Performance for Virtual Environments and Spatialized Auditory Displays	506
Upgrading Ground-Combat Attrition and Movement for Item	507
America’s Army-Combat Medic.....	507
Army Game Project	507
The Context Machine.....	508
Inertial Motion Tracking for Inserting Humans into a Networked Synthetic Environment.....	508
The MOVES Institute	508
Virtual Vaudeville.....	508
Faculty Publications and Presentations	509

CENTER FOR INTERDISCIPLINARY REMOTELY PILOTED AIRCRAFT STUDIES (CIRPAS)

Center Overview.....	515
Faculty Listing.....	519
Research Summaries	
Aura Engineering Flight Test Support	521
CIRPAS Coordination F/Scientific Outreach.....	521
CIRPAS Predator Flight Support	521
CIRPAS Predator Flight Support F/EDU-2	521
CIRPAS Predator Flight Support for Millenium Challenge 02.....	522
CIRPAS Support of Swarm Deployment.....	522
HERT Integration and Flight Test Support	522
Integration of Aerosol and Wind Lidar onto CIRPAS’ Twin Otter	522
JCIET Pelican Flight Support	523
JTFEX02-1 UAV Flight Support.....	523
Predator Flight Operations for CVW-14.....	523
Formation and Perpetuation of Rifts and Gradients in Optical and Microphysical Properties of Maritime Stratus and Stratocumulus.....	524
NPS/CIRPAS Support of Office of Naval Research Airborne Research Objectives	524
Faculty Publications and Presentations	525

SCHOOL OF AVIATION SAFETY

School Overview	531
Faculty Listing.....	533
Research Summaries	
Analysis of Aggregate Statistical Data.....	535
Organizational Risk Model Development.....	536
Organizational Safety Risk Assessment System	537
Analysis of Aggregate Statistical Data from the Command Safety Assessment and Maintenance Climate Assessment Systems	538
Human Factors Tools and Interventions for Improving Maintenance Error Management.....	539
Maintenance Error Risk Assessment and Strategic Intervention	540
Reliability Business Process Reengineering	541
Faculty Publications and Presentations	543

INDEX BY PRINCIPAL INVESTIGATOR.....	547
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**SCHOOL OF INTERNATIONAL
GRADUATE STUDIES**

**PAUL STOCKTON
DEAN**

**DEPARTMENT OF
NATIONAL SECURITY AFFAIRS**

**JAMES WIRTZ
CHAIR**

NATIONAL SECURITY AFFAIRS

OVERVIEW:

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

CURRICULA SERVED:

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

DEGREE GRANTED:

- Master of Arts in National Security Affairs

RESEARCH THRUSTS:

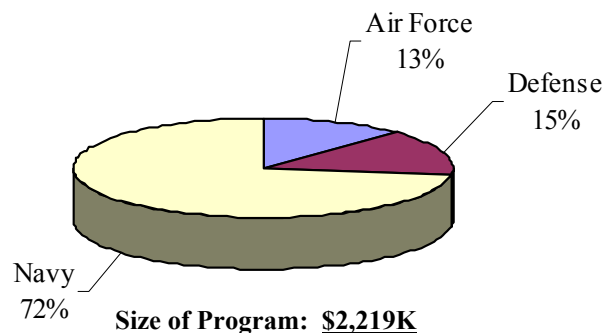
- Strategic Studies
- Joint Intelligence
- Regional Security Studies
- Civil-Military Relations and International Security
- Resource Planning and Management for International Defense (RePMID)

RESEARCH CENTERS:

- Center for Contemporary Conflict

SPONSORED RESEARCH PROGRAMS (Research and Academic)-FY2002:

The Naval Postgraduate School's sponsored program exceeded \$61 million in FY2002. Sponsored programs included both research and educational activities funded from an external source. A profile of the sponsored program for the Department of National Security Affairs is provided below:



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NATIONAL SECURITY AFFAIRS

IRAN'S NUCLEAR WEAPONS PROGRAM

Ahmad Ghoreishi, Lecturer

Department of National Security Affairs

Sponsor: Naval Information Warfare Activity

OBJECTIVE: To advance understanding of Iran's nuclear weapons program. This includes analyzing and assessing capabilities and intentions of the program.

KEYWORDS: Iran, Nuclear Weapons

POLICY AND STRATEGY FOR PEACE SUPPORT OPERATIONS

Karen Guttieri, Assistant Professor

Department of National Security Affairs

Sponsor: Defense Institute of International Legal Studies

OBJECTIVE: This research included developing a survey for peacekeeping decision makers and participation in focused discussion on civil-military coordination. Do certain conditions exist within a country that make it more or less likely to participate effectively in peacekeeping? What are state motivations to send troops? What does peacekeeping strategy formulation involve and how do civil and military actors coordinate their operations?

KEYWORDS: Peacekeeping, Civil-Military Coordination

CENTER FOR CONTEMPORARY CONFLICT/ REGIONAL SECURITY EDUCATION PROGRAM. STRATEGIC INSIGHTS

Peter R. Lavoy, Assistant Professor and Associate Chair for Research

Department of National Security Affairs

Sponsors: Naval Postgraduate School, Office of Naval Research

OBJECTIVE: The aim of this contract was to support Naval Postgraduate School (NPS) faculty members and contractors to produce strategic insights for the website of the Center for Contemporary Conflict and the Regional Security Education Program. URL: www.ccc.nps.navy.mil.

KEYWORDS: Center for Contemporary Conflict

COMMAND/CONTROL PRACTICES OF NEW MILITARY POWERS

Peter R. Lavoy, Assistant Professor and Associate Chair for Research

Department of National Security Affairs

Sponsor: Naval Engineering Logistics Office

OBJECTIVE: The goal of this research was to analyze command and control arrangements of states that recently have acquired or are in the process of acquiring weapons of mass destruction (WMD).

NATO AND BIO-DEFENSE

Peter R. Lavoy, Assistant Professor and Associate Chair for Research

Department of National Security Affairs

Sponsor: Defense Threat Reduction Agency

OBJECTIVE: The goal of this project was to host a NATO seminar on Bio-defense in Monterey, CA, 27-29 June 2001.

KEYWORDS: Biological Weapons, NATO

NATIONAL SECURITY AFFAIRS

POLITICAL-MILITARY ANALYSIS

**Peter R. Lavoy, Assistant Professor and Associate Chair for Research
Department of National Security Affairs
Sponsor: Defense Intelligence Agency**

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

KEYWORDS: Nuclear Weapons, India, Pakistan

REGIONAL SECURITY ANALYSIS

**Peter R. Lavoy, Assistant Professor and Associate Chair for Research
Department of National Security Affairs
Sponsor: Naval Engineering Logistics Office**

OBJECTIVE: The aim of this multi-author research project was to analyze the lessons learned by Indian and Pakistani political and military officials from the 1999 India-Pakistan Kargil conflict with regard to the likelihood and character of war in south Asia today.

KEYWORDS: Nuclear Weapons, India, Pakistan

REGIONAL SECURITY EDUCATION PROGRAM FOR CARL VINSON BATTLE GROUP

**Peter R. Lavoy, Assistant Professor and Associate Chair for Research
Department of National Security Affairs
Sponsor: Commander Pacific Fleet**

OBJECTIVE: The aim of this project was to enable NPS faculty members to conduct the Regional Security Education Program for the Carl Vinson Battle Group.

REGIONAL SECURITY EDUCATION PROGRAM FOR THE LINCOLN BATTLE GROUP

**Peter R. Lavoy, Assistant Professor and Associate Chair for Research
Department of National Security Affairs
Sponsor: Commander Pacific Fleet**

OBJECTIVE: The aim of this project was to enable NPS faculty members to conduct the Regional Security Education Program for the Lincoln Battle Group.

THE NAVY AND GLOBALIZATION

**James Wirtz, Professor and Chair
Robert E. Looney, Professor
Dan Moran, Associate Professor
Department of National Security Affairs
Sponsor: National Defense University**

NATIONAL SECURITY AFFAIRS

MILITARY POLICIES OF POST-SOVIET STATES: SOURCES AND CONDUCT

Mikhail Tsyarkin, Associate Professor

Department of National Security Affairs

Sponsors: Naval Information Warfare Activity, Naval Postgraduate School

OBJECTIVE: This multi-year research process directly supports DON mission. Research conducted provides the sponsor with reports on various aspects of the problem being investigated as required.

SUMMARY: This research involved one research trip to Russia and a research report on Russian security policy in the aftermath of the September 2001 terrorist attacks on the US. This work also involved organizing an international conference on Russian security policy after 9/11; papers presented at the conference were provided to the sponsor. The researcher continued to manage, as required by the sponsor, a fellowship in the US for a Russian specialist on strategic systems.

THESES DIRECTED:

Andrew, R.B., "The Implications of Russian Federation Membership in NATO," Master's Thesis, Naval Postgraduate School, June 2002.

Garvie, B.A., "Chechnya and Russia: Conflict and Self-determination," Master's Thesis, Naval Postgraduate School, December 2002.

Gray, J., "Russian Relationships with the West: the Implications for Military Reform," Master's Thesis, Naval Postgraduate School, December 2002.

Morris, G.L., "Japan, Russia and the Northern Territories Dispute: Neighbors in Search of a Good Fence," Master's Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: Russia, Military, Security, Terrorism

U.S.-RUSSIAN WORKSHOP ON CONFIDENCE-BUILDING MEASURES IN STRATEGIC COMMAND, CONTROL AND COMMUNICATIONS

Mikhail Tsyarkin, Associate Professor

Department of National Security Affairs

Sponsor: Defense Threat Reduction Agency

OBJECTIVE: Establish feasibility of U.S.-Russian cooperation on new confidence-building measures in strategic command, control and communications (C3).

SUMMARY: A U.S.-Russian workshop, with participation of specialists on strategic C3 from both sides, was conducted. Participants agreed that such new confidence building measures are both possible and necessary. A recommendation was made to prepare for joint U.S.-Russian modeling of strategic scenarios. Papers by participants were presented to the sponsor.

ARMS CONTROL COMPLIANCE: FUTURE ISSUES

James Wirtz, Professor and Chair

Department of National Security Affairs

Sponsor: Strategic Systems Program

OBJECTIVE: The purpose of this project was to provide support to the Naval Treaty Implementation Program (SP2025) by responding to a series of research questions related to arms control compliances.

KEYWORDS: Arms Control, WMD, Counter Proliferation

NATIONAL SECURITY AFFAIRS

CHINA'S NUCLEAR FUTURE
James Wirtz, Professor and Chair
Department of National Security Affairs
Sponsor: U.S. Air Force Academy

OBJECTIVE: The aim of this project was to conduct a small workshop on future Chinese nuclear force structure and doctrine and the way China's nuclear weapons will affect international relations in Asia and between China and the United States.

KEYWORDS: China, Nuclear Weapons, Counter Proliferation, Deterrence

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

OBJECTIVE: This project supported the defense threat reduction agency program "Outreach 21" by fostering research efforts and outreach initiatives that foster greater awareness of issues related to nuclear strategy, policy and threat reduction.

KEYWORDS: Weapons of Mass Destruction, Terrorism/Nuclear Strategy, Nuclear Weapons, Biological Weapons, Chemical Weapons

ANALYZING NEW STRATEGIC CONCEPTS
David S. Yost, Professor
Department of National Security Affairs
Sponsor: U.S. Air Force Headquarters (XONP)

OBJECTIVE: The purpose of this project was to analyze the policy implications of the conceptual framework outlined in the Quadrennial Defense Review (QDR) and the Nuclear Posture Review. The focus was on effectively translating general principles into specific actionable tasks for deterrence, operations, and arms control.

SUMMARY: The concept of "dissuasion" was advanced in the 2001 QDR as one of America's four defense policy goals, along with assuring friends and allies, deterring threats, and (if deterrence fails) defeating adversaries. Dissuasion differs from deterrence in that the objective is to persuade adversaries not to compete with the United States in the acquisition of military power, while deterrence concerns persuading an enemy not to employ capabilities during a specific contingency. The concept of "dissuasion" raises important questions concerning its practical operationalization against adversaries and its significance in U.S. relations with allies and security partners. Somewhat paradoxically, the United States has for decades been engaged in activities now termed "dissuasion" but little historical or theoretical analysis of dissuasion has been conducted. At least according to some definitions of these concepts, the United States has at times evidently achieved "dissuasion" effects (discouraging the acquisition of military capabilities) while performing "assurance" functions vis à vis allies and security partners.

THESES DIRECTED:

Fischl, K.E., "NATO-Russian Relations: Opportunities and Obstacles," Master's Thesis, Naval Postgraduate School, June 2002.

Garvie, B.A., "Chechnya and Russia: Conflict and Self-Determination," Master's Thesis, Naval Postgraduate School, December 2002.

NATIONAL SECURITY AFFAIRS

Johnson, J.L., "NATO's Crisis Management in the Balkans," Master's Thesis, Naval Postgraduate School, June 2002.

KEYWORDS: Quadrennial Defense Review, Nuclear Posture Review, Russia, NATO, Strategy, ABM Treaty, Arms Control, Deterrence, Nuclear Weapons, Missile Defenses

EUROPE AND INFORMATION WARFARE
David S. Yost, Professor
Department of National Security Affairs
Sponsor: Naval Information Warfare Activity

OBJECTIVE: The objective of this continuing project was to advance understanding of European security policy developments, especially with regard to the information warfare aspects of the "Revolution in Military Affairs." This includes matters such as doctrine, education and training, system development, and technology transfer policy in major NATO European governments, military organizations, and industrial establishments.

SUMMARY: Some theorists contend that a "Revolution in Military Affairs" takes place when new technologies are combined with innovative operational concepts and organizational adaptations that fundamentally change the character and conduct of military operations. This research effort has emphasized the analysis of primary sources from publications in NATO Europe regarding the information warfare aspects of the "Revolution in Military Affairs." A broad definition of "information warfare" has been utilized, in order to encompass means to exploit information systems, to attack those of adversaries, and to protect one's own and those of allies.

THESES DIRECTED:

Goodpasture, M.C., "Ambitions Versus Capabilities: The European Union's Security and Defense Policy," Master's Thesis, Naval Postgraduate School, June 2002.

Kelemen, T., "Defense Planning and NATO-European Union Relations," Master's Thesis, Naval Postgraduate School, June 2002.

Pelkola, R.J., "The European Union's Headline Goal: An Operational Assessment," Master's Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: France, Europe, Information Warfare, NATO, Nuclear Deterrence, Revolution in Military Affairs

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

OBJECTIVE: The objective was to advance understanding of European security policy developments, notably with regard to NATO nuclear weapons policy. This included matters such as nuclear deterrence doctrine in the Alliance and policy debates in major NATO European countries. The issues included the future of nuclear deterrence, conventional deterrence and force planning, missile defense, developments in Russia and elsewhere in the former Soviet Union, the proliferation of weapons of mass destruction, and European security and defense policy.

SUMMARY: Expert observers on both sides of the Atlantic have expressed concern regarding Russian non-strategic nuclear forces (NSNF), including the lack of transparency and the uncertainties about

NATIONAL SECURITY AFFAIRS

Moscow's implementation of the 1991-1992 commitments. The Russians have to date been relatively unresponsive regarding NATO's proposed confidence and security-building measures (CSBMs) for NSNF.

PUBLICATION:

Yost, D.S., "Transatlantic Relations and Peace in Europe," *International Affairs*, Vol. 78, pp. 277-300, April 2002.

THESES DIRECTED:

Klima, K.T., "Interpretations of Article 5 of the North Atlantic Treaty, 1949-2002," Master of Arts, Naval Postgraduate School, March 2002.

Lazar, C.D., "Russian Strategic Nuclear Command and Control," Master's Thesis, Naval Postgraduate School, March 2002.

KEYWORDS: Strategy, France, Europe, NATO, Nuclear Deterrence, Revolution in Military Affairs

**DEPARTMENT OF
NATIONAL SECURITY AFFAIRS**

**2002
Faculty Publications
and Presentations**

NATIONAL SECURITY AFFAIRS

PUBLICATION

Yost, D.S., "Transatlantic Relations and Peace in Europe," *International Affairs*, Vol. 78, pp. 277-300, April 2002.

**GRADUATE SCHOOL OF
OPERATIONAL AND
INFORMATION SCIENCES**

**WAYNE HUGHES
DEAN**

**DEPARTMENT OF COMPUTER
SCIENCE**

**LCDR CHRIS EAGLE, USN
ACTING CHAIR**

COMPUTER SCIENCE

OVERVIEW:

The Department of Computer Science provides graduate training and education in major areas of computer science. Thus, both basic and advanced graduate courses are offered. Course work and research lead to either the degree of Master of Science or Doctor of Philosophy. The requirements to complete either program are rigorous and are 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
- 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 Luqi, Professor Valdis Berzins, Professor Ted Lewis, Associate Professor Man-Tak Shing, Military Instructor CDR Deborah Kern, and Military Instructor LCDR Chris Eagle
- Databases:
Associate Professor Thomas Wu, Research Assistant Professor Wolfgang Baer, and Professor Robert McGhee
- Information Security:
Associate Professor Cynthia Irvine, Lecturer Daniel Warren, and Lecturer Paul Clark
- Artificial Intelligence:
Professor Robert McGhee, Professor Neil Rowe, and Assistant Professor Chris Darken
- Modeling, Virtual Environments and Simulation (MOVES) Institute/Computer Graphics:
Professor Michael Zyda, Assistant Professor Rudy Darken, Lecturer Eric Bachmann, Research Professor John Hiles, and Research Professor Michael Capps
- Networks:
Associate Professor G. M. Lundy, Assistant Professor Geoffrey Xie, and Associate Professor Bret Michael
- Programming Languages:
Associate Professor Dennis Volpano

RESEARCH FACILITIES:

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

COMPUTER SCIENCE

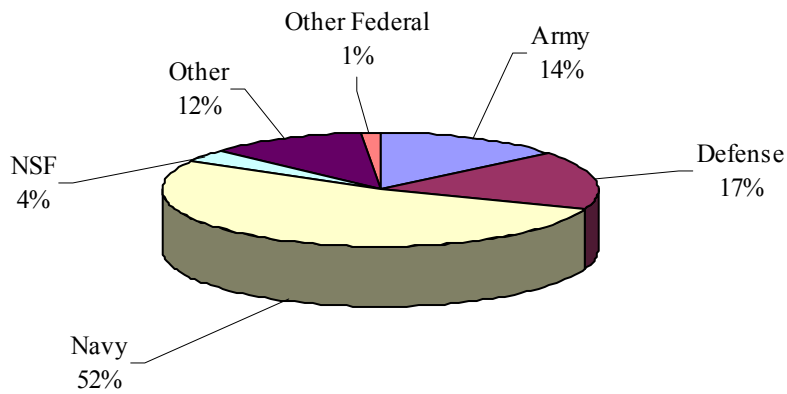
- Visual Database and Interface Laboratory

RESEARCH CENTERS:

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

SPONSORED RESEARCH PROGRAMS (Research and Academic)-FY2002:

The Naval Postgraduate School's sponsored program exceeded \$61 million in FY2002. Sponsored programs included both research and educational activities funded from an external source. A profile of the sponsored program for the Department of Computer Science is provided below:



Size of Program: \$2,858K

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GENERATIVE DECISION SUPPORT ARCHITECTURE PROJECT

Valdis Berzins, Professor

Department of Computer Science

Sponsor: Space and Naval Warfare Center - San Diego

OBJECTIVE: Decision support is one of the most important elements in system support for mission critical software. Generative decision provides advanced dynamic functions for the software. This research developed this technology for the software architecture and enabled the function for this software.

KEYWORDS: Decision Support, Software

EMERGENCY RESPONSE FOR CYBER INFRASTRUCTURE MANAGEMENT/PROTECTING PACKET-SWITCHED COMMUNICATIONS NETWORKS

George Dinolt, Associate Professor

LCDR Kelly Cormican, USN, Military Faculty

Department of Computer Science

Sponsor: U.S. Department of Justice

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

First, provide satisfactor (non-simulation) mathematical models of the behavior of packet-switched communications networks, with initial focus on the Navy-Marine Corps Intranet (NMCI). Second, provide optimization-based methods for the attack and defense of such networks.

KEYWORDS: Computer Security, Network Security, Information Assurance

APPLYING RUN-TIME MONITORING TO THE DEEP-IMPACT FAULT PROTECTION ENGINE

Doron Drusinsky, Associate Professor

Department of Computer Science

Sponsor: Time Rover, Inc.

OBJECTIVE: Apply a new verification methodology and corresponding tool (DBRover) to the verification of the fault protection engine of the National Aeronautics and Space Administration's (NASA) Deep Impact flight code.

SUMMARY: The investigation succeeded in that NASA engineers identified unknown bugs using the method. In addition, NASA engineers used the method and associated tool to simulate formal requirements for use by other formal verification tools.

PRESENTATION:

Drusinsky, D. and Watney, G., "Applying Run-time Monitoring to the Deep-Impact Fault Protection Engine," 27th IEEE/NASA ICECCS Workshop, 2002.

KEYWORDS: Temporal Rules, Requirements, Run-time Monitoring

EXPERIMENTS WITH TEST CASE GENERATION AND RUNTIME ANALYSIS

Doron Drusinsky, Associate Professor
Department of Computer Science
Sponsor: Time Rover, Inc.

OBJECTIVE: To conduct experiments in the integration of model checking, automatic code generation, and runtime verification using a planetary rover controller as an example.

SUMMARY: The investigation succeeded in that NASA engineers constructed an automatic method for (i) test case generation, and (ii) temporal specification requirements, from the rover's high-level plans language. The tests cases of (i) were automatically applied to the rover code, which was then executed and monitored by the DBRover using the temporal specification requirements of (ii). This provided an automatic method for rigorously testing the rover's code.

PRESENTATION:

Artho, C., Drusinsky, D., Goldeberg, A., Havelund, K., Lowry, M., Pasareanu, C., et al., "Experiments with Test Case Generation and Runtime Analysis," 10th International Workshop on Abstract State Machines, Sicily, Italy, 2003, (invited).

KEYWORDS: Temporal Rules, Requirements, Run-time Monitoring

INTEGRATION OF RAPID PROTOTYPING AND RUNTIME VERIFICATION

Doron Drusinsky, Associate Professor
Man-Tak Shing, Associate Professor
Department of Computer Science
Sponsor: Naval Postgraduate School

OBJECTIVE: Integration of rapid prototyping (SEATools) and run-time monitoring (DBRover) tools.

SUMMARY: The investigation succeeded with the integration of SEATools rapid prototyping tools and the DBRover run-time monitoring and verification tool, using an example of the fish-farm control system augmented with temporal logic assertions (including real-time and time-series constraints). This illustrates how run-time monitoring and verification can be performed early in the design process, in tandem with rapid prototyping. This approach helps identify errors earlier in the design process and also helps debug the requirements.

The executable prototype consists of 3968 lines of source code, 2048 of which are Ada and C codes generated by the SEATools and the DBRover. Socket communications was used to provide a simple interface between the SEATools runtime environment and the DBRover System. Only a single atomic operator in the PSDL model was created per temporal requirement. The Ada implementation of each of these atomic operators consists of a one-line procedure call in the to invoke the corresponding C routine implementing the temporal rule. Although the use of socket communication introduces additional time delay between the detection of events during the prototype execution and the checking of the affected temporal properties by the DBRover, it has negligible effect on the accuracy of the verification result because DBRover allows user to specify time based on the client's clock. All events detected during prototype execution are stamped with the local clock before sending to the DBRover for verification.

KEYWORDS: Temporal Rules, Requirements, Run-time Monitoring, Rapid Prototyping, Sockets, Ada, C

COMPUTER SCIENCE

FY02 SUPPORT FOR COMPUTER NETWORK RESEARCH LAB

LCDR Chris Eagle, USN, Military Faculty and Acting Chair

Randy Borchardt, Research Associate

Department of Computer Science

Sponsor: National Security Agency

OBJECTIVE: This proposal for computer network research laboratory projects expenditures over the next three years and specifically requests FY02 funding for lab research support and required equipment upgrades.

KEYWORDS: Network, Security, Computer, Software, Information Operations

PKI RESEARCH AND TRAINING LABORATORY

J.D. Fulp, Lecturer

Department of Computer Science

Sponsor: Office of the Secretary of Defense

OBJECTIVE: To provide Naval Postgraduate School (NPS) students with an opportunity to participate in a practical network attack-and-defend exercise that involves all elements of computer and network security, including the use of public key cryptography to digitally sign and encrypt sensitive message traffic.

SUMMARY: In April of 2002, approximately 25 NPS students from several academic programs participated in the second inter-service academy Cyber Defense Exercise. The exercise tested the students' ability to plan and coordinate a thorough and comprehensive network defense against professional computer hackers from the National Security Agency (NSA) and several Department of Defense (DoD) Red Team organizations. The NPS team competed against teams from West Point and the Naval, Air Force, and the Coast Guard Academies. Points were awarded from White Team (referee) evaluators from Carnegie Mellon's Software Engineering Institute based upon the quality of each defending team's protective posture and situational awareness. Public key cryptography was used to digitally sign and encrypt situation reports that were sent from each defending team to the White Team evaluators at the end of each day the four day attack period. These reports summarized each teams' systems' status and included an analysis any attacks that were detected. Additional points were awarded based upon the accuracy of these daily reports. The NPS team was the high scorer in both the 2000 and 2001 exercise. This exercise will be repeated again in 2003 along with some embellishment to enhance its realism and use of PKI technology.

KEYWORDS: Computer Security, Network Security, Public Key Infrastructure (PKI), Information Assurance Education, Cyber Defense

CISR INFORMATION ASSURANCE SCHOLARSHIP PROGRAM

Cynthia E. Irvine, Associate Professor

Department of Computer Science

Sponsor: National Security Agency

OBJECTIVE: The objective of the proposed work was to provide Masters and Ph.D. level education in the science and practice of Information Assurance to selected U.S. military and U.S. Department of Defense (DoD) civilian students who will subsequently serve as DoD civilians or military personnel.

SUMMARY: The Center for Information Security Studies and Research (CISR) implementation of the Information Assurance Scholarship Program (IASP) provides Master's and Ph.D. level education in the science and practice of Information Assurance to selected DoD civilian and military students. This work will lessen the current personnel gap in Information Assurance for the DoD. With preparation provided through a broad course of study enhanced by a special emphasis on computer security and focused research

on a pertinent topic in computer security, IASP graduates will be uniquely qualified to participate at a managerial or high technical level for a variety of DoD Information Assurance programs.

For the Master's level program, students with undergraduate computer science degrees have been placed into a specially designed two-year computer security track at CISR. The Ph.D. program is targeted toward candidates who already have achieved a Masters Degree in Computer Science and is a three-year effort involving both classes and dissertation research.

Each Masters student completes a thesis project in collaboration with other students, faculty, and research staff. Ph.D. candidates will conduct original dissertation research. Thesis and dissertation research permits exploration of a topic in depth and ensures an appreciation of the unsolved problems and challenges in Information Assurance, as well as providing valuable experience in critical thinking and writing.

In July 2002, five (5) USAF students matriculated into the program.

KEYWORDS: Education, Information Assurance, Pedagogy

CISR INFORMATION ASSURANCE STUDIES AND RESEARCH PROGRAM

Cynthia E. Irvine, Associate Professor

Department of Computer Science

Sponsor: Chief of Naval Operations (N643)

OBJECTIVE: The aim of this research was to provide support for the Center for Information Security Studies and Research (CISR) in an integrated approach to Information Assurance research and studies. The program will focus on network and platform security problems of importance to the Department of the Navy (DoN) and the Department of Defense (DoD). The program will include support of student research, laboratory improvements, curriculum enhancements and invited lectures.

SUMMARY: This research provided an overarching umbrella for a wide range of educational and research activities at the CISR.

To enhance the availability of information regarding the output of CISR, its web pages were reorganized to be more coherent and more easily navigable. The site includes information regarding research projects, lectures and special event, as well as publications and student theses. It is located at <http://cizr.nps.navy.mil>.

The Visiting Professor Program hosted William Hugh Murray during the Fall of 2002. He taught two classes on the secure management of systems and also presented a well-attended series of lectures on the application of cryptography to security.

In cooperation with the Cebrowski Institute, CISR hosted a visit by Richard Clarke, Executive Office of the President. Mr. Clarke presented a lecture for the Superintendents Guest Lectures to the entire student body. Other invited lectures included:

- Privacy-enhanced Internet, Yves Deswarte, LAAS-CNRS, Toulouse, France
- A National Strategy to Secure Cyberspace, Marcus Sachs,
- The Five Flavors of Open Source: Myth, Magic, and Reality, Jan Hauser, Global Sustainability
- Immunity from Viruses, Safety from Geeks Bearing Gifts, Mark Miller, CTO - Combex, Inc., Open Source Coordinator - ERights.org
- America's Critical Information Infrastructure and Homeland Defense: The Military's Role, William L. Tafoya, Computer Sciences Corporation

This effort supported research on the dangers of subversion in the context of protection of systems. It was found that a single individual in approximately three months could devise a highly effective system subversion. The work also supported research on the types of security that could be offered by Internet Service Providers to relive clients and customers of some of the policy enforcement burdens.

Issues of platform and network security were addressed and recommendations were made for the creation of a high assurance trusted computing exemplar as well as for the national trusted computing strategy for cyberspace. The exemplar project was formulated.

This effort also included enhancements to several of the Information Assurance courses taught at the Naval Postgraduate School.

TECHNICAL REPORTS:

Irvine, C., Levin, T. and Dinolt, G.W., "Diamond HASP Trusted Computing Exemplar," Naval Postgraduate School Technical Report, NPS-CS-02-004, September 2002.

Irvine, C.E., Levin, T.E. and Dinolt, G.W., "A National Trusted Computing Strategy," Naval Postgraduate School Technical Report, NPS-CS-02-003, May 2002.

Irvine, C., Levin, T. and Dinolt, G.W., "Protected Domains for Cyber Infrastructure Management," Naval Postgraduate School Technical Report, NPS-CS-02-007, October 2002.

THESES DIRECTED:

Anderson, E., "A Demonstration of the Subversion Threat: Facing a Critical Responsibility in the Defense of Cyberspace," Master's Thesis, Naval Postgraduate School, March 2002.

Price, P.D., "Toward an Internet Service Provider (ISP) Centric Security Approach," Master's Thesis, Naval Postgraduate School, March 2002.

KEYWORDS: Information Assurance, Subversion, Service Provider Security

CRITICAL INFRASTRUCTURE PROTECTION: AN INTERDISCIPLINARY COURSE

Cynthia E. Irvine, Associate Professor

Department of Computer Science

Sponsor: Department of the Navy Chief Information Officer

OBJECTIVE: The purpose of this research was to create an interdisciplinary class that permitted students from a variety of curricula to participate in an effort to solve challenges in critical infrastructure protection by addressing real problems and hypothetical incidents.

SUMMARY: The purpose of this effort was to develop a class in Critical Infrastructure Protection (CIP) that was taught at the Naval Postgraduate School as a special course offered by the Institute for Information Superiority and Innovation in the Summer of 2002. The objective was to create an interdisciplinary class that permitted students from a variety of curricula to participate in an effort to solve challenges in Critical Infrastructure Protection by addressing real problems and hypothetical incidents.

The newly formed Institute for Information Superiority and Innovation is dedicated to interdisciplinary research and education on problems of high relevance to the Department of the Navy (DoN). The involvement of faculty experts and students from a wide variety of disciplines provide an ideal "laboratory" for the study of CIP problems.

This innovative course had two primary objectives. The first was to address one or more CIP problems throughout a recognized CIP lifecycle. The lifecycle, bisected by an incident, consisted of analysis, assessment and vulnerability mitigation on one side, and by mitigation, response, and reconstitution on the other.

Because CIP issues cross the boundaries of many fields the second objective was to teach students new management skills to address problems where experts from a wide variety of areas are needed. Solutions in the CIP problem space require team building and cooperation involving individuals from many sectors such as: legal, health, communications, transportation, public relations, etc.

The course built upon expertise developed at the Naval Postgraduate School (NPS) to address difficult or so-called "wicked" problems. A major aspect of this problem solving technique involves group management methodologies. The effort consisted of three phases.

Phase I related the course to the needs of Navy constituencies.

Phase II consisted of course development and instructor training.

Phase III was presentation of the course.

COMPUTER SCIENCE

KEYWORDS: Critical Infrastructure Protection, Vulnerability Exploitation, Threats, Remediation Management

EMERGING TECHNOLOGIES IMPACTING INFORMATION ASSURANCE

Cynthia E. Irvine, Associate Professor

Department of Computer Science

Sponsor: Office of Naval Research

OBJECTIVE: The objective of this research was to investigate three areas of emerging technology and their impact and use for network security: (1) Analysis and exploitation of the IEEE 802.11b network communications protocol; (2) Location-based authentication for wireless perimeter definition; and (3) A system security analysis of Windows XP.

SUMMARY: The ability of network intruders with high-gain antennas to establish anonymous connections from a distance constitutes a threat to wireless local area networks. This research explored the use of relative position in granting access to potential users. Analysis of the latency of layer-two data acknowledgement control frames generated by the WLAN was explored as a method to infer the distance between 802.11b access points and mobile systems. Using this analysis a location-based access policy can be formulated.

Research was conducted to determine if Windows XP, when used as a workstation operating system in domain-based networks, provides adequate security policy enforcement for organizations. A security analysis of the Windows XP operating system was performed. Its vulnerabilities were assessed and recommendations were made for XP configurations and use as an extension of enterprise network. A new security template was created by combining the best of these templates. The new template also contained additional security settings not found in the built-in templates. This study provided recommendations for secure Windows XP configuration in Windows 2000 domains.

THESES DIRECTED:

Goktepe, M., "Windows XP Operating System Security Analysis," Master's Thesis, Naval Postgraduate School, September 2002.

Morrison, J.D., "IEEE 802.11 Wireless Local Area Network Security Through Location Authentication," Master's Thesis, Naval Postgraduate School, September 2002.

Vojtik, R., "Exploiting IEEE 802.11B Networks: An Electronic Warfare Approach," Master's Thesis, Naval Postgraduate School, June 2002.

KEYWORDS: Information Assurance, Wireless Security, Windows XP

FAA ANALYSES

Cynthia E. Irvine, Associate Professor

Department of Computer Science

Sponsor: Federal Aviation Administration

OBJECTIVE: The objective of this project was to perform computer security research that will benefit the Information Assurance posture of the FAA. Current projects are: (1) to investigate the application of biometric technologies to provide continuous assessment of flight deck personnel status, and (2) to study the feasibility of continuous, secure transmission of "black box" flight information to ground-based data storage locations.

SUMMARY: Recent events in aviation have highlighted the need to understand the security status of an airborne vehicle at all times. A significant part of the aircraft status is the minute-to-minute situation in the cockpit area. The Biometrics Project investigated how various biometric and other technologies may be

suitable for continuous authentication of personnel in an enclosed area, and designed and developed a prototype for applying those devices to the aviation authentication problem. Critical technical factors effecting feasibility of different authentication technologies were assessed, including the required computing power, the false positive rates, and how to store, communicate and protect the authentication and status data.

A primary focus of this project was to investigate the state of the art for biometric devices, and to determine what is the best combination of methods to provide continuous authentication of aircraft cockpit personnel. It was anticipated that the results of this research will have application in other critical military and civilian activities that require continuous personnel authentication.

During flight, the “black box” on a commercial aircraft records a variety of voice and data signals. This information is normally used only after an unusual flight event, such as an accident, to help understand the determining factors related to the event. The information stored in a black box is sometimes unavailable after an event, for example, if the black box becomes lost or damaged. The purpose of the Black Box Project is to examine methods to preserve black box information by broadcasting it continuously to ground locations.

There were several security considerations regarding black box data that were addressed by this work, including privacy, integrity and confidentiality, and longevity. Some of the data is considered private to the occupants of the flight deck: care needs to be taken that this data is used only for its intended purpose. The data may be critical to understanding catastrophic events, so its integrity must be protected. Certain flight data is confidential to the airlines, and this must be protected from disclosure to outside interests. And finally, black box data currently has a lifetime of about an hour; after that, unless an “event” occurs, new data overwrites the old data. If flight data is broadcast to ground locations, assurance may need to be provided that the data is purged in a similar timeframe.

KEYWORDS: Computer Security, Information Assurance, Biometrics

IA TUTORIALS AND WORKSHOPS FOR EDUCATORS

Cynthia E. Irvine, Associate Professor

Department of Computer Science

Sponsor: National Science Foundation

OBJECTIVE: The primary objective of the proposed work was to increase the capacity of the United States higher education enterprise to produce professionals in the fields of Information Assurance (IA) and computer security by hosting a series of workshops for education in Information Assurance. The target audience of the workshops is college-level educators who have responsibility for teaching curricula that are, or could be, related to Information Assurance issues.

SUMMARY: The goals of this effort are being met with a two-year series of invitational workshops for Information Assurance education. The format for each workshop will be three sequential sessions: a tutorial session, a refereed paper session, and a working session. This sequence will allow newer practitioners to become knowledgeable about the basics of IA, will provide an opportunity for experienced practitioners to present new ideas for discussion, and will allow both groups to interact in a problem solving context to develop solutions for point issues presented by the workshop.

The tutorial sessions will educate faculty about the fundamentals of information assurance and computer security and will improve their instructional capability in these areas. The paper session will provide a forum for presentation and discussion of recent pedagogical and technical advances in the field. Activities in the working session will encourage creative interaction regarding current issues for education in Information Assurance. It is anticipated that graduate students will participate.

The workshops are intended to enhance the sense of community for IA educators, fostering collaboration and dialogue among institutions offering courses and programs in Information Assurance. The multi-year format will allow faculty to spend time in their own environment and return to the workshop with experiential questions and insight.

The output of the workshops will include model materials for classroom presentation and demonstration, as well as example materials for laboratory experimentation. The net effect of the proposed activities is to

COMPUTER SCIENCE

directly increase the national capacity for education in Information Assurance as well as to extend the knowledge and expertise of IA to a range of participants that is more representative of the national profile. The tutorial workshop (the Fifth Workshop on Education in Computer Security) will be held for three days, it will be followed by a workshop sponsored in conjunction with the IFIP WG 11.8 (Information Security Education) and is called World Conference on Information Security Education (WISE). The latter will last for 2.5 days and is the third of its kind. The workshop and conference will be held in June 2003.

KEYWORDS: Computer Security, Information Assurance, Security Education

INFORMATION ASSURANCE LABORATORY DEVELOPMENT

Cynthia E. Irvine, Associate Professor

Department of Computer Science

Sponsor: Office of Naval Research

OBJECTIVE: Research to enhance and upgrade lab facilities to increase the effectiveness of computer security education, in order to support the Navy's Information Assurance goals.

SUMMARY: This project helped to increase the capability of the U.S. Navy to meet its Information Assurance goals by providing students with the tools and resources necessary for learning about and understanding current technologies. The objective was met through laboratory exercises and student research work. In particular, research funds were used to support the labor costs associated with running a computer laboratory, developing software for laboratory exercises, and for the purchase of new equipment to support thesis research.

Although no thesis students were directly involved in research related to this topic, there were ten Masters students and two Ph.D. students who benefited from the resources provided by the laboratory.

Two software programs were developed for use in a new laboratory exercise, in support of the teaching of cryptography. These were designed and developed after a product search determined that there were no commercial or freeware/shareware products that met the requirements.

KEYWORDS: Information Assurance, Education, Laboratory

INFORMATION ETHICS DEVELOPMENT FOR THE U.S. NAVY

Cynthia E. Irvine, Associate Professor

Department of Computer Science

Sponsor: Office of Naval Research

OBJECTIVE: The objective of this research was to develop material to support the Information Assurance (IA) objectives of the U.S. Navy in the areas of Information Ethics.

SUMMARY: This work involved the development of materials in the area of information ethics for officers, system administrators, and the general population, with the intent of increasing the ability of the Navy to maintain a high level of ethical behavior in the cyber space domain. This work was divided into two tasks, one to improve information ethics education in the Navy through the development and presentation of a course in Information Ethics to graduate students at the Naval Postgraduate School, and the second to develop training and awareness materials for use in the training of Navy IA personnel and to increase awareness of information ethics issues throughout the Navy.

A course, offered in the Fall of 2001, examined the situational effects unique to information technologies and identify the kinds of ethical choices that may arise from their use. The choices addressed are difficult in part because they are in novel space, the values are difficult to identify and compare, because the right choices are more difficult than the working, and in part because they may have consequences that are neither certain nor easily predicted.

The course focused on understanding techniques for understanding and analyzing ethical choices as they relate to information technology issues.

COMPUTER SCIENCE

Task two built upon the philosophical and logical foundations established in the Information Ethics course. The material targeted training and awareness activities rather than graduate-level course work. An unclassified interactive CD was developed to provide the Department of the Navy personnel with a training tool that furthers their understanding of the ethical responsibilities that are required when using Information Technology and to provide a broad knowledge base that facilitates better decision making when facing ethical dilemmas.

OTHER:

Senter, J., Thorton, C., Rose, M. and Irvine C., "Information Technologies Ethics Training Course," Compact Disk, Version 1.1, September 2002.

THESIS DIRECTED:

Senter, J., and Thornton, C., "Information Technology (IT) Ethics: Training and Awareness Materials for the Department of the Navy," Master's Thesis, Naval Postgraduate School, June 2002.

KEYWORDS: Computer Security, Information Assurance, Open Source, Security Policy

INFORMATION SYSTEM CERTIFIER EDUCATION

**Cynthia E. Irvine, Associate Professor
Department of Computer Science**

Sponsors: Space and Naval Warfare Center - San Diego, Naval Postgraduate School

OBJECTIVE: Develop a curriculum for the purpose of educating U.S. Navy information system certifiers, and prepare introductory materials to facilitate familiarization of certifiers-to-be with the requisite knowledge and skills.

SUMMARY: This is an ongoing project. The Navy has a critical shortage of information system certifiers in uniform, and the Naval Postgraduate School (NPS) Cebrowski Institute is uniquely well-qualified to address this problem. Under contract to PMW161, the NPS Cebrowski Institute is developing an educational program for new certifiers. An outline for the course and a bibliography of applicable Government documents were developed, and development of the course material was initiated. Students in the program will be of two types: short course students and resident graduate students. Short course students will be individuals who may already be working in the area of certification and accreditation or those who are moving into this field. The short Certifier Education program students will spend approximately eight weeks in formal courses over a period of from eighteen months to two years. The courses will be of short duration and high intensity with eight hours devoted to class and laboratory exercises each day. The intervening periods between visits to school will be spent in the field, where students acquire essential experience. Resident students will include certifier courses as electives as part of their graduate program, which depending upon student background, validation of prerequisites, and other factors can last between 12 and 24 months. A prerequisite for all students is an undergraduate degree in computer science or closely related engineering field. With two exceptions, the curriculum comprises courses already in the catalogue. The exceptions are the newly designed CS4680 (Introduction to Certification and Accreditation) and CS4685 (Case Studies in Certification).

A CD-ROM was produced, containing an overview of the Certification and Accreditation process specifically targeted at students entering the program. Because of unusual attributes of Naval systems and procedures, PMW161 requested an introduction that was Navy-specific. Accordingly, dozens of Department of Defense (DoD) and Department of the Navy (DoN) documents on certification and accreditation were reviewed, researchers met with personnel from PMW161, and the result was a product that would introduce the prospective Navy certifier to the responsibilities, skill sets, and requisite knowledge associated with the job.

PRESENTATIONS:

Dinolt, G., "The Navy Certifier Program," Cebrowski Institute Symposium, Monterey, CA, 30 July 2002.

Rasmussen, C., "A Program for Education in Certification and Accreditation," WISE 3/WECS 5, Monterey, CA, 26-28 June 2003.

OTHER:

"The System Certification and Accreditation Process," Introduction to certification and accreditation for prospective Navy certifiers, [CD-ROM].

KEYWORDS: Information Assurance, Computer Security, Certification and Accreditation

MONTEREY SECURITY ENHANCED ARCHITECTURE PROJECT

Cynthia E. Irvine, Associate Professor

Department of Computer Science

Sponsor: Defense Advanced Projects Research Agency

OBJECTIVE: The goal of the Monterey Security Enhanced Architecture (MYSEA) project was to construct a prototype demonstration of an open source high assurance distributed operating environment for enforcing multi-domain security policies while supporting popular office productivity applications without modification.

SUMMARY: The MYSEA project provides a prototype demonstration of a potential high assurance distributed operating environment for enforcing multi-domain security policies. This prototype is composed of a combination of many low-assurance commercial components and relatively few specialized (e.g., high assurance) multi-domain components, based upon a security-enhanced version of the OpenBSD operating system that supports unmodified commercial-off-the-shelf productivity applications.

The main elements of this research approach include: (1) innovative high assurance multi-domain distributed architecture, (2) integration of multi-domain support into an existing open source operating system, (3) local and remote trusted path, (4) single sign-on for access to multiple trusted servers and (5) integration of security policy management with internal security services. It is expected that this project will result in new and improved security functionality for existing open source operating systems, and will contribute significantly to the ability of distributed open source components to interoperate securely.

In this period this research completed the Server and Trusted Path Extension security functions, transitioned the multi-domain policy enforcement to the Extended Attribute framework, integrated basic QoS for client/server communications, and completed local and remote (client-side) trusted path functionality. Enhancements include a point and click interface for trusted path services, implementation of Trusted Path Extension reduced form factor (i.e., handheld PDA via USB port) and a diskless client demonstration configuration. Additionally, an assessment of tools for high assurance system development was performed.

PUBLICATION:

Irvine, C., Levin, T., Wilson, J., Shifflett, D. and Pereira, B., "An Approach to Security Requirements Engineering for a High Assurance System," *Requirements Engineering Journal*, Vol. 7, No. 4, pp. 192-206, 18 December 2002.

CONFERENCE PAPERS:

Syropoulou, E., Agar, C., Levin, T. and Irvine, C., "IPsec Modulation for Quality of Security Service," *Proceedings of the International System Security Engineering Association Conference*, Orlando, FL, 13 March 2002.

COMPUTER SCIENCE

Xie, G.G., Irvine, C. and Levin, T., "Quantifying Effect of Network Latency and Clock Drift on Time-driven Key Sequencing," *Proceedings of the Workshop on Assurance in Distributed Systems and Networks*, Vienna, Austria, 2 July 2002.

PRESENTATIONS:

Irvine, C., "An Extended OpenBSD Security Architecture: MYSEA," Secure Trusted Operating System Workshop, Monterey, CA, August 2002.

Irvine, C., "Monterey Security Architecture (MYSEA) Project," Navy Information Assurance Leadership Conference, Washington, D.C., October 2002.

Levin, T., "Monterey Security Architecture (MYSEA) Project," Cebrowski Institute Symposium, Monterey, CA, 29 July 2002.

Levin, T., "Quality of Security Service," Cool Security Trends Panel, Symposium on Access Control Models and Technologies, June 2002.

THESIS DIRECTED:

Mohan, R., "XML Based Adaptive IPSEC Policy Management in a Trust Management Context," Master's Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: Computer Security, Information Assurance

PROJECT CHALLENGE PROBLEMS

**Cynthia E. Irvine, Associate Professor
Department of Computer Science**

Sponsor: Pacific Northwest National Laboratories

OBJECTIVE: The Center for Information Systems Security Studies and Research (CISR) collaborated on this project with Pacific Northwest National Laboratories (PNNL). The project was of a classified nature and will require both staff and facilities cleared at the appropriate level.

SUMMARY: This was classified research on a challenging problem. The Naval Postgraduate School tasks included: (1) coordination and facilitation of project workshops, conferences and demonstrations; (2) participation in the execution of the classified research on a selected challenge problem; and (3) conduct of literature review and background data for the project team.

PUBLICATIONS:

The classified nature of this effort did not lend itself to publications.

THESIS DIRECTED:

A thesis is in progress.

KEYWORDS: Computer and Network Security

COMPUTER SCIENCE

SECURITY-ENHANCED WINDOWS CE

Cynthia E. Irvine, Associate Professor

Department of Computer Science

Sponsor: Microsoft Corporation

OBJECTIVE: The objective of the Secure Windows CE project was to examine the data protection and self protection features of the Windows CE Operating System and to develop demonstrations, modifications and enhancements for increasing its level of self protection. As a result, users would have greater confidence of the ability of Windows CE devices to withstand attempts to penetrate or subvert them, and consequently to have greater confidence in the ability of Windows CE to protect data entrusted to it.

SUMMARY: Security engineering requires a combination of features and assurance to provide confidence that security policy is correctly enforced. Rigorous engineering principles are applicable across a broad range of systems. The purpose of the OS Complexity Analysis Project was to analyze and compare three operating systems, including two general-purpose operating systems (Linux and OpenBSD) and a commercially available, embedded operating system (Talisker). The basis for the comparison considered secure software design principles, such as information hiding, hierarchical structuring, and modularity, as well as software complexity metrics, such as the McCabe Cyclomatic Complexity and the number-of-lines-of-code.

This complexity analysis used a reverse engineering tool to show how the three operating systems compare to each other with respect to the qualities of a secure operating system design. The operating systems, their kernels, and their scheduling subsystems were analyzed and compared. From the results, it was shown that the OpenBSD operating system, kernel, and scheduler are the best when considering hierarchical structuring, modularity, and information hiding. The Linux kernel and scheduler and the Talisker operating system were least complex when considering the McCabe complexity and the number-of-lines-of-code.

A fundamental characteristic of computing systems that have not been developed to have “high assurance” is their vulnerability to the subversion of their protection mechanisms. While many theoretically appreciate such a threat, it is arcane in practice. The purpose of the Subversion Demonstration Project is to provide a concrete demonstration that shows the drastic effects that subversion can have on a system’s ability to enforce its policies, the ease with which a subversion can be implanted, and the difficulty of finding a subversive artifact, once it is in place. Preliminary work was started in 2002 on the analysis and design of subversion artifacts related to the next generation of WinCE.

THESES DIRECTED:

Smith, K.R., “Linux, OpenBSD, and Talisker: A Comparative Complexity Analysis,” Master’s Thesis, Naval Postgraduate School, March 2002.

KEYWORDS: Computer Security, Information System Security, INFOSEC, Information Assurance, Network Security

SECURE ENVIRONMENTS RESEARCH, PHASE III (PROJECT 107305)

Cynthia E. Irvine, Associate Professor

Department of Computer Science

Sponsor: Naval Engineering Logistics Office

OBJECTIVE: The purpose of this research was to investigate designs for utilizing the standard data processing protocols for protecting information in secure environments. Modifications to protocol utilization scenarios and methodologies as well as to the protocols themselves are examined.

SUMMARY: This research investigated approaches for how User Datagram Protocol (UDP) could be utilized to support secure audio and video collaboration without exposing the vulnerabilities existing in today’s UDP-based collaboration tools. Fundamental vulnerabilities exist in providing any persistent

session services over UDP, since UDP was designed to be “sessionless.” Problems regarding the confidentiality, integrity and availability of UDP session packets result. The research explored approaches for how to run UDP securely without changing commercial-off-the-shelf programs. The primary approach was to utilize associated protocols for securely managing UDP sessions. Examples are Single Object Access Protocol (SOAP), SOCKS and Virtual Private Network (VPN) tunnels.

Another project was to analyze and provide prototype development of a capability to employ Controlled Access Program Coordination Office (CAPCO)-compliant MetaData security tags (viz., Hyper Text Markup Language (HTML) and Extensible Markup Language (XML) tags) as the basis for making information technology (IT) security decisions. The customer’s current IT architecture requires that all documents be marked with security tags, yet it does not make automated security decisions based on these tags. The use of Intelink/CAPCO metadata tags to support visual labeling of paragraph markings, as well as access control to XML/HTML documents was investigated. A strawman framework was defined for managing documents based on XML security tags, and a prototype was developed for demonstrating the resulting security behavior.

Based upon the need to provide standard commercial-grade productivity applications as the general purpose user interface to high-assurance data processing environments is compelling in the context of “trusted” systems, this work explored the problem of integrity in architectures comprised of both traditional trusted components and less trusted components. This research characterized some of these systems as a class of architecture. This led to the development of a general integrity property that systems can only be trusted to manage modifiable data whose integrity is at or below that of their interface components. This project’s analysis had the effect that in terms of integrity, high-assurance systems cannot be composed of a combination of high assurance policy-enforcement components and low assurance commercial interface/application components. Another effect is that this type of these hybrid-security systems are only applicable to processing environments where the integrity of data is consistent with that of low-assurance software.

PUBLICATION:

Irvine, C. and Levin, T., "A Cautionary Note Regarding the Data Integrity Capacity of Certain Secure Systems," *Integrity, Internal Control and Security in Information Systems*, ISBN 1-4020-7005-5, Brussels Belgium, 2002.

THESIS DIRECTED:

Aposporis, P., “Framework for Managing Metadata Security Tags as the Basis for Making Security Decisions,” Master’s Thesis, Naval Postgraduate School, December 2002.

KEYWORDS: Computer Security, Information Assurance, Multilevel Security, Integrity

SIM SECURITY

**Cynthia E. Irvine, Associate Professor
Department of Computer Science**

Sponsor: Chief of Naval Education and Training

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

SUMMARY: This project is ongoing. The following summarizes project objectives and project status (also see report to co-sponsor: NSA):

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

The lab was based on existing course material that meets the National Security Telecommunications and Information Systems Security Committee (NSTISSC) Standard 4011 as well as all or part of the other NSTISSC Standards pertinent to Information Assurance.

COMPUTER SCIENCE

SimSecurity packaged an Information Assurance laboratory in the form of an interactive computer game in which players may perform various roles involved in Information Assurance (IA): manager, security administrator, attacker, etc. Through the use of commercial computer game development and presentation techniques, the laboratory engaged students in lesson-focused scenarios that respond to the decision or omissions of students, providing them with a customized learning experience. The game design permits construction of customized scenarios to facilitate extensions as new threats and countermeasures in the real world IA landscape evolve.

The laboratory supported both IA Training and IA Education. It can be used in an ad hoc fashion to teach users IA concepts and vocabulary. When used as a self-contained laboratory it provides an introduction and tutorial providing a basic introduction to IA concepts and their application. When combined with a course, students navigate through the IA lab in a systematic program. When used in conjunction with learning modules and courses, such as those developed by the Center for INFOSEC Studies and Research at the Naval Postgraduate School, students progress through a rigorous sequence of labs and lectures to a NSTISSC-based certification and/or course credit from NPS.

IA education scenarios have been constructed and considerable player reference material has been developed. A study into the feasibility of using commercial computer game development and presentation techniques was conducted. The results of this study included the following elements: Technical Specification, Game Design, User Interface design, Technical Design and project schedule. Game prototype development work was underway during this period.

PRESENTATIONS:

Irvine, C., "SimSecurity," Secure Trusted Operating System Workshop, Monterey, CA, August 2002.

Irvine, C. and Thompson, M., "Teaching Objectives of a Simulation Game for Computer Security," Informing Science and Information Technology Joint Conference, Pori, Finland, 24-27 June 2003.

THESIS DIRECTED:

VanPutte, M., "A Computational Model and Multi-Agent Simulation of Information Assurance," Doctoral Dissertation, Naval Postgraduate School, June 2003.

KEYWORDS: Education, Information Assurance, Simulation

SIM SECURITY ENHANCEMENTS

Cynthia E. Irvine, Associate Professor

Department of Computer Science

Sponsor: National Security Agency

OBJECTIVE: The purpose of this research was to enhance the creation of an education, training, and awareness tool using a resource management game as the vehicle. The tool will constitute a virtual laboratory for experimentation with security mechanisms. A range of threats to computer and network security will allow users to understand the strengths and limitations of various approaches and will foster an appreciation of the difference between ad hoc mechanisms and those included as part of an a priori design. Student participation in this project will ensure its suitability for use in the Department of the Navy (DoN) and the Department of Defense (DoD).

SUMMARY: This project is ongoing. The following summarizes project objectives and project status (also see report to Chief of Naval Education and Training (CNET)).

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

The lab was based on existing course material that meets the National Security Telecommunications and Information Systems Security Committee (NSTISSC) Standard 4011 as well as all or part of the other NSTISSC Standards pertinent to Information Assurance.

COMPUTER SCIENCE

SimSecurity will package an Information Assurance laboratory in the form of an interactive computer game in which players may perform various roles involved in IA: manager, security administrator, attacker, etc. Through the use of commercial computer game development and presentation techniques, the laboratory will engage students in lesson-focused scenarios that respond to the decision or omissions of students, providing them with a customized learning experience. The game design permits construction of customized scenarios to facilitate extensions as new threats and countermeasures in the real world IA landscape evolve.

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KEYWORDS: Education, Information Assurance, Simulation

PROVIDE DL ARCHITECTURE
Ted Lewis, Professor
Department of Computer Science
Sponsor: U.S. Department of Justice

OBJECTIVE: Provide an architecture for the distance-learning delivery of courses in the new Homeland Security Curriculum.

SUMMARY: The Naval Postgraduate School launched the first Master of Arts degree program in Homeland Security and Defense, which commenced on January 6, 2003. This new program is novel in several respects, most particularly in the hybrid delivery mechanism, which consists of 40 hours (two weeks) in residence and 8 weeks online as a distance learning (DL) experience. The DL architecture has to support both resident and non-resident participation of students and faculty. The learning objectives were to combine the advantages of human face-to-face lectures with the timesaving advantages of network-based learning (NBL) from a distance. In particular, the NBL content focused on reinforcement and experiential learning as an enhancement to the traditional in-resident lectures. The NBL component uses scenarios and simulations as a method of conveying experience, and collaboration (via e-mail) with a live instructor as a method of reinforcement. Currently, 14 students are going through the 18-month degree program. It is too early to conclude whether this is a satisfactory DL architecture or not.

KEYWORDS: Homeland Security, Education, Distance Learning, Network-based Learning

COMPUTER SCIENCE

AUTOMATED SOFTWARE/HARDWARE INTEGRATION IN DOD

Luqi, Professor

Department of Computer Science

Sponsor: U.S. Air Force Aeronautical Systems Center

DEVELOPMENT OF SOFTWARE ENGINEERING FOR NAVSEA WEAPON SYSTEM SOFTWARE SAFETY PROGRAM

Luqi, Professor

Department of Computer Science

Sponsor: Naval Ordnance Safety and Security Activity

OBJECTIVE: Develop a web-based version of the weapons system safety course. Initiate development of an advanced course in weapon system software safety.

KEYWORDS: Software Engineering, Weapon System Safety

DYNAMIC ASSEMBLY FOR SYSTEMS ADAPTABILITY, DEPENDABILITY, AND ASSURANCE (DASADA) PROJECT

Luqi, Professor

Department of Computer Science

Sponsor: Defense Advanced Research Projects Agency

OBJECTIVE: For the Naval Postgraduate School (NPS) to support the Defense Advanced Research Projects Agency's (DARPA) efforts with the DASADA project on software technology and development for future adoption in military systems. The expected benefits of the proposed effort are to assess potential for Department of Defense (DoD) application, to facilitate the transition of DASADA technologies to military applications, to prepare young officers for technical missions involving such technologies, and to lower barriers between war-fighters and technologies. It is an investment for the training of our future admirals.

SUMMARY: Important results accomplished in 2002 include:

- Educated DoD engineers and military officers on DASADA technologies via distance learning.
- Integrated concepts and technologies of DASADA into our software engineering courses:
 - SW4599 – Automated Hardware/Software Integration in DoD
 - SW4582 – Weapon Systems Software Safety
- Conducted research on MetaH avionics architecture description language.
- Developed models and methods for solving the integration and interoperability problems in component-based distributed heterogeneous systems.
- Developed a modified model to predict software development time and assess the risk on the basis of reliable measures collected in early phases of SW development.

In FY02, many efforts were made on educational programs to propagate the DASADA technologies to the military students and direct doctoral and master students to apply DASADA technologies to DoD projects. Two courses (SW4599 and SW4582) were offered to integrate the concepts and technologies of DASADA.

An in-depth study of DASADA technologies was conducted, including the following:

- MetaH (modeling, timing analysis),
- UNCLE (constraint consistency gauges),
- QRAM (resource allocation gauges),
- IMPACT (system load tracking and visualization),
- SIM-TABASSCO (Semantic Interoperability Measures: Template-Based Assurance of Semantic Interoperability in Software Composition),

- Veridian Pacific-Sierra Research (terrain-reasoning software being reconfigured via the Venice tool),
- Proteus (run time and design time gauges for alternate architecture deployment).

On the basis of the study of these technologies, this curricula's doctoral and master's students were directed to conduct a series of research efforts on areas including rapid reconfigurable weapon software architecture, software module interoperability, commercial-off-the-shelf (COTS) integration and software (SW) development time predicting.

This project conducted research on the MetaH avionics architecture description language and a study to identify ways in which the emerging Society of Automotive Engineers (SAE) standard Avionics Architecture Description Language (AADL) and associated tools and methods can beneficially support avionics safety and airworthiness certification. Also, a comparative survey of Federal Aviation Administration (FAA) and Army avionics airworthiness certification processes, guidelines, standards and methods was conducted.

Also, a study on software module interoperability and COTS integration was performed. This research developed the Object-Oriented Model for Interoperability (OOMI) to capture the information required for resolving modeling differences in a federation of independently developed heterogeneous systems. This study provided an efficient way to integrate existing stand-alone systems and enable the software module interoperability for many DoD large-scale applications. Moreover, the issue of interoperability in DoD legacy system database was addressed and Extensible Markup Language (XML) was evaluated as a tool for transferring message data between varied systems. Additionally, a software program was developed to generate select messages in their native and XML formats. This work proposed a new interoperability model for re-engineering of old procedural software of the multifunctional information distributed system low volume terminal (MISD-LVT) to a modern object-oriented architecture. Using this model each legacy CSCI component can be redesigned independently without affecting the others.

Further, this work studied the methods for predicting software development time and assessing the risk. A set of metrics was developed for risk assessment and development efforts prediction. Based on the metrics, the modified risk model was developed. This model is versatile enough to be adapted to any software development activity and can predicate the required efforts of software development.

CONFERENCE PAPERS:

Bryant, B., Auguston, M., Raje, R., Olson, A. and Burt, C., "Formal Specification of Generative Component Assembly Using Two-level Grammar," *Proceedings of the 14th International Conference on Software Engineering and Knowledge Engineering*, 2002.

Drummond, J., Luqi, Kemple, W., Auguston, M. and Chaki, N., "Quality of Service Behavioral Model from Event Trace Analysis," *Proceedings of the 7th International Command and Control Research and Technology Symposium (CCRTS 2002)*, Quebec City, Quebec, 16-20 September 2002.

Kiselyov, O., "A Better XML Parser through Functional Programming," *Proceedings of the 4th International Symposium on Practical Aspects of Declarative Languages*, Portland, OR, January 2002.

Puett, J., "Holistic Framework for Establishing Interoperability of Heterogeneous Software Development Tools and Models," *Proceedings of the 24th International Conference on Software Engineering*, Orlando, FL, May 2002.

Ray, W., Luqi and Berzins, V., "Optimizing Systems by Work Schedules (A Stochastic Approach)," *Proceedings of the Workshop on Software Performance (WOSP 2002)*, Rome, Italy, pp.75-82, 23-26 July 2002.

Young, P., Berzins, V., Ge, J. and Luqi, "Using an Object Oriented Model for Resolving Representational Differences Between Heterogeneous Systems," *Proceedings of 17th ACM Symposium on Applied Computing (SAC)*, Madrid, Spain, pp. 976-983, 10-14 March 2002.

Zhao, W., Bryant, B., Raje, R., Auguston, M., Olson, A. and Burt, C., "A Unified Approach to Component Assembly Based on Generative Programming," *Proceedings of 2002 Workshop on Generative Programming (GP 2002)*, Austin, TX, April 2002.

THESES DIRECTED:

Lee, S.C., "Class Translator for the Federation Interoperability Object Model (FIOM)," Master's Thesis, Naval Postgraduate School, March 2002.

Moua, T.C., "Application Programmer's Interface (API) for Heterogeneous Language Environment and Upgrading the Legacy Embedded Software," Master's Thesis, Naval Postgraduate School, March 2002.

Murrah, M.R., "Enhancements and Extensions of Formal Models for Risk Assessment in Software Projects," Doctoral Dissertation, Naval Postgraduate School, September 2002.

Pradeep, K., "XML as a Data Exchange Medium for DoD Legacy Databases," Master's Thesis, Naval Postgraduate School, March 2002.

Young, P.E., "Heterogeneous Software System Interoperability Through Computer-aided Resolution of Modeling Differences," Doctoral Dissertation, Naval Postgraduate School, June 2002.

KEYWORDS: Software Engineering, Systems Adaptability, Dependability, Assurance

ENGINEERING AUTOMATION FOR RELIABLE SOFTWARE

Luqi, Professor

Department of Computer Science

Sponsor: U.S. Army Research Office

OBJECTIVE: This research addressed the problem of how to produce reliable software that is also flexible and cost effective for the Department of Defense (DoD) distributed software domain. Current and future DoD software systems fall into two categories: Information systems and Warfighter systems. Both kinds of systems can be distributed, heterogeneous and network-based, consisting of a set of components running on different platforms and working together via multiple communication links and protocols. This project approached the problem with a "wrap and glue" technology that is based on a domain specific distributed prototype model. The key to make this approach reliable, flexible, and cost-effective is the automatic generation of glue and wrappers based on the designer's specifications. Glue and wrappers are software that bridge the interoperability gap between individual commercial-off-the-shelf (COTS)/government-off-the-shelf (GOTS) components. The proposed research is on enabling technologies for this approach including prototyping, automatic program generation, inference for design checking, reliability assessment, and reliability improvement.

SUMMARY: This research focused on "wrap and glue" technology based on a domain-specific distributed prototype model. Glue and wrappers consists of software that bridges the interoperability gap between individual commercial-off-the-shelf (COTS)/government-off-the-shelf (GOTS) components. The key to making the proposed approach reliable, flexible, and cost-effective is the automatic generation of glue and wrappers based on a designer's specification. The proposed "wrap and glue" approach allows system designers to concentrate on the deeper interoperability problems such as differences in meaning and level of detail and defines solutions in terms of deeper and more significant interoperability issues, while freeing designers from implementation details. The objective of this research is to develop an integrated set of formal models and methods for system engineering automation. These results will enable building decision support tools for concurrent engineering. This research addresses complex modular systems with embedded control software and real-time requirements.

Longer-term goals are to construct an integrated set of software tools that can improve software quality and flexibility by automating a significant part of the process and providing substantial decision support for the aspects that cannot be automated. The resulting development environment should be adaptable to

enable (a) maintaining integrated support in the presence of business process improvement, (b) incorporation of future improvements in engineering automation methods, and (c) specialization to particular problem domains.

In FY02, the investigator studied models and methods for solving the integration and interoperability problems in component-based distributed heterogeneous systems. As a result, an Object Oriented Model for Interoperability (OOMI) was developed to capture the information required for resolving the representational differences that exist in autonomously developed systems. Defining the interoperation between systems in terms of an object model of externally visible interfaces provides a foundation for easy extension as new systems are added to the existing federation of systems, while minimize the amount of agreement needed to report effective interoperation.

An initial investigation was conducted into the development of a holistic framework that provides seamless interoperability between these tools and models improving both process and product. The existence of such a framework enhances the discovery of dependencies among different aspects of the software engineering process and allows software engineers to implement process improvements that proved produce integrity with respect to those dependencies.

The use of proxy-based network buffers was investigated as an inter-process communication layer and developed a basic program structure for the Distributed Computer Aided Prototyping System (DCAPS) to automatically generate code for user-defined distributed real-time systems prototypes.

Moreover, the method for automatically creating test cases for system generators was studied. The result is significant because constructing branch-coverage-complete sets of test case is not computable in the general case. This project's approach enables complete automation of test case generation with a guarantee of complete branch coverage of the generation rules.

In addition, a Module Driver and Output Analyzer Generator (MDOAG) was designed and developed for automated test code generation based on Attributed grammars. Automatic debugging tools based on precise program execution behavior models that enable a systematic approach were investigated. This approach is non-intrusive with respect to program source code and provides a high level of abstraction for debugging activities. The framework supports formalization of typical bug descriptions and debugging rule design.

Furthermore, formal models and mechanisms were investigated for describing the Quality of Service (QoS) attributes and techniques to assure the specified QoS and a framework was developed that allows an interoperation of heterogeneous and distributed software components.

Also, a QOS behavior model was developed based on the event trace analysis and techniques to provide decision support for optimizing distributed object servers utilization, as well as using software decoys to improve the security of distributed heterogeneous systems.

Finally, a case study on the prototyping of infusion pump software was conducted. SEATools were used to generate the prototyping software for a computer assisted resuscitation algorithm (CARA) system of interest to the Walter Reed Army Institute of Research.

PUBLICATIONS:

Auguston, M., Jeffery, C. and Underwood, S., "A Framework for Automatic Debugging," *Proceedings of the 17th IEEE International Conference on Automated Software Engineering 2002*, Edinburgh, U.K., 23-27 September 2002.

Berzins, V., "Lightweight Inference for Automation Efficiency," *Science of Computer Programming, Special Issue on Methods of Software Design: Techniques and Applications*, Vol. 42, No.1, pp. 61-74, January 2002.

Brahnmath, G., Raje, R., Olson, A., Auguston, M., Bryant, B. and Burt, C., "A Quality of Service Catalog for Software Components," *Proceedings of the 2002 Southeastern Software Engineering Conference*, 2002.

Bryant, B., Auguston, M., Raje, R., Olson, A. and Burt, C., "Formal Specification of Generative Component Assembly Using Two-Level Grammar," *Proceedings of the 14th International Conference on Software Engineering and Knowledge Engineering*, 2002.

Drummond, J., Luqi, Kemple, W., Auguston, M. and Chaki, N., "Quality of Service Behavioral Model from Event Trace Analysis," *Proceedings of the 7th International Command and Control Research and Technology Symposium (CCRTS 2002)*, Quebec City, Quebec, 16-20 September 2002.

Kiselyov, O., "A Better XML Parser through Functional Programming," *Proceedings of the 4th International Symposium on Practical Aspects of Declarative Languages*, Portland, OR, January 2002.

Kordon, F. and Luqi, "A Introduction to Rapid System Prototyping," *IEEE Transactions on Software Engineering, Special issue on Rapid System Prototyping*, Vol. 28, No. 9, pp. 817-821, September 2002.

Luqi and Broy, M., "Software Engineering Beyond Our Planning Horizon: Automation for Computer-based Systems," *Science of Computer Programming, Special Issue on Engineering Automation for Computer Based Systems*, Vol. 42, No. 1, pp.1-10, January 2002.

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Nada, N., Shing, M., Berzins, V. and Luqi, "Automated Prototyping Tool-kit (APT)," *Journal of Information Sciences*, 140(3-4), pp. 241-253, March 2002.

Puett, J., "Holistic Framework for Establishing Interoperability of Heterogeneous Software Development Tools and Models," *Proceedings of the 24th International Conference on Software Engineering*, Orlando, FL, May 2002.

Ray, W., Berzins, V. and Luqi, "Optimizing Systems by Work Schedules (A Stochastic Approach)," *3rd International Workshop on Software and Performance (WOSP) 2002*, Rome, Italy, pp.75-82, July 2002.

Young, P., Berzins, V., Ge, J. and Luqi, "Using an Object Oriented Model for Resolving Representational Differences Between Heterogeneous Systems," *Proceedings of 17th ACM Symposium on Applied Computing (SAC)*, Madrid, Spain, pp. 976- 983, 10-14 March 2002.

Zhao, W., Bryant, B., Raje, R., Auguston, M., Olson, A. and Burt, C., "A Unified Approach to Component Assembly Based on Generative Programming," *Proceedings of 2002 Workshop on Generative Programming (GP 2002)*, Austin, TX, April 2002.

THESES DIRECTED:

Alexander, B., "Legacy System Upgrade for Software Risk Assessment," Master's Thesis, Naval Postgraduate School, December 2001.

DaBose, M., "A Layered Software Architecture for Hard Real Time (HRT) Embedded Systems," Doctoral Dissertation, Naval Postgraduate School, March 2002.

Demirtas, T., "Scheduling and Prototyping of Distributed Real-Time Systems (An Approach using Jini/JavaSpaces)," Master's Thesis, Naval Postgraduate School, March 2002.

Drummond, J., "Specifying Quality of Service for Distributed Systems Based Upon Behavior Models," Doctoral Dissertation, Naval Postgraduate School, June 2002.

Dupont, J., "Complexity Measure for the Prototype System Description Language (PSDL)," Master's Thesis, Naval Postgraduate School, June 2002.

Lee, S.C., "Class Translator for the Federation Interoperability Object Model (FIOM)," Master's Thesis, Naval Postgraduate School, March 2002.

COMPUTER SCIENCE

Mata, M., "MIDS Universal Interface for the Selection of Link 16 Messages," Master's Thesis, Naval Postgraduate School, March 2002.

Pradeep, K., "XML as a Data Exchange Medium for DoD Legacy Databases," Master's Thesis, Naval Postgraduate School, June 2002.

Saboe, M., "A Software Technology Transition Entropy Based Engineering Model," Doctoral Dissertation, Naval Postgraduate School, March 2002.

Young, P., "Integration of Heterogeneous Software Systems Through Computer-aided Resolution of Data Representation Differences," Doctoral Dissertation, Naval Postgraduate School, March 2002.

KEYWORDS: Engineering Automation, Reliability, Glue and Wrapper Technology, Computer-aided Decision Support

METCAST QUERIES DEVELOPMENT AND CONSULTING

Luqi, Professor

Department of Computer Science

Sponsor: Fleet Numerical Meteorology and Oceanography Center

OBJECTIVE: Meteosat Cloud Assimilation and Advection (METCAST) development. Develop METCAST interfaces (web pages) to use as "web services." Develop a METCAST parser module. Implement JMPLAT. Participate in Joint Extensible Markup Language (XML) Meteorology and Oceanography (METOC) Working Group. Provide consulting about METCAST decoders, web services, and portals.

KEYWORDS: Software Engineering, Automation, Project Management

METCAST SOFTWARE INTEGRATION

Luqi, Professor

Department of Computer Science

Sponsor: Space and Naval Warfare Systems -San Diego

OBJECTIVE: Meteosat Cloud Assimilation and Advection (METCAST) development. Perform verification and validation of products and data assimilation techniques developed for fleet applications.

KEYWORDS: Software Engineering, Automation, Project Management

SOFTWARE RISK ASSESSMENT

Luqi, Professor

Department of Computer Science

Sponsor: U.S. Air Force Aeronautical Systems Center

TESTING OF LARGE SOFTWARE INTENSIVE SYSTEM

Luqi, Professor

Department of Computer Science

Sponsor: Space and Naval Warfare Systems -San Diego

COMPUTER SCIENCE

WEAPON SOFTWARE SAFETY PROGRAM IN NPS SOFTWARE ENGINEERING AUTOMATION CENTER

Luqi, Professor

Department of Computer Science

Sponsor: Naval Sea Systems Command

OBJECTIVE: For the Software Engineering Automation Center at the Naval Postgraduate School (NPS) to support instructional effort to develop Software Engineering Courses on weapon software safety in software engineering curriculum, and to establish a weapon software safety chair and Computer/telecommunication support.

SUMMARY: Modern weapon systems rely on software for virtually all aspects of their functionality. Software controls almost all aspects from the detection and classification of threats to launching the ordnance, guiding it to the threat, and, in some cases, initiating the explosive warhead. An error or failure in any of the software modules controlling the weapon system could have catastrophic results, such as misidentifying a friendly track as hostile or initiating the warhead while still in close proximity to the launching platform.

The Navy needs highly trained individuals capable of developing and assessing the software for modern weapon systems to ensure that it can reliably perform its mission without posing an unacceptable risk to the fleet. Weapon Systems Software Safety is a discipline that integrates Systems Engineering, System Safety Engineering, and Software Engineering into a cohesive discipline that provides the knowledge and skills necessary to perform this risk assessment. The discipline is Software Engineering intensive due to the complexity of the software in modern weapon systems. However, it uses a true Systems Engineering approach to address the issues. The proposed curriculum will provide a cadre of individuals trained in the development of critical software with the fundamental knowledge necessary to develop software that provides an acceptable level of risk in the system and operational context without sacrificing mission effectiveness or functionality. Key courses in the curriculum will also provide individuals with the knowledge and skills necessary to perform the required design, analysis, testing, and risk assessment to verify the safety of the software in the system context.

Software Engineering and Information Technology are rapidly evolving disciplines. NPS is at the forefront of both disciplines. To be effective, Weapon Systems Software Safety must evolve with these disciplines and provide the direction necessary to maintain both the effectiveness and safety of the associated technology as it is applied to Navy weapon systems. NPS is in an enviable position to accomplish that mission. Qualified individuals must also perform both the theoretical and applied research necessary to provide the Weapon System Safety community with the tools and techniques necessary to assess the risk associated with the introduction of new technologies, the integration of existing technologies with our existing systems, as well as the integration of existing system into systems of systems. The students at NPS have backgrounds directly relevant to the discipline: many have first hand experience with the software developed for modern weapon systems. Therefore, NPS has a cadre of highly skilled individuals available to conduct this vital research.

Establishing a Chair in Weapon Systems Software Safety at NPS has many distinct advantages, including those listed in the previous paragraph. The student body consists of individuals who will be managing weapon system programs involving software, managing the development of software for future weapon systems, or perhaps even developing the software themselves. The position will allow the direction of thesis and research topics to provide the necessary tools and techniques to evaluate software in complex weapon systems. The position will also allow direct access to research conducted at NPS and other universities in Software Engineering and Information Technology and evaluate its application, or possible impact, on the safety of modern weapon systems. Evaluating this research gives the Navy the opportunity to address these topics before they become a part of a Navy weapon system.

In this project, briefing slides were developed and work commenced on the initial effort of Navy Software Safety Program at NPS.

KEYWORDS: Software Engineering, Weapon Systems Software Safety, Automation

**MAGMA: A LIQUID SOFTWARE APPROACH FOR FAULT TOLERANCE AND SECURITY
FOR SERVER AGENT-BASED ACTIVE NETWORKING MANAGEMENT (SAAM)**

**LCDR Margulis, USN, Military Faculty
Geoffrey Xie, Assistant Professor
Department of Computer Science**

Sponsors: National Reconnaissance Office, Space and Naval Warfare Systems - San Diego

OBJECTIVE: Provide fault tolerance, security, and network regeneration by creating a software application that will allow a Server Agent-based Active Network Management (SAAM) server to move from one host to another, randomly or manually.

KEYWORDS: Networking Regeneration, Mobile Code, Liquid Software, Fault Tolerance, Network Security

**COMPUTATIONAL SUPPORT FOR TESTING AND EVALUATING COMPOSED
HETEROGENEOUS DISTRIBUTED MISSILE SYSTEMS**

**James Bret Michael, Associate Professor
Department of Computer Science
Phillip E. Pace, Professor
Murali Tummala, Professor
Department of Electrical and Computer Engineering
Man-Tak Shing, Associate Professor
Department of Computer Science
Center for Joint Services Electronic Warfare
Sponsor: Missile Defense Agency**

OBJECTIVE: To develop a systematic engineering-based approach for constructing a high-level architecture for a specific system-of-systems: the Ballistic Missile Defense System (BMDS).

SUMMARY: The first phase of this research yielded multiple versions of a preliminary architecture specification for the BMDS, which in turn served as the basis for constructing a new theory about how to systematically architect system-of-systems using well established principles of software engineering. In a system-of-systems, the number of possible combinations of interactions among the systems is theoretically infinite. System “unravelings” have an intelligence of their own as they expose hidden connections, neutralize redundancies, and exploit chance circumstances for which no system engineer might plan. In the paradigm this project developed for architecting systems, rather than decompose each system within the system-of-systems in a functional fashion, the system-of-systems is treated as a single entity that is comprised of abstract classes. So far this project has demonstrated how its paradigm can be used to both avoid the introduction of accidental complexity and control essential complexity by applying object-oriented concepts of decentralized control flow, minimal messaging between classes, implicit case analysis, and information-hiding mechanisms. It is argued that this paradigm can aid in the creation of sound designs for the system-of-systems in contrast to creating a federation of systems through a highly coupled communication medium, the latter being the dominant paradigm used in legacy missile systems. Additional funding was secured for continuation of this project through the end of FY 2004.

PUBLICATIONS:

Caffall, D.C. and Michael, J.B., "System-of-systems Design for the Ballistic Missile Defense System," *Lecture Notes in Computer Science*, Heidelberg, Germany: Springer-Verlag, (to appear).

Caffall, D.C. and Michael, J.B., "System-of-systems Design from an Object-oriented Paradigm," *Proceedings of the Monterey Workshop: Radical Innovations of Software and Systems Engineering in the Future*, U.S. Army Research Office, Venice, Italy, pp. 146-157, October 2002.

THESIS DIRECTED:

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

KEYWORDS: Architecture, Missile Defense, Software Engineering

ENGINEERING TECHNOLOGIES FOR THE WARFIGHTER 2002

James Bret Michael, Associate Professor

Michael L. Brown, Visiting Lecturer

Department of Computer Science

Sponsor: Navy Inventory Control Point/Swedish National Defence College

OBJECTIVE: To prepare and deliver an eight-hour intensive course on weapon systems software safety to a delegation of students from the Swedish National Defence College.

SUMMARY: The full eleven-week course on weapon systems software safety was condensed into an eight-hour intensive course of the subject. The course material was redesigned to consist of the following learning modules: background and principles of system safety engineering; hazard identification, classification, and prioritization; introduction to software systems safety; identification of safety-critical functions; software causal factors; standards; system effects and system integration hazards; system and software architecture software development methodologies; software systems safety testing; and non-developmental items. The course was well received by the Swedish National Defence College and will be offered again in FY 2003.

OTHER:

Brown, M.L. and Michael, J.B., "Course Notes on Weapon Systems Software Safety," Center for Joint Services Electronic Warfare, Naval Postgraduate School, [CD-ROM].

KEYWORDS: Safety, Software, Weapon Systems

INTELLIGENT SOFTWARE DECOYS

James Bret Michael, Associate Professor

Neil C. Rowe, Professor

Mikhail Auguston, Associate Professor

Doron Drusinsky, Associate Professor

Department of Computer Science

Hy S. Rothstein, Senior Lecturer

Department of Defense Analysis

Thomas C. Wingfield, Consultant

Aegis Research Corporation

Sponsor: U.S. Department of Justice

OBJECTIVE: To conceptualize, architect, prototype, and experiment with mechanisms for effecting software-based deception.

SUMMARY: In this project, which is part of the Naval Postgraduate School's portfolio of research efforts conducted under the aegis of its Homeland Security Research and Technology Program, the technical feasibility and institutional issues associated with applying software-based deception techniques as part of Homeland defense were explored. At present, the embodiment of software-based deception is referred to as *intelligent software decoys*, although this name may change in the next phase of research. The key idea currently under pursuit is that software-based deception can be used to harden operational software assets against attack. One of the novel aspects of this research is the introduction of the concept of conducting counterintelligence and intelligently employing countermeasures in cyberspace via software-based deception: such a capability can be used to counter attacks conducted by technology-savvy terrorists and criminals, in addition to information warriors from rogue or enemy nation-states. Conventional countermeasures will likely be ineffective against the sophisticated arsenal of cyber weapons at the disposal of such attackers, and any countermeasure will be difficult to deploy without reliable counterintelligence, particularly if the users of countermeasures intend to avoid becoming cyber war criminals.

The development of a partial prototype of the tools to support the automatic generation of intelligent software decoys was completed, and some preliminary experiments were conducted to test the technical feasibility of the concept tools and deception mechanisms. The initial results indicate that software-based deception could play a pivotal role in protecting the U.S. critical information infrastructure and critical software applications that rely on that infrastructure. The project will continue through the end of 2003.

CONFERENCE PAPERS:

Gorodetsky, V., Kotenko, I. and Michael, J.B., "Multi-agent Modeling and Simulation of Distributed Denial-of-service Attacks on Computer Networks," *Proceedings of the Third International Conference on Navy and Shipbuilding Nowadays*, Krylov Shipbuilding Research Institute, St. Petersburg, Russia, June 2003.

Michael, J.B., "On the Response Policy of Software Decoys: Conducting Software-based Deception in the Cyber Battlespace," *Proceedings of the Twenty-sixth Annual Computer Software and Applications Conference, IEEE*, Oxford, England, pp. 957-962, August 2002.

Michael, B., Auguston, M., Rowe, N. and Riehle, R., "Software Decoys: Intrusion Detection and Countermeasures," *Proceedings of the 2002 IEEE Workshop on Information Assurance*, United States Military Academy, West Point, NY, pp. 130-139, June 2002.

Michael, J.B., Fragkos, G. and Auguston, M., "An Experiment in Software Decoy Design: Intrusion Detection and Countermeasures via System Call Instrumentation," *Proceedings of the Eighteenth IFIP Int. Inf. Security Conference, Norwell, MA*, Kluwer Academic Publishers, Athens, Greece, May 2003.

Michael, J.B. and Wingfield, T.C., "Lawful Cyber Decoy Policy," *Proceedings of the Eighteenth IFIP TC11 Int. Inf. Security Conference, Norwell, MA*, Kluwer Academic Publishers: Athens, Greece, May 2003.

TECHNICAL REPORT:

“Phase I Report on Intelligent Software Decoys: Technical Feasibility and Institutional Issues in the Context of Homeland Security,” Naval Postgraduate School Technical Report, NPS-CS-03-001, December 2002.

THESES DIRECTED:

Fragkos, G., “An Event-trace Language for Software Decoys,” Master’s Thesis, Naval Postgraduate School, September 2002.

Julian, D.P., “Delay Type Responses for Use by Software Decoys,” Master’s Thesis, Naval Postgraduate School, September 2002.

Schummann, M.A., “Network Intruder Identification via Covert Data Using Location-aware Code Embedded in a Benign Software Application,” Master’s Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: Deception, Homeland Security, Information Operations, Software

POLICIES FOR DISTRIBUTED SYSTEMS AND NETWORKS

James Bret Michael, Associate Professor

Department of Computer Science

Sponsor: Office of Naval Research

OBJECTIVE: To attract nationally recognized speakers and panelists for the Third International Workshop on Policies for Distributed Systems and Networks, in addition to organizing and obtaining formal technical and financial sponsorship for the workshop from a well-respected technical society.

SUMMARY: In 1994, the sponsor and the National Science Foundation co-funded the founding of the First Workshop on Computer Support for Policy, for which the principal investigator served as the co-convenor. In 2002, full technical and financial sponsorship for the workshop was obtained from the Computer Society of the Institute for Electrical and Electronics Engineers. The workshop was held at the Naval Postgraduate School in June 2002. The funding from the Office of Naval Research was used to remunerate the keynote speakers and panelists, in addition to covering some of the labor involved in both organizing the workshop and advising thesis research at NPS on the topic of computational support for policy. Seventeen technical papers (out of sixty-seven manuscripts received) were published and presented at the workshop. Over 140 participants attended this workshop, representing over twenty nations. The papers, presentations, and panel sessions addressed the technical aspects of managing policies for systems both in the large and in the small, the latter case requiring innovative techniques to manage and enforce policy with limited computing resources. As part of this project, some of the latest research sponsored by the U.S. Department of Defense (DoD) on the subject of policies for distributed systems and networks was showcased at the workshop.

The thesis research related to this project yielded innovations in modeling security policy in a computation form, as well as specifying and enforcing security policy across distributed run-time virtual environments.

PUBLICATION:

Proceedings of the Third Int. Workshop on Policies for Distributed Systems and Networks, IEEE, Monterey, CA, June 2002.

THESES DIRECTED:

Custy, E.J., "An Architecture for the Semantic Processing of Natural Language Input to a Policy Workbench," Master's Thesis, Naval Postgraduate School, March 2003.

Sallés, E.J., "The Impact on Quality of Service When Using Security Enabling Filters to Provide for the Security of Run-time Virtual Environments," Master's Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: Distributed Systems, Networks, Policy

TESTING OF LARGE SOFTWARE-INTENSIVE SYSTEMS

James Bret Michael, Associate Professor

Department of Computer Science

Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: To investigate innovative methods and techniques for improving the testability and quality of large software-intensive systems.

SUMMARY: This project had both a research and an oversight component. The research component involved investigating how to improve the likelihood that, with advances in software-testing tool technology, the U.S. Department of the Navy (DoN) can produce better quality software than today; this project also explored what tool support is currently available; and formulated a theory and approach for measuring the effectiveness of software-testing tools. A means for systematically measuring the quality of software project management was successfully developed and the resulting metric can be used as means for providing the managers of large Department of Defense (DoD) software development projects with feedback on their performance. The remainder of the effort expended on this project was used to serve in an oversight capacity on the Interim Government Advisory Board and Research Coordinating Council for the National Institute for System Testing and Productivity (NISTP); the U.S. DoN sponsors the Institute to explore ways in which to produce quality software for naval information systems. This project will continue through the end of FY 2003.

PUBLICATIONS:

Michael, J.B., "Metrics for Evaluating Software-testing Tools," *Empirical Software Engineering Journal*, (submitted).

Michael, J.B., Bossuyt, B.J. and Snyder, B.B., "Metrics for Measuring the Effectiveness of Software-testing Tools," *Proceedings of the Thirteenth Int. Symposium on Software Reliability Eng., IEEE*, Annapolis, MD, pp. 117-128, November 2002.

Osmundson, J.S., Michael, J.B., Machniak, M.J. and Grossman, M.A., "Quality Management Metrics for Software Development," *Journal of Information and Management*, (accepted).

PRESENTATION:

Michael, J.B., "Quality Management Metrics for Software Development," IEEE Thirteenth Int. Symposium on Software Reliability Eng., Annapolis, MD, November 2002.

THESES DIRECTED:

Acantilado, N.J.P. and Acantilado, C.P., "SIMPLE: A Prototype Software Fault-injection Tool," Master's Thesis, Naval Postgraduate School, December 2002.

COMPUTER SCIENCE

Bossuyt, B.J. and Snyder, B.B., "Software Testing Tools: Metrics for Measurement of Effectiveness on Procedural and Object-oriented Source Code," Master's Thesis, Naval Postgraduate School, September 2001.

KEYWORDS: Metrics, Productivity, Project Management, Software, Testing

FIRE PLAN SKETCH MANAGER FOR C2PC, SOFTWARE PROJECT
Richard Riehle, Visiting Professor
Major Steve Grass, USMC, Student
Department of Computer Science
Sponsor: United States Marine Corps – Marine Corps Systems Command

OBJECTIVE: Develop the Fire Plan Sketch Manager, a software tool that manages a Marine Corps Fire Plan Sketch.

KEYWORDS: Common Operating Picture System

AUTOMATED LINGUISTIC ANALYSIS OF BATTLEFIELD INTELLIGENCE REPORTS
Neil C. Rowe, Professor
Department of Computer Science
Sponsor: Defense Advanced Research Projects Agency

OBJECTIVE: Develop software to extract location expressions concerning military units and targets from battlefield intelligence reports for use in a system for tracking enemy movements.

SUMMARY: This project developed prototype software to extract location expressions from the free-form text portion of sample intelligence reports. This software used methods of modern data mining and text extraction including quick focus on the typically few items of relevant text within a large body of messages, thereby providing strong information filtering capability. A "partial parser" was exploited that defined precisely the forms of patterns of location expressions and their associated categories of words, building on the 20,000-word dictionary previously developed for the MARIE project for understanding Navy captions.

The prototype was implemented efficiently in Java and research showed much better speed than previously developed natural-language software. Good accuracy of the prototype was demonstrated in locating relevant expressions for a demonstration for the sponsor at the end of the project.

PUBLICATIONS:

Rowe, N.C., "MARIE-4: A High-recall, Self-improving Web Crawler that Finds Images Using Captions," *IEEE Intelligent Systems*, Vol. 17, No. 4, July/August 2002.

Rowe, N.C., "Thorough Indexing of Images on the World Wide Web," *IASTED Artificial Intelligence and Applications Conference*, Malaga, Spain, pp. 192-197, September 2002.

Rowe, N.C., "Virtual Multimedia Libraries Built from the Web," *Second ACM-IEEE Joint Conference on Digital Libraries (JCDL02)*, Portland, OR, pp.158-159, July 2002.

OTHER:

Rowe, N.C., Coffman, J., Degirmenci, Y., Hall, S., Lee, S. and Williams, C., "Automatic Removal of Advertising from Web-page Display," *Second ACM-IEEE Joint Conference on Digital Libraries (JCDL02)*, published poster and presentation, Portland, OR, p. 406, July 2002.

THESES DIRECTED:

Carroll, C., "Population and Maintenance of an Intelligence Database Utilizing Intelligent Agent Technologies," Master's Thesis, Naval Postgraduate School, March 2002.

Hall, S., "Automatic Text Categorization Applied to E-Mail," Master's Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: Natural-language Processing, Intelligence Reports, Information Filtering, Data Mining, Location Expressions, Partial Parsing

**DISTANCE LEARNING THESIS SUPPORT FOR THE AUTOMATED POLICY
SPECIFICATION RESEARCH**

**Man-Tak Shing, Associate Professor
Department of Computer Science**

Sponsor: Space and Naval Warfare Systems Center, San Diego

OBJECTIVE: The project provided distance learning thesis support for research to automate the process of administering and distributing policy effectively and efficiently in a bandwidth-constrained environment. The thesis research investigated (1) techniques to facilitate the exchange of data and information between applications sharing a common information model over low bandwidth communications, (2) automated policy specification interfaces to integrate commercial and developmental products into a common policy specification environment, and (3) agent technology to provide intelligent management and use of the available assets.

SUMMARY: In FY02, the use of Resource Description Framework (RDF) and Extensible Markup Language (XML) technologies were studied to advance the Naval Tactical Knowledge Management (KM), which is critical to the success of the On Scene Commanders. Today's Tactical Knowledge Manager typically operates in a high stressed environment with a multitude of knowledge sources including detailed sensor plans, rules of engagement contingencies, and weapon delivery assignments. Many of these sources have been information oriented and have been formatted as Naval Messages for delivery to decision makers. Recent advances in web technologies provide an opportunity to automate the existing Naval Message architecture and improve the knowledge management process. Resource Description Framework (RDF), Extensible Markup Language (XML), and software agent technologies provide the potential of increased machine reasoning within KM design. The challenges in applying these new technologies to the unique environment of a tactical platform were evaluated.

KEYWORDS: Software Engineering, Automated Policy Specification, Knowledge Management

ENHANCED SENSOR FORMULA FOR THE TACTICAL REMOTE SENSOR SYSTEM (TRSS)

**Man-Tak Shing, Associate Professor
Capt. Jeff Hoaglund, USMC
Department of Computer Science**

Sponsor: Marine Corps Systems Command

OBJECTIVE: This project addressed the USMC's need to enhance a Marine Air-Ground Task Force (MAGTF) or unit commander's remote sensing capability by improving the robustness and efficiency of the Sensor Formula software module within the Tactical Remote Sensor System (TRSS). The current Sensor Formula limits the processing and validation of activation data. It is based on an outdated and limiting threat model, which is ill-suited for a dynamic threat, particularly in an Operations Other Than War (OOTW) environment. Updating the Sensor Formula will allow a MAGTF or unit commander to extend his remote sensing capability in any environment, not just a major theater conflict where large ground forces will be engaging one another through traditional "cold war" era maneuver.

SUMMARY: This study examined the existing Sensor Formula and target classification capabilities of the Tactical Remote Sensor System (TRSS), and developed an object-oriented architecture for the Sensor Formula software and a new algorithm for processing the sensor information. The previous design was limited in its ability to analyze threats beyond the parameters of the Former Soviet Union (FSU) threat model. The parameters for vehicle spacing, rate of speed, length of column, etc. were coded into the actual algorithm and could not be modified if the threat varied its tactics. The new algorithm allows for adaptation and modification of parameters through an object-oriented class structure. As new threat models are required, new classes can be created both inheriting the attributes of the parent class and incorporating region specific information. Unlike the old design, the new algorithm also validates its output against current weather and terrain information. The object-oriented design facilitates module-based analysis and testing, rather than relying on testing the entire system as a whole. Recommendations on how the formula structure can be further improved through the implementation of weather and terrain data stores which are updated on a near-real-time basis were also provided.

THESIS DIRECTED:

Hoaglund, J., "Analysis and Design of an Improved Sensor Formula for the Tactical Remote Sensor System (TRSS)," Master's Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: Remote Sensing, Sensor Formula

BASIC RESEARCH IN INFORMATION PRIVACY

Dennis Volpano, Assistant Professor

Department of Computer Science

Sponsor: National Science Foundation

OBJECTIVE: To investigate new confinement models for concurrent programming languages and systems that integrate information flow and cryptography.

KEYWORDS: Concurrency, Security, Privacy

A NETWORKING PROTOCOL FOR UNDERWATER ACOUSTIC NETWORKS

Geoffrey Xie, Assistant Professor

Department of Computer Science

Sponsor: National Science Foundation

OBJECTIVE: To develop a network layer protocol necessary to increase the utility of acoustic communications in the shallow water environment. Increasing attention has been given to collecting data from difficult to access coastal waters for diverse activities, to include scientific research, industrial and commercial concerns, and military applications. The preponderance of activity has focused on developing reliable methods for transmitting the information collected through the difficult time-varying shallow water medium. However, current network protocols, which are responsible for determining traffic routing, do not provide for guaranteed quality of services. Current protocols also may cause unnecessary message delays.

To overcome the scalability issue of proactive networks and control the delay variance suffered in reactive networks, the Server and Agent Based Active Network Management (SAAM) Protocol introduces a mechanism for controlling the allocation of network resources by a central server and performing all route decisions at that server. The SAAM protocol controls the network as a hierarchy of coordinated routers. Each router reports its status and hosted interfaces to the central server. The server determines all routes through the network based on the reported node status and allocates network resources to applications requesting support. By generating and maintaining the routing paths periodically the protocol has some aspects of proactive routing. However, by periodically probing the network for router status it accomplished much of the adaptability of ad hoc networks. SAAM researchers have also addressed server fault tolerance and security issues. Their initial results show that SAAM is very suitable for managing

land-based high-speed integrated service networks with point-to-point links. However, it is still unclear how the SAAM approach can be adapted to underwater acoustic networks. This research addresses this question.

KEYWORDS: Shallow Water Environment, SAAM, Network Layer Protocol, Underwater Acoustic Networks

SAAM: NETWORK MANAGEMENT FOR INTEGRATED SERVICES

Geoffrey Xie, Assistant Professor

Department of Computer Science

Sponsor: Defense Advanced Research Projects Agency

OBJECTIVE: A novel server and agent based active management system for the next generation Internet is being developed.

SUMMARY: Progress was made in the following areas: realistic traffic generation, dynamic bandwidth provisioning, rerouting of real-time flows, survivable SAAM service, best effort traffic engineering, policy-based networking, and application of SAAM concept in underwater acoustic networks.

The SAAM prototype system has been enhanced to incorporate the aforementioned work.

INTEGRATION OF HETEROGENOUS SOFTWARE SYSTEMS THROUGH COMPUTER-AIDED RESOLUTION OF DATA REPRESENTATION DIFFERENCES

CAPT P.E. Young, USN

Department of Computer Science

Sponsor: Space and Naval Warfare Systems Center - San Diego

OBJECTIVE: The proposed research consists of investigating methods for using computer aid for achieving interoperability between legacy, commercial-off-the-shelf (COTS), and government-off-the-shelf (GOTS) software systems.

KEYWORDS: Integration, Interoperability, Heterogenous Software Systems

**DEPARTMENT OF
COMPUTER SCIENCE**

**2002
Faculty Publications
and Presentations**

PUBLICATIONS

Berzins, V., "Lightweight Inference for Automation Efficiency," *Science of Computer Programming, Special Issue on Methods of Software Design: Techniques and Applications*, Vol. 42, No.1, pp. 61-74, January 2002.

Irvine, C. and Levin, T., "A Cautionary Note Regarding the Data Integrity Capacity of Certain Secure Systems," *Integrity, Internal Control and Security in Information Systems*, ISBN 1-4020-7005-5, Brussels Belgium, 2002.

Irvine, C., Levin, T., Wilson, J., Shifflett, D. and Pereira, B., "An Approach to Security Requirements Engineering for a High Assurance System," *Requirements Engineering Journal*, Vol. 7, No. 4, pp. 192-206, 18 December 2002.

Kordon, F. and Luqi, "A Introduction to Rapid System Prototyping," *IEEE Transactions on Software Engineering, Special issue on Rapid System Prototyping*, Vol. 28, No. 9, pp. 817-821, September 2002.

Luqi and Broy, M., "Software Engineering Beyond Our Planning Horizon: Automation for Computer-based Systems," *Science of Computer Programming, Special Issue on Engineering Automation for Computer Based Systems*, Vol. 42, No.1, pp.1-10, January 2002.

Michael, J.B., "Metrics for Evaluating Software-testing Tools," *Empirical Software Engineering Journal*, (submitted).

Nada, N., Shing, M., Berzins, V. and Luqi, "Automated Prototyping Tool-kit (APT)," *Journal of Information Sciences*, 140(3-4), pp. 241-253, March 2002.

Osmundson, J.S., Michael, J.B., Machniak, M.J. and Grossman, M. A., "Quality Management Metrics for Software Development," *Journal of Information and Management*, (accepted).

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Zhao, W., Bryant, B., Raje, R., Auguston, M., Olson, A. and Burt, C., "A Unified Approach to Component Assembly Based on Generative Programming," *Proceedings of 2002 Workshop on Generative Programming (GP 2002)*, Austin, TX, April 2002.

PRESENTATIONS

Dinolt, G., "The Navy Certifier Program," Cebrowski Institute Symposium, Monterey, CA, 30 July 2002.

Drusinsky, D. and Watney, G., "Applying Run-time Monitoring to the Deep-Impact Fault Protection Engine," 27th IEEE/NASA ICECCS Workshop, 2002.

Irvine, C., "An Extended OpenBSD Security Architecture: MYSEA," Secure Trusted Operating System Workshop, Monterey, CA, August 2002.

Irvine, C., "Monterey Security Architecture (MYSEA) Project," Navy Information Assurance Leadership Conference, Washington, D.C., October 2002.

Irvine, C., "SimSecurity," Secure Trusted Operating System Workshop, Monterey, CA, August 2002.

Levin, T., "Monterey Security Architecture (MYSEA) Project," Cebrowski Institute Symposium, Monterey, CA, 29 July 2002.

Levin, T., "Quality of Security Service," Cool Security Trends Panel, Symposium on Access Control Models and Technologies, June 2002.

Michael, J.B., "Quality Management Metrics for Software Development," IEEE Thirteenth Int. Symposium on Software Reliability Engineering, Annapolis, MD, November 2002.

TECHNICAL REPORTS

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Irvine, C.E., Levin, T.E. and Dinolt, G.W., "A National Trusted Computing Strategy," Naval Postgraduate School Technical Report, NPS-CS-02-003, May 2002.

Irvine, C., Levin, T. and Dinolt, G., "Protected Domains for Cyber Infrastructure Management," Naval Postgraduate School Technical Report, NPS-CS-02-007, October 2002.

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OTHER

Brown, M.L. and Michael, J.B., "Course Notes on Weapon Systems Software Safety," Center for Joint Services Electronic Warfare, Naval Postgraduate School, [CD-ROM].

Senter, J., Thorton, C., Rose, M. and Irvine C., "Information Technologies Ethics Training Course," Compact Disk, Version 1.1, September 2002.

"The System Certification and Accreditation Process," Introduction to certification and accreditation for prospective Navy certifiers, CD-ROM.

**DEPARTMENT OF
DEFENSE ANALYSIS**

**GORDON MCCORMICK
CHAIR**

DEFENSE ANALYSIS

OVERVIEW:

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

CURRICULUM SERVED:

- Special Operations

DEGREE GRANTED:

- Master of Science in Defense Analysis

RESEARCH THRUSTS:

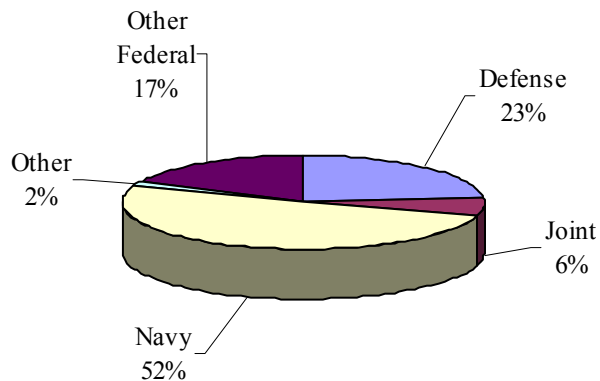
- Special Operations
- Asymmetric Warfare
- Sub-State Conflict
- Terrorism
- Information Operations
- Defense and Foreign Policy

RESEARCH CENTERS:

- Center on Terrorism and Irregular Warfare

SPONSORED PROGRAM (Research and Academic)-FY2002:

The Naval Postgraduate School’s sponsored program exceeded \$61 million in FY2002. Sponsored programs include both research and educational activities funded from an external source. A profile of the sponsored program of the Department of Defense Analysis is provided below:



Size of Program: \$641K

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DEFENSE ANALYSIS

DECEIVING TERRORISTS

**John Arquilla, Associate Professor
Department of Defense Analysis**

Sponsor: Office of the Secretary of Defense

OBJECTIVE: Identify and analyze historical cases where deception has been used against terrorists, and select options, suggested by these cases, which might be applicable to the current terror war.

KEYWORDS: Terrorism, Deception

RESEARCH AND ANALYSIS OF TERRORIST INFORMATION OPERATIONS (RATIO):

PHASE ONE

**John Arquilla, Associate Professor
David Tucker, Associate Professor
Department of Defense Analysis**

Sponsor: Joint Special Operations Command

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

KEYWORDS: Cyberterror, Terrorism, Information Warfare, Psychological Operations

RESEARCH AND ANALYSIS OF TERRORIST INFORMATION OPERATIONS (RATIO):

PHASE THREE: 2001

**John Arquilla, Associate Professor
David Tucker, Associate Professor
Department of Defense Analysis**

Sponsor: Defense Intelligence Agency

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

KEYWORDS: Cyberterror, Terrorism, Information Warfare, Psychological Operations

TERRORIST IO ANALYSIS TO SUPPORT FORCE PROTECTION: PHASE TWO

**John Arquilla, Associate Professor
David Tucker, Associate Professor
Department of Defense Analysis**

Sponsor: Naval Air Warfare Center -Training Systems Division

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

KEYWORDS: Cyberterror, Terrorism, Information Warfare, Psychological Operations

DEFENSE ANALYSIS

MILITARY INNOVATIONS: THE CASE OF SPECIAL OPERATIONS FORCES

David Tucker, Associate Professor

Department of Defense Analysis

Sponsor: Smith Richardson Foundation

OBJECTIVE: To understand why some military organizations are better at innovating than others by examining innovation in special operations forces.

KEYWORDS: Special Operations, Innovation, Roles, Missions

**DEPARTMENT OF
INFORMATION SCIENCE**

**DAN BOGER
CHAIR**

INFORMATION SCIENCE

OVERVIEW:

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

CURRICULA SERVED:

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

DEGREES GRANTED:

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

RESEARCH THRUSTS:

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

RESEARCH FACILITIES:

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

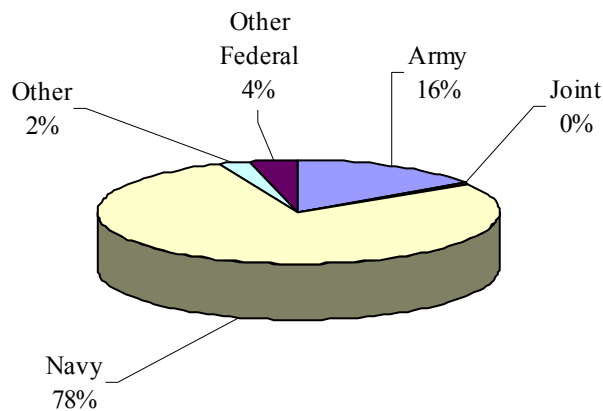
INFORMATION SCIENCE

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

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

RESEARCH PROGRAM (Research and Academic)-FY2002:

The Naval Postgraduate School's sponsored program exceeded \$61 million in FY2002. Sponsored programs include both research and educational activities funded from an external source. A profile of the sponsored program for the Department of Information Science is provided below.



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INFORMATION SCIENCE

HIGH RESOLUTION TERRAIN DATA GENERATION

**Wolfgang Baer, Research Associate Professor
Department of Information Science**

Sponsor: U.S. Army TRADOC Analysis Command

OBJECTIVE: Test Prototype Terrain Database toolkit on sample 16x16 km area of Ft. Hood, TX and deliver a terrain database.

SUMMARY: This study utilized tools developed under earlier contracts to generate a sample terrain database over an area of Ft. Hood, TX. Aerial-Photo of the area was provided along with contractor extracted 4-meter post elevations. The NPS team identified standard elevation background data source and develop import routines. Terrain features were identified, measured and fit to #D models in order to populate the concealment and cover region. Automation scripts were developed and run to test the ability of the software tools (named PVNT) to produce terrain updates automatically. The resulting terrain was tested for accuracy utilizing several dozen control points measured by a team from TRAC-White Sands Missile Range (WSMR).

KEYWORDS: Terrain, Battlefield Visualization, Line-of-sight, Image Processing, Remote Sensing

MICRO TERRAIN TOOL DISTRIBUTION SUPPORT

**Wolfgang Baer, Research Associate Professor
Department of Information Science**

Sponsor: U.S. Army TRADOC Analysis Command

OBJECTIVE: Provide Documentation and Distribution Kit and special application tailoring for the PVNT terrain database generation toolkit.

SUMMARY: The database generation toolkit software will be upgraded to allow application for target mensuration and techniques such as 3D editing and the use of difference image feedback implemented for concept demonstration. Software test and debug will be conducted as part of the operations and demonstration manual production. Concept demonstration software for 3D editing will be developed in order to show the utility and automation potential of database updating when corrections and new information is added in the image projections from which measurements are taken. Publications will be produced to describe and disseminate knowledge of this capability.

CONFERENCE PAPER:

Baer, W. and Slattery, C., "Bi-directional Reflectance Distribution Function for Reducing Remote Sensing Data to Computer Graphics Databases," *Proceedings of the Summer Computer Simulation Conference*, San Diego, CA, 13-16 July 2002.

THESIS DIRECTED:

Tanner, M., "Defining the Digital Environment: A Survey of Tools and Techniques to Define and Register Digital Terrain for Situated Java Ground Combat Simulations," Master's Thesis, Naval Postgraduate School, December 2003.

KEYWORDS: Terrain, Battlefield Visualization, Line-of-sight, Image Processing, Remote Sensing

INFORMATION SCIENCE

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

OBJECTIVE: Provide software development for prototype high resolution aerial-photo terrain data extraction toolkit

SUMMARY: This research explored and developed database formats, data sources and algorithms for the rapid construction of high-resolution terrain databases. The design was implemented in a C++ software package and delivered to the sponsor. The software will concentrate on automatic procedures for extracting terrain features such as trees, rocks, houses which add visibility, concealment, and cover to tactical operations.

KEYWORDS: Terrain, Battlefield Visualization, Line-of-sight, Image Processing, Remote Sensing

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

OBJECTIVE: Explore network management systems capability to identify intrusion detection patterns within the framework of SNMP MIBs analysis in wireless C4I networks.

SUMMARY: This study involved setting up a peer-to-peer (P2P) wireless collaborative network testbed with Simple Network Management Protocol (SNMP) agents active at each node of the wireless network. The Spectrum systems security management and case-based reasoning agents will be used to identify the SNMP Management Information Base (MIB) variables most sensitive to the set of denial of service attacks. The results have to be compared with Aprisma findings on managing North Carolina Internet 2 Giga points of presence (POP) and compiled in network management knowledge base. Recommendations to Situational Awareness agents providing feedback on network state during the attack will complement the research.

KEYWORDS: Adaptive Network Management, Wireless Collaborative Networks, C4I Networks, SNMP MIBs, Intrusion Detection, Knowledge-base, Management

FEEDBACK MECHANISMS FOR AGENT-BASED QOS ADAPTIVE MANAGEMENT OF NETWORKING RESOURCES
Alexander Bordetsky, Associate Professor
Department of Information Science
Sponsor: SBC Research Labs

OBJECTIVE: The goal of this research was to develop a better understanding of how the behavior of two main types of networking nodes, the edge nodes and tandem nodes, could be improved based on the presence of intelligent agents at different observation points within the network. The specific research task was to identify the feedback mechanisms capable of utilizing information gathered by intelligent agents for optimizing network resources usage. The study focused on the experimental research based on testing and proof-of-concept experiments. The research provided an experimental background for addressing the problems of networking resources adaptation in Quality of Service Management.

SUMMARY: The project was conducted in two phases:

- The project work in phase 1 focused on exploring the effects of individual intelligent agents on the usage of edge and tandem node resources. Problems and ways of agents-facilitators communication with SNMP agents and SNMP agents manager were explored, in addition to the

effects of agents allocation (concentration) within the network, and usage patterns of agents shared memory.

- The second phase focused on the effects of intelligent agents cooperation for optimizing the usage of networking resources. Agents performance and memory responsiveness effect on the agents solution on resource reservation along the lines of Call Setup and Connection Control adaptation cycles was also studied. Lastly, the research examined how implementation of ANN could improve the agents performance in adaptation of networking resources.

KEYWORDS: Network Operations Management, Intelligent Agents, Adaptation, Feedback, Agents Memory

THE INTEGRATED THEATER ASSESSMENT PROFILING SYSTEM (iTAPS)

Alexander Bordetsky, Associate Professor

Department of Information Science

Sponsor: Office of Naval Research

OBJECTIVE: Create an Integrated Theater Assessment Profiling System (iTAPS) to succeed the stove-piped Theater Assessment Profiling System(TAPS) in use by the Second Fleet Staff. The system is a decision support system that is used to synthesize data for the Commander, Second Fleet and his staff to help them assess how operations in progress are performing. Basically, it uses data (grades and comments) input from the Second Fleet staff to create weighted grades in top-level functional areas. The main goal of the project was to design web-based, easy-to-use version of TAPS be made that eliminates the stove-piping while preserving all functionality.

Fundamentally the task was one of eliminating the layers of the current system and utilizing the best web-tools at hand to give Second Fleet something that required minimal maintenance and upkeep. Since Second Fleet is standardized on Microsoft products it was deemed reasonable to utilize Microsoft products for maximum compatibility within the network.

SUMMARY: A tree-diagram model with parent and child nodes is an appropriate way to describe iTAPS. Basically, there are areas of the operation that are assigned and graded by personnel on the Second Fleet staff. There can be hundreds, if not thousands of areas to be graded. This fine granularity is synthesized upwards into more general categories by weighting the grades as the Commander desires. The data is ultimately synthesized into a top-level display. This display has categories that synthesize all the data “below” that tier in the system. In this way, an area that requires additional attention can be identified and drilled-down into by the Commander to get finer resolution. This helps the Commander focus his limited resources quickly where his attention is most needed so he or she can make timely, correct decisions in time of conflict.

THESIS DIRECTED:

Hadley, M. and Wiest, A., “The Integrated Theater Assessment Profiling System (iTAPS),” Master’s Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: Decision Support, Theater Assessment, Context-driven Radar Diagrams

INTELLIGENT AGENT ARCHITECTURES TO SUPPORT AIRCRAFT CARRIER DECK OPERATORS

Alexander Bordetsky, Associate Professor

Department of Information Science

Sponsor: Naval Air Systems Command

OBJECTIVE: The main goal for this project was to evaluate system and process requirements for the next generation Aircraft Handler’s Aircraft Status Board (aka Ouija Board). The study targeted suitability of transforming the two-dimensional static board to an electronic, dynamic display that utilizes sensors and

other systems' information to develop a complete picture of the current flight and hangar decks aboard U.S. Navy Aircraft Carriers.

SUMMARY: The study enabled to evaluate the current process and make recommendations for what the new system would need to display, how that information may be displayed, what systems would need to feed information to the Digital Ouija, how the use of intelligent agents would transform the static display to a powerful decision support tool that will allow the Handler to manage the Flight (and Hangar) deck in the most efficient method possible.

THESIS DIRECTED:

Thate, T. and Michaels, A., "Requirements for Digitized Aircraft Spotting (Quija) Board for Use on U.S. Navy Aircraft Carriers," Master's Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: Decision Support, Intelligent Agents, Sensors, Collaborative Tools, Wireless Network

LIMITED OBJECTIVE EXPERIMENT ON PEER-TO-PEER WIRELESS COLLABORATION

**Alexander Bordetsky, Associate Professor
Department of Information Science**

Sponsor: U.S. Joint Forces Command (J-9 Joint Futures Laboratory)

OBJECTIVE: The Joint Forces Command requested the NPS to set up a limited objective experiment to test the use of collaborative peer-to-peer (P2P) communications in a wireless networked environment. This experiment was intended to provide initial data to evaluate the potential impact of using this technology in an urban warfare environment. The experiment was conducted on the Naval Postgraduate School (NPS) campus in March 2002 and involved a hostage search and rescue scenario within the confines of the NPS campus quad. The main research objective was to evaluate the effects of roaming on application sharing, performance, and integration with client-server applications. The other objective was to address the challenges of self-organizing behavior in the Groove system environment of peer-to-peer collaborative communications.

SUMMARY: This experiment demonstrated that wireless P2P collaborative networks are feasible, but the application programs used for communications are not yet robust enough to support mission critical environments. Future research should focus on the stability of the application layer and the capabilities from the communications programs to automatically re-establish communications if dropped from a mobile network. While bandwidth was not an issue in this small experiment, it is important to remember that much of the utilization of the bandwidth that was used came from the re-transmission of data packets lost through application drop-off.

KEYWORDS: Wireless Networks, Collaborative Systems, Situational Awareness, Network Management, Multiagent Systems, GPS Monitoring, Reconnaissance and Surveillance

NETWORK OPERATION CENTER COLLABORATIVE MANAGEMENT

**Alexander Bordetsky, Associate Professor
Daniel R. Dolk, Professor
George Zolla, Lecturer**

**Department of Information Science
Sponsor: Unfunded**

OBJECTIVE: The ultimate goal of our research is to create a model that will facilitate Network Operation Fusion (collaborative management) of multiple Network Operations Centers (NOCs) across the Internet.

INFORMATION SCIENCE

SUMMARY: At present there is very little coordination between Network Operation Centers (NOC) across organizational domains or across the Internet. As organizational networks expand and collaboration between organizations increases, coordination between intra-organizational and inter-organizational NOCs is needed to ensure efficient and productive dataflow. Our goal is to create a model to facilitate this process. We introduce the concept of using Application Management Information Base (MIB) components within a Knowledge Management Gateway for structuring knowledge management across multiple NOCs. SNMP Network Element (NE) MIB agents are used to gather network information and Application MIBs are used as a metric for a Mission-Policy-Metrics- $\{\text{Sense-Analyze-Adapt}\}$ feedback loop that is used to analyze the effectiveness of network operations. We believe that the combination of collaborative technology, enhanced application MIBs, and multiple agents that execute the relationships of the adaptation loop will create a desirable knowledge management architecture for Knowledge Management Gateways. This architecture will not only enhance NOC efficiency but could also lead to prioritization of network applications and the creation of a multiple level NOC collaborative environment.

CONFERENCE PAPER:

Bordetsky, A., Dolk, D. and Zolla, G., "Application MIBs for Network Operation Centers Collaborative Management," *Proceedings of the Seventh Annual Conference on Information and Technology (INFORMS)*, San Jose, CA, 17-20 November 2002.

PRESENTATION:

Bordetsky, A., Dolk, D. and Zolla, G., "Application MIBs for Network Operation Centers Collaborative Management," Seventh Annual Conference on Information and Technology (INFORMS), San Jose, CA, 17-20 November 2002.

KEYWORDS: Network Operations Center, Knowledge Management, Application Management Information Base, MIB

DEVELOPMENT OF HF RADIO-WAN

**Rex A. Buddenberg, Senior Lecturer
Department of Information Science
Sponsor: Office of Naval Research**

OBJECTIVE: This study developed extended line of sight Rf communications system for maritime purposes. The Rf aspects of this project were the primary area for Applied Research Laboratory, University of Texas (ARL:UT). Naval Postgraduate School issues were data framing, media access control and interoperability with other IP networks.

KEYWORDS: HF Radio-Wan

FY 02 IO/IW RESEARCH

**LCDR Raymond Buettner, USN, Military Faculty
Department of Information Science
Sponsor: Naval Engineering Logistics Office**

OBJECTIVE: Support CNSG's information warfare curriculum, faculty and student research efforts and IO/IW fleet support activities.

KEYWORDS: Information Operations, Information Warfare, Modeling and Simulation

INFORMATION SCIENCE

GUN WEAPONS SYSTEM COMMAND AND CONTROL PROJECT

**Alexander J. Callahan, Jr., Research Assistant Professor
Department of Information Science**

Sponsor: Naval Surface Warfare Center, Crane Division and Dahlgren Division

OBJECTIVE: Provide consulting and simulation analysis of gun system performance to include the development of operational scenarios in support of major caliber gun ammunition program procurement and maintenance decisions.

SUMMARY: Several Naval Simulation System (NSS) scenarios were developed in this study to estimate performance of various modifications of naval gun systems played against various sets of targets. This simulation environment was then used to address procurement levels of different types of conventional ammunition and also variation in components.

KEYWORDS: Modeling and Simulation, Assessment

MULTI-MISSION MARITIME AIRCRAFT (MMA) SIMULATION PROJECT

**Alexander J. Callahan, Jr., Research Assistant Professor
Department of Information Science**

Sponsor: Naval Air Warfare Center, Aircraft Division

OBJECTIVE: Provide the MMA program office an analysis environment in order to evaluate alternative proposals to replace the P-3.

SUMMARY: The Naval Simulation System (NSS) was evaluated to provide the required analytical environment for proposed Multi-mission Maritime Aircraft. Several areas were identified in NSS that required design changes to the model. Changes have been accomplished and validation and verification of those changes is in progress. NSS scenarios are being constructed and will be tested. The effort has become an iterative process of identify modification, change design and test. This project is expected to continue into a next phase of advanced system design.

KEYWORDS: Modeling and Simulation

NAVAL SIMULATION SYSTEM (NSS) COURSE DEVELOPMENT, OA/MV4655

**Alexander J. Callahan, Jr., Research Assistant Professor
Department of Information Science**

Sponsor: Chief of Naval Operations (N61M)

OBJECTIVE: The objective of this work was to develop a simulation course using NSS to provide broad and detailed exposure and use of a major naval simulation model.

SUMMARY: Course outlines and laboratory outlines were developed. Course materials were produced and evaluated in a working group environment to validate them. The course is being prepared for offering both early next academic year and in a distance-learning mode.

KEYWORDS: Modeling and Simulation

INFORMATION SCIENCE

NAVAL SIMULATION SYSTEM (NSS) DEVELOPMENT AND TESTING

Alexander J. Callahan, Jr., Research Assistant Professor
Department of Information Science
Sponsor: Commander Pacific Fleet

OBJECTIVE: This study evaluated development changes to the Naval Simulation System (NSS) particularly in the areas of interest to the Pacific Fleet.

SUMMARY: The Naval Postgraduate School has developed several Naval Simulation System (NSS) scenarios to estimate performance of various modifications of NSS. This environment was then stressed to validate its scope of capabilities in the desired operational areas.

KEYWORDS: Modeling and Simulation, Assessment

NAVAL SURFACE FIRE SUPPORT PROJECT

Alexander J. Callahan, Jr., Research Assistant Professor
Department of Information Science
Sponsor: Naval Surface Warfare Center, Crane Division

OBJECTIVE: This research provided simulation analysis of gun system performance to include the evaluation of using simulation modeling to measure marginal contribution to performance of ammunition components. In addition, the ability to support the land warrior during changing levels of conflict was evaluated.

SUMMARY: Several variations of Naval Simulation System (NSS) scenarios were developed to estimate gun system performance. Variations of the simulation were constructed to model the effects caused by engineering changes to ammunition. This baseline of scenarios was modified to evaluate escalating levels of conflict.

KEYWORDS: Modeling and Simulation, Assessment

FOSSAC: STUDY OF LEGACY SYSTEMS AND APPLICATION INTEGRATION

LCDR Glen L. Cook, USN, Military Faculty
Department of Information Science
Sponsor: Fitting Out and Supply Support Assistance Center

OBJECTIVE: The purpose of this study was to conduct a survey of current Fitting Out and Supply Support Assistance Center (FOSSAC) systems architecture, including FOSSAC unique legacy systems. A recommendation was made about how to improve systems through integration and reduction of redundancies.

KEYWORDS: NAVSUP, Architecture

TOTAL FORCE ADMINISTRATION SYSTEM (TFAS) SUPPORT

Daniel R. Dolk, Professor
Department of Information Science
Sponsor: MSCS

OBJECTIVE: To provide database server hardware to be housed at NPS in support of computer science and information technology research by NPS faculty and U.S. Marine Corps students involved in USMC information technology and manpower programs.

KEYWORDS: Web-enabling Database

**USAREC RECRUITING STRATEGIC VISION PROGRAM (RSVP) WARGAME: AN
OPERATIONAL DECISION MAKING AGENT-BASED SIMULATION SYSTEM**

**Daniel R. Dolk, Professor
Department of Information Science
Sponsor: U. S. Army Recruiting Command**

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

SUMMARY: Although a second full scale war game was scheduled for Summer 2002, USAREC was not able to decide upon a date, and so this event was postponed until FY2003. Therefore, this research focused on building an operational decision support system (ODSS) which provided the identical interfaces used in the simulation, but with a connection to the USAREC data warehouse instead of the simulation. This will allow in the future the ability to access real data in real time and then segue seamlessly to the simulation environment to play "what if" scenarios.

KEYWORDS: Agent-based Simulation, Business War Game

**USAREC RECRUITING STRATEGIC VISION PROGRAM (RSVP)/ RECRUITING MARKET
SIMULATION (RMS) WARGAME**

**Daniel R. Dolk, Professor
Department of Information Science
Sponsor: U.S. Army TRADOC Analysis Command**

OBJECTIVE: This is the second phase of the RSVP project for implementing strategic business war-gaming at the U.S. Army Recruiting Command (USAREC). The objective of this phase was to develop a detailed recruiting market simulation (RSVP/RMS) that will allow USAREC to test the virtual effectiveness of various new recruiting-oriented products and market strategies. Leveraging the powerful agent technology of the seas environment, this simulation will be able to emulate meaningful market segments and provide valuable insight into relevant market behavior. This will facilitate the preliminary identification of "more promising" vs. "less promising" products prior to the expensive activity of national testing.

KEYWORDS: Agent-based Simulations, Military Recruiting Policy

**TECHNICAL SUPPORT ON THE COMMAND AND CONTROL INTERFACE FOR THE
EXPEDITIONARY SENSOR GRID (ESG) ENABLING EXPERIMENT PROGRAM**

**Douglas Horner, Research Associate Professor
Alexander J. Callahan, Jr., Research Assistant Professor
Department of Information Science
Sponsor: Office of Naval Research**

OBJECTIVE: The purpose of the research was to investigate the Command and Control (C2) interface for the ESG Enabling Experiments (EEE).

SUMMARY: The experiments were designed to test hypotheses regarding the use of agent-based architectures to support sensor management. The C2 interface is the tool that allows the user to create and monitor agents tasked with specific objectives, monitor the performance of the grid network and receive,

display and analyze information received from the agent network. This work investigated requirements for the interface and investigated existing potential GOTS and COTS solutions.

KEYWORDS: Expeditionary Sensor Grid, Agents, User Interfaces, Sensor Management, CoABS

COGNITIVE TASK ANALYSIS OF INTELLIGENCE INFORMATION MANAGERS

Susan G. Hutchins, Research Assistant Professor

Department of Information Science

Sponsor: Office of Naval Research

OBJECTIVE: Intelligence analysts (IA) engage in information seeking, evaluation, prediction, and reporting behavior in an information-intensive work environment. The purpose of this effort was to support research on the development of models of information foraging and knowledge crystallization. Knowledge crystallization involves locating and gathering information from large collections of information, synthesizing and developing an understanding of this information. A product is then typically developed in the form of a briefing, analysis, or a recommendation regarding a decision.

Cognitive task analysis (CTA) is an extension of traditional task analysis techniques to produce information regarding the knowledge, thought processes, and goal structures that provide the foundation for task performance. The goal of CTA is to discover the cognitive activities that are required for performing a task in a particular domain to identify opportunities to improve performance by providing improved support of these activities. CTA involves a variety of techniques and tools to describe the knowledge and strategies required for task performance. These include structured interview techniques, critical incident analysis methods, field study methodologies, and observation methods of performance in high-fidelity simulators.

A detailed, accurate cognitive model that delineates the essential procedural and declarative knowledge is necessary to develop effective training procedures and systems. This entails building a model that captures the analysts' understanding of the demands of the domain, the knowledge and strategies of domain practitioners, and how existing artifacts influence performance. CTA can be viewed as a problem-solving process where the questions posed to the subject-matter experts, and the data collected, are tailored to produce answers to the research questions, such as training needs and how these training problems might be solved.

Analysis of a complex cognitive task, such the intelligence analyst's job, often requires the use of multiple techniques. When results from several techniques converge, confidence is increased regarding the accuracy of the CTA model. Several approaches rely on verbal introspection, where the participant is asked to focus on specific behavioral examples that they experienced in the past and the person is guided through a "verbal introspection." The Applied Cognitive Task Analysis Method uses interview techniques to elicit information about the tasks performed and provides tools for representing knowledge. The Critical Decision Method (CDM) emphasis on non-routine or difficult incidents produces a rich source of data about the performance of highly skilled personnel. The CDM is also efficient as it aids in uncovering elements of expertise that might not be found in routine incidents. An emphasis on non-routine cases helps to ensure a comprehensive coverage of the subject matter.

SUMMARY: A Cognitive Task Analysis (CTA) was conducted to capture data that will provide input to support development of a model of the analyst's processes, biases, and analytic strategies. A hybrid method was used to conduct the CTA, including a modified version of the critical decision method. In phase one, six subject-matter experts were interviewed to determine the general framework for the knowledge that is to be obtained and what tasks will be the focus of the more detailed CTA. Initial semi-structured interviews were conducted to identify the type of knowledge representations that are used by practitioners, the context of the work, and to identify a representative set of problems or cases. This initial set of knowledge representations for the intelligence information manager's job will provide the basis for the more detailed CTA. In phase two, a modified version of the critical decision method was developed and used to interview four additional participants (this phase is on-going).

Several factors contribute to making the IA's task challenging: (i) time pressure to produce reports in a shorter timeframe, (ii) a high cognitive workload, and (iii) difficult human judgments that are required regarding uncertain validity and reliability of the data. Human judgments are involved in considering the

plausibility of information, deciding what information to trust, and determining how much weight to place on specific pieces of data. This task requires collecting information from distributed, heterogeneous sources, interpreting the information, and integrating products into a distributed, human decision-making process. This problem is challenging because it involves aspects of data mining, data correlation and human judgment. The ability to sort through a vast amount of information, produced from a variety of sources, to construct an accurate depiction of a situation, represents the hallmark of the IA's job. Products of this information foraging and analysis are used by senior decisionmakers to make high-stakes decisions. One goal for the research reported here is to capture data that will provide input to building models of the intelligence analyst and analytic processes used by intelligence analysts.

CONFERENCE PAPER:

Hutchins, S.G., Pirolli, P. and Card, S., "Cognitive Task Analysis of Intelligence Analysts," *Human Factors and Ergonomics Annual Meeting*, Denver, CO, October 2003, (submitted).

PRESENTATION:

Hutchins, S.G., Pirolli, P. and Card, S., "Cognitive Task Analysis of Intelligence Analysts," *Human Factors and Ergonomics Annual Meeting*, Denver, CO, October 2003, (submitted).

KEYWORDS: Intelligence Analysis, Information Management, Cognitive Task Analysis

ADAPTIVE ARCHITECTURES FOR COMMAND AND CONTROL

William G. Kemple, Assistant Professor

Department of Information Science

Sponsor: Office of Naval Research

OBJECTIVE: The Adaptive Architectures for Command and Control (A2C2) research project is a multi-year program of basic and applied research featuring model-based experimentation. The objective of the A2C2 research program is to experiment with C2 architectures designed, using a model-test-model-experiment paradigm, by the A2C2 research team. There is a need to integrate optimization, modeling, and simulation-based research efforts with psychology-based and experimental activities. To address this need, this research followed a model-driven approach. The models produced by the modeling/simulation research teams should support the formulation of hypotheses, the determination of key variables and parameter values, and the prediction of organizational performance and processes of adaptation. The experimental data, in turn, are collected and produced in a way that both allows examination of the hypotheses and can be easily used by the modelers for post-experimental model-data comparison.

The A2C2 experiment design combines an operational scenario with computer-based architecture models and tests these architectures within decision-making organizations in a series of team-in-the-loop experiments using military officers operating in a Joint setting as the test subjects. Results from each experiment are then used to refine the models and help prepare for the next experiment. This research includes experimentation to study Network-Centric Warfare-based alternatives to current traditional organizational hierarchies. This Model-Test-Experiment-Model approach provides a rigorous means to study new C2 architectures. The experiment tests these architectures in a series of human-in-the-loop experiments using military officers operating in a Joint setting as the test subjects and also provides feedback to the models. A key feature of the NPS participation in the A2C2 project is the involvement of the military officer-students.

The Systems Technology Battle Lab has been upgraded to support experimental capabilities in terms of extending the distributed dynamic decisionmaking simulator capabilities to capture important team-in-the-loop, C2 issues of coordination and synchronization for time-critical strike and other types of mission tasks. Timing constraints inherent in time-critical strike place additional emphasis on coordination and synchronization of those strikes with other theater operations. Network-centric operations provide the basic foundation required for a successful TCS missions to occur: (i) rapid information sharing, (ii) more timely development of situation awareness, (iii) more efficient use of available resources — all lending support to achieving faster decision cycles.

Emerging technologies contribute the essential infrastructure that provides the foundation for rapid sharing of information; however, the *human decision making process* must also be accelerated by enabling self-synchronization to occur. The basic idea of self-synchronization is to push decision-making authority down to the lower levels within the organization by relaxing the traditional hierarchical approach to command and control. Continuing the A2C2 focus on the role of organizational structure on performance and process, for an experiment designed to examine the enablers of self-synchronization, the research design examined the differences in conduct of the mission and use of self-synchronization by teams using two different structures: functionally-focused or platform-focused.

For the past several years, the Adaptive Architectures for Command and Control (A2C2) research team has examined the concept of organizational “congruence.” This theory proposes that organizational effectiveness can be mediated when characteristics like organizational structure are designed to fit the requirements of a mission or environment. This view suggests that when organizational structure is out of “alignment,” quality of performance should be reduced, and if significant, this misalignment may drive organizational adaptation. Some previous A2C2 efforts have examined ways to measure “fit” or “alignment” between structure and task requirements. Building on this research, our goal in Experiment 8, the focal experiment for FY02, was to understand the processes that underlie performance as teams attempt to cope with and adapt to misalignment. In order to conduct an experiment that will provide data to address this question, several preparatory activities were required.

In the winter of 2002, two scenarios were developed based on data from Concept Experiment 8, and with the input of another cohort of students in the C4I Systems Evaluation course and a student using this work as the basis for his MS thesis. These scenarios were pilot tested by students as well as members of the Naval Postgraduate School (NPS) research team. Data related to the design of the structures and scenarios, and derived from the preliminary experimental efforts, were analyzed by modelers (e.g., UCONN, CMU, and GMU). Feedback from the modelers was incorporated in scenario refinements. The goal of these refinements was to increase the likelihood that a particular structure would face significant challenges in the conduct of the scenario that was constructed to “fit” the other structure. This design was central to addressing the primary question of Experiment 8 – how do teams perform (what processes, what outcomes) when the structure they are using is significantly “mis-aligned” with the task requirements of the mission? Experiment 8 was conducted in August 2002, and results from this effort will be used to advance the A2C2 efforts toward Experiment 9, which will focus on the actual process of adaptation.

The major impact of the work described above on Experiment 8 and the preliminary activities was to provide data on the types of critical signals that can inform decision-makers that structural adaptation is required to improve organizational performance. The key hypothesis tested in Experiment 8 was that when a structure is not aligned with the task requirements, process adjustments are required and performance is impeded. Identification of factors of “mis-alignment” that can be highlighted for decisionmakers and thus facilitate adaptation is the key application of this phase of experiments. These indicators will ultimately define the design factors for Experiment 9 that will focus on mechanisms that can facilitate adaptation.

SUMMARY: Significant progress has been achieved in all three research areas: basic research extending understanding of adaptive command and control; outreach to DoD/DoN experimental and concept development domains (e.g., SSG, Global and USJFC, J9) and improving the technical capabilities for the conduct of human-in-the-loop experiments. Basic research activities related to adaptive command and control occurred in three phases. The first two phases (a concept experiment and scenario pilot testing) were preparatory for Experiment 8, which was the culmination event for FY02. The focus of Experiment 8 (August 2002) was to design two distinct organizations and create two distinct task/resource requirements that would allow the examination of performance and processes in two conditions: (1) where the organization structure was congruent with the task requirements and (2) where the structure was incongruent. The Concept Experiment 8 conducted in Fall 2001 focused on the preliminary evaluation of two structures (divisional and functional) with a single scenario that emphasized time-critical tasks. The pilot testing conducted in Winter 2002 examined two significantly revised scenarios. The revisions incorporated a series of offensive “mission tasks” that were integrated with the time critical tasks used on Concept 8 experiment. The two scenarios were also designed such that the task requirements would be more readily accomplished by one structure (e.g., divisional) and hypothetically be more challenging for the other structure (e.g., functional).

Global Wargame 2001. NPS A2C2 participation in Global Wargame 2001 increased understanding of Joint C2 operations, including Information Technology tools that will be used in the future and new processes and ways of organizing a Joint Force. Military forces, operating as a networked force, can plan, decide, and act collaboratively and concurrently to accomplish many tasks simultaneously. Operating in a collaborative information environment will enable the joint force to transition from the use of a hierarchical, serial planning and execution process to the use of a parallel, collaborative planning process to produce reduced decision times and an increased tempo of operations.

Support to Joint Forces Command (JFCOM), J9 (Joint Experimentation). Members of the NPS A2C2 research team, along with other NPS researchers, conducted several activities in support of JFCOM, J9:

Three members of the NPS A2C2 research team were invited in August 2001 to be working group participants in the JFCOM J9 workshop on the emerging concept of a Standing Joint Force Headquarters and its relationship to external (civilian and coalition) organizations. This activity builds on A2C2 research experience on the design of joint task forces and individual members' expertise in inter-organizational relations, civil-military collaboration, and joint experimentation.

Members of the NPS A2C2 research team, along with others, conducted two Limited Objective Experiments (LOE) in support of JFCOM, J9. The Effects Tasking Order (ETO)-to-Actions LOE was conducted at Joint Forces Command from 3-14 December 2001 to examine and refine the organizations and processes that future Joint Forces will employ to bring all aspects of national power (Diplomatic, Informational, Military and Economic) to bear on future enemies.

3. The Peer-to-Peer LOE was conducted at NPS from 12-14 March 2002 to examine several concepts surrounding peer-to-peer computing, collaborative tools, and command and control structure. In a peer-to-peer architecture, computers that have traditionally been used solely as clients communicate directly among themselves and can act as both clients and servers — assuming whatever role is most efficient for the network. Within DoD, peer-to-peer (P2P) collaboration technology is generating a lot of interest as a paradigm for Command and Control. Advocates assert that P2P offers several apparent advantages over classical client-server collaboration that historically supports traditional hierarchical C2. The LOE scenario was centered on a reconnaissance and surveillance team on the ground at the scene at the start of the scenario. Their primary mission was to build-up sufficient situational awareness for a (constructive) Hostage Rescue Team to conduct a rescue mission when it arrives.
4. Several of the key concepts in both LOEs are directly relevant to the A2C2 program (e.g., Distributed, Collaborative Planning, Decentralized Execution, Joint Interactive Planning, and the Common Relevant Operational Picture). These concepts reflect the need for unprecedented human and technological synergy in organizational structure, process, collaboration and display media, and adaptation to dynamic circumstances.

Strategic Studies Group XXI (SSG XXI). Continuing several years of A2C2 support to the Navy's Strategic Studies Group, the NPS A2C2 research team hosted a visit by the Fellows of SSG XXI in February 2002. NPS expertise and experience in organizational design, team decision making, collaboration, and model-based analysis was deemed very valuable to the SSG, and they requested further support. This was followed by participation (along with other A2C2 researchers and others) in an April 2002 SSG Cognitive Issues Workshop conducted to examine cognitive issues in FORCEnet implementation. At that workshop, it was agreed to undertake an intense model-based analysis of the performance of FORCEnet command and control structures. The scenario developed for Concept Experiment 8 (see above) was used by all of the A2C2 modeling teams and one other to conduct the analysis. NPS and other A2C2 researchers synthesized the results, briefed them to the SSG, were invited participants in the SSG Plenary Session, and provided a detailed report to the SSG (see Technical Reports below). Several key results from this analysis are included in the SSG briefing to the CNO.

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

Levchuk, G.M., Levchuk, Y.N., Luo, J., Pattipati, K.R. and Kleinman, D.L., "Normative Design of

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CONFERENCE PAPERS:

Diedrich, F.J., Hocevar, S.P., Entin, E.E., Hutchins, S.G., Kemple, W.G. and Kleinman, D.L., “Adaptive Architectures for Command and Control: Toward an Empirical Evaluation of Organizational Congruence and Adaptation,” *Proceedings of the 2002 Command and Control Research and Technology Symposium*, Naval Postgraduate School, June 2002.

Levchuk, G.M., Levchuk, Y.N., Pattipati, K.R. and Kleinman, D.L., “Mapping Flows onto Networks to Optimize Organizational Processes,” *2002 Command and Control Research and Technology Symposium*, Monterey, CA, June 2002.

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PRESENTATIONS:

Diedrich, F.J., Hocevar, S.P., Hutchins, S.G., Kemple, W.G., Kleinman, D.L. and Entin, E.E., “Adaptive Architectures for Command and Control: Toward an Empirical Evaluation of Organizational Congruence and Adaptation,” *2002 Command and Control Research and Technology Symposium*, Naval Postgraduate School, June 2002.

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Serfaty, D., MacMillan, J., Baker, K., Entin, E., Wetteland, C., Miller, J., et al., “On the Performance of FORCEnet Command and Control Structures in Support of Strategic Studies Group XXI: Modeling and Simulation Analysis,” 2002.

CONTRIBUTION TO BOOK:

Wang, W.P., Kleinman, D.L. and Luh, P.B., “Modeling Team Coordination and Decisions in a Distributed Dynamic Environment,” *Coordination Theory and Collaborative Technology*, pp. 673-710, Mahwah, NJ: L. Erlbaum Associates, G.M. Olsen, T.W. Malone and J.B. Smith (Eds.), 2001.

THESIS DIRECTED:

Clark, F.J., “Scenario Design: Adaptive Architectures for Command and Control Experiment Eight,” Master’s Thesis, Naval Postgraduate School, June 2002.

INFORMATION SCIENCE

CENTER FOR DEFENSE TECHNOLOGY AND EDUCATION FOR MILITARY SERVICE

William G. Kemple, Assistant Professor

Department of Information Science

Sponsor: U.S. Joint Forces Command

OBJECTIVE: New warfighting concepts are currently under development at U.S. Joint Forces Command (JFCOM), J9, Joint Experimentation Directorate, to be employed by the U.S. military as it transitions to the fighting force described in Joint Vision 2020. Their primary focus is to develop new joint warfighting concepts and capabilities that will improve the ability of future Joint Force Commanders to rapidly and decisively conduct particularly challenging and important operational missions. A series of experiments and exercises is being conducted to help refine the new concepts and processes under development at JFCOM. Each experiment is designed to support the assessment of these proposed future capabilities and modify current doctrine, organization, training, materiel, leadership, personnel, and facilities.

Several limited objective experiments were conducted on a joint basis between the Naval Postgraduate School (NPS) and JFCOM. Support provided by NPS included planning for the conduct of the experiment, developing training materials for the experiment participants, developing survey questionnaires, data collection and analysis plans, and authoring reports on the results. The objective for this research was to conduct experiments and participate in activities that support Joint experimentation and enhance Joint capabilities. Research included conducting limited objective experiments to address experimentation objectives of the Information Superiority, Command and Control, Common Relevant Operational Picture, Joint Interactive Planning, Rapid Decisive Operations, and Focused Logistics concepts. NPS was responsible for experimental design, survey design/ implementation, and data collection for the Effects-Tasking Order-to-Actions and the Peer-to-Peer Limited Objective Experiments (LOEs), as well as providing input for the planning and conduct of several other LOEs. NPS coordinated with J9 to select the experiment objectives to be examined, design the experiments, develop metrics, develop data collection and analysis plans, conduct the experiments, collect and analyze the data, and provide a final report.

Effects Tasking Order-to-Actions Limited Objective Experiment. Effects-based Operations (EBO) is defined as a process for obtaining a desired strategic outcome, or ‘effect’ on the enemy, through the synergistic and cumulative application of the full range of military and nonmilitary capabilities at all levels of conflict. An effect is the physical, functional, or psychological outcome, event, or consequence that results from specific military or non-military actions. The EBO concept is based on the tenet that a better understanding of the adversary and the increased involvement of other national agencies will lead to better-reasoned options to engage potential adversaries. Characteristics that distinguish effects-based planning from traditional objectives-based planning include development of a broader and deeper insight into the adversary through the fusion of information from a broad spectrum of sources, including national and international, government and non-governmental. Insight into the adversary is developed through conducting a complex “system of systems analysis” of the adversary. Planners conduct this systems analysis collaboratively with a networked and distributed team of experts (cultural, behavioral, technical, economic, and military) and centers of excellence. A second distinguishing characteristic of EBO is the sophisticated planning process. EBO planning goes a step further than consideration of which actions will produce an objective (i.e., the traditional approach) to consider the full range of potential results of our actions (including direct and indirect effects, desired and undesired effects).

An experiment entitled Effects Tasking Order-to-Actions Limited Objective Experiment (ETO-to-Actions LOE), was conducted at the US Joint Forces Command (JFCOM), Joint Experimentation Center, Suffolk, VA, 3-14 December, 2001, to examine aspects of EBO, and to specifically assess and refine the effects-based planning and assessment processes. This experiment was designed and conducted by a partnership of the Naval Postgraduate School, JFCOM J9, and the Navy Warfare Development Command. Previous experiments and events focused primarily on the Joint Force Headquarters (JFHQ) level of command, with the majority of effort directed at refining the process down to producing an ETO (which effectively issues effects-based orders to the subordinate functional components). The ETO-to-Actions LOE focused within and below the JFHQ to examine the required coordination and collaboration processes (both vertically and horizontally) between the Joint Force and functional components headquarters, which is needed to collaboratively develop the ETO and translate the effects directed in it into tactical actions on the battlefield.

Peer-to-Peer Limited Objective Experiment. Peer-to-peer (P2P) computing is the sharing of computer resources and services by direct exchange between systems. In a P2P architecture, computers that have

traditionally been used solely as clients communicate directly among themselves and can act as both clients and servers, assuming whatever role is most efficient for the network. Within DoD, P2P collaboration technology is generating a lot of interest as a paradigm for Command and Control. Advocates assert that P2P offers several apparent advantages over classical client-server collaboration that historically supports traditional hierarchical C2. In order to discover issues associated with P2P as an integral part of military C2, the United States Joint Forces Command initiated a LOE. The Joint Futures Laboratory of the Joint Forces Command Joint Experimentation Directorate and the Naval Postgraduate School conducted the experiment over a period of several months culminating with a role-playing scenario 12-14 March 2002. The LOE was centered around the use of peer-to-peer computing on hand-held and portable devices in a wireless network environment.

The setting for the LOE was a hostage situation in an urban area. The LOE centered around a reconnaissance and surveillance team (RST) on the ground at the scene at the start of the scenario. Their primary mission was to build-up sufficient situational awareness for a (constructive) Hostage Rescue Team to conduct a rescue mission when it arrived. The LOE included participants pretending that a trained HRT was en route to the scene to conduct a take-down-hostage rescue mission upon arrival. The HRT was represented by a cell within the LOE control group; no actual takedown or hostage rescue was conducted.

Functions of the HRT Cell were to: (1) prompt the RST for information needed to develop situational awareness (using LOE checklists pre-planned with the help of experts); (2) check-off information received against checklists; and (3) determine when sufficient situational awareness has been built-up for the HRT mission (and completion of the LOE event). Six LOE participants used mobile P2P equipment. The RST conducted reconnaissance and surveillance in preparation for the en route HRT. The goal for the RST was to gather sufficient situational awareness for the HRT to execute a hostage rescue immediately upon arrival. The challenges for the RST were self-organization within the RST, shared-awareness within the RST, collaborative planning and rapid re-planning within Team, collaborative planning with the HRT and others, dealing with P2P network outages, participants dropping out (due to enemy action), and participants joining or rejoining, etc.

SUMMARY: Support was also provided to help refine concept models based on data collection during other events (e.g., Global Wargame) and other LOE experiment results. As part of this effort, NPS participated in Global Wargame 2001 to support the Knowledge Management Metrics Group where the goal was to measure and evaluate how network-centric capabilities, such as information technology (IT) and collaborative tools, support rapid decisive operations in military command and control organizations. The overall hypothesis is that network-centric technology increases the warfighters' capability to execute rapid decisive operations by providing critical information faster and more accurately than it is currently available using current technology. Two surveys were developed and administered to participants at Global to obtain empirical data on possible advantages to be gained with IT tools and with actual advantages accrued by their use. IT tool functionality was evaluated by developing and administering a survey to capture user perceptions of the usefulness of these new IT tools. Online surveys were administered to capture participants' reactions to IT tool usefulness, usability, reliability, functionality, how the tools impacted decision making, and what features they would like to see incorporated into future tool development. A Post-Wargame Survey was developed and administered to assess the effectiveness of the organization in supporting mission accomplishment, promoting situation awareness, providing access to information, flexibility of the organization, participant perceptions regarding strengths and weaknesses of way the forces were organized, and any adaptations made by members of the organization.

Additional research was conducted to formulate and study state space models for sensor-to-shooter operations in joint warfare with a view towards guiding allocation of acquisition and eventually operational resources. The emphasis is on modeling the impact of inter-service sharing of information obtained from realistically imperfect sensor systems on interactive and joint conflicts. High-level-low-resolution models for the study of effectiveness of the Common Relevant Operational Picture, (CROP), have been formulated, studied and used to provide insight of the benefits of the common relevant operational picture.

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KEYWORDS: Joint Experimentation, Joint Warfare, Knowledge Management, Experimentation Courseware, Concept Modeling

A VULNERABILITY ANALYSIS OF CELL PHONES

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Sponsor: U.S. Department of Justice

INFORMATION SCIENCE

EFFECTS OF EA-6B JAMMING ON ANTI-SHIP MISSILE DEFENSE (ASMD)

D. C. Schleher, Professor
Department of Information Science
Department of Electrical and Computer Engineering
Sponsor: Navy Warfare Development Command

OBJECTIVE: Evaluate the effects of coordinated and uncoordinated jamming using the EA-6B and SLQ-32 on anti-ship cruise missile seekers targeted against aircraft carriers.

SUMMARY: Simulations were conducted for an anti sub/ship cruise missile (ASCM) attack against an aircraft carrier battle group (CVBG) with an EA-6B defending the aircraft carrier. Initial simulations assumed independent operation of the EA-6B and SLQ-32 self-defense jamming systems. Optimum flight profiles and strategy were determined for the EA-6B. Experimental results determined the interference levels of the EA-6B jamming signals on the SLQ-32 and these were incorporated into the simulation. Further Monte Carlo simulations were run using a JTIDS coordinated SLQ-32 and EA-6B defending the aircraft carrier. These were expanded using connectivity between AEGIS ships, E2-C and the SPQ-9. Results are documented in a classified report and TACMEMO.

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KEYWORDS: Anti-Ship Cruise Missile Defense

JAMMING TACTICS AND EMPLOYMENT OF EA-6B AGAINST ADVANCED RADAR AND TACTICAL DATA LINK SYSTEMS

D. C. Schleher, Professor
Department of Information Science
Department of Electrical and Computer Engineering
Sponsor: Naval Warfare Development Command

OBJECTIVE: Investigate jamming tactics using the EA-6B Universal Exciter Upgrade (UEU) against advanced J-Band radars and tactical data link systems.

SUMMARY: Performance of a 3-D pulse compression MTI and J-Band pulsed Doppler radar, IFF system and tactical data link for a surface-to-air missile system were determined under various environmental conditions. Jamming effects against these systems using UEU waveforms and chaff were analyzed to develop a jamming strategy against the overall missile system. Parametric studies were performed to determine the relative effectiveness of various UEU waveforms as a function of the jamming ERP and waveform parameters. Results are documented in a classified report and TACMEMO.

KEYWORDS: EW, Tactical Data Link Jamming

JAMMING TACTICS AND EMPLOYMENT OF UEU AGAINST ADVANCED RADAR AND COMMUNICATIONS SYSTEMS

D. C. Schleher, Professor
Department of Information Science
Department of Electrical and Computer Engineering
Sponsor: Navy Information Warfare Activity

OBJECTIVE: Develop Universal Exciter Upgrade (UEU) employment tactics and advanced jamming techniques to counter communications, data links and advanced J-Band threats.

SUMMARY: A number of advanced threats susceptible to the new UEU jammer capability available in the EA-6B were identified. These include advanced radars using pulse compression and pulsed Doppler type waveforms. Sensitivity curves allowing the UEU to negate the radar processing gain of these types of waveforms were generated. Communications jamming is accomplished using CW, Narrow Spot Noise, FM Tone and FM Squarewave available in the UEU. This can be accomplished with minimum spurious components from the UEU that prevent interference with friendly communications systems. Data links can be jammed using programmed pulse patterns generated by the UEU.

KEYWORDS: EW, Communications Jamming

MISSILE IMU MODEL
D. C. Schleher, Professor
Department of Information Science
Department of Electrical and Computer Engineering
Sponsor: Naval Air Warfare Center/Weapon Division

OBJECTIVE: To develop inertial measurement unit (IMU) models that allow a missile's attitude to be determined from telemetry data provided by rate sensors aboard the missile. One model is to be developed for non-rolling missiles that use IMU quartz rate sensors. A second model is to be developed for a rolling missile that uses magnetohydrodynamic rate sensors and a magnetoresistive spin sensor. The model is to provide outputs that are within 2 degrees of the actual missile attitude. A three-dimensional animation of the missile's attitude is to be provided.

SUMMARY: SIMULINK models were successfully developed for both the rolling and non-rolling missiles. The models were calibrated using Carco Table test data that matched expected values to within 2 degrees RMS on each axis. An animation capability was developed that allowed the resulting accurate attitude profile to be visually observed.

The models accept digitized strapdown telemetry data that represent distorted rate sensor data. The non-rolling missile model compensates for the distortions and then applies these data through a Euler transformation to convert the strapdown rates to earth-referenced attitude measurements. An alternate Quaternion model is also provided that allows the model to function at all missile attitudes.

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

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

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KEYWORDS: Missile Attitude, SIMULINK, IMU

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

**Norman Schneidewind, Professor
Department of Information Science**

Sponsor: IEEE Standards Board (unfunded, continuing)

OBJECTIVE: Develop an IEEE Software Engineering Standard for Software Dependability.

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

KEYWORDS: Standards, Software Reliability

ESTIMATE AND CONTROL SOFTWARE FAULT CONTENT MORE EFFECTIVELY

**Norman Schneidewind, Professor
Department of Information Science**

Sponsor: Jet Propulsion Laboratory, California Institute of Technology

OBJECTIVE: The purpose of this research was to identify the attributes of requirements that cause the software to be unreliable and to quantify the relationship between requirements risk and reliability. If these attributes can be identified, then policies can be recommended to NASA for recognizing these risks and avoiding or mitigating them during development. Further, this work was extended and validated on the Space Shuttle to the Goddard Space Flight Center and the Jet Propulsion Laboratory software projects.

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

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

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

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

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KEYWORDS: Software Reliability, Software Metrics, Modeling

INVESTIGATION OF THE RISK TO SOFTWARE RELIABILITY OF REQUIREMENTS CHANGES

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Department of Information Science

Sponsor: National Aeronautics and Space Administration Integrated Verification and Validation Facility

OBJECTIVE: This overall objective of this research was to identify the attributes of software requirements that cause the software to be unreliable and to quantify the relationship between requirements risk and reliability. If these attributes can be identified, then policies can be recommended to the software engineering community for recognizing these risks and avoiding or mitigating them during development. The objective of these policy changes is to prevent the propagation of high-risk requirements through the various phases of software development.

Given the lack of emphasis in measurement research on the critical role of requirements, this research investigated the following issues:

- What is the relationship between requirements attributes and reliability and maintainability? That is, are there requirements attributes that are strongly related to the occurrence of defects and failures in the software?
- What is the relationship between requirements attributes and software attributes like complexity and size? That is, are there requirements attributes that are strongly related to the complexity and size of software?
- Is it feasible to use requirements attributes as predictors of reliability and maintainability? That is, can static requirements change attributes like the size of the change be used to predict reliability in execution (e.g., failure occurrence) and the maintainability of this code?
- Which requirements attributes pose the greatest risk to reliability and maintainability?

SUMMARY: Report # 1 on the NASA IV&V Facility Project “Investigation of the Risk to Software Reliability and Maintainability of Requirements Changes”:

This report covers the discriminate analysis experiment. In order to continue to make progress in software measurement, as it pertains to reliability and maintainability, the emphasis must shift from design and code metrics to metrics that characterize the risk of making requirements changes. Although these software attributes can be difficult to deal with due to the fuzzy requirements from which they are derived, the advantage of having early indicators of future software problems outweighs this inconvenience. This study developed an approach for identifying requirements change risk factors as predictors of reliability and maintainability problems. This project’s case example consisted of twenty-four Space Shuttle change requests, nineteen risk factors, and the associated failures and software metrics. The approach can be generalized to other NASA domains with numerical results that would vary according to the application.

Report # 2 on the NASA IV&V Facility Project ”Investigation of the Risk to Software Reliability and Maintainability of Requirements Changes”:

This report covers the trend analysis experiment. In Report # 1, an approach was developed for identifying requirements change risk factors as predictors of reliability and maintainability problems. This work’s case example consisted of twenty-four Space Shuttle change requests, nineteen risk factors, and the associated failures and software metrics of the Space Shuttle “Three Engine Out” software (designated “OIO” in this report). The approach can be generalized to other NASA domains with numerical results that would vary according to the application.

In Report # 1, four Space Shuttle requirements change risk factors were identified that had a statistically significant effect on reliability. These were the following: the amount of memory space required to implement a requirements change (“space”), the number of requirements issues (“issues”), the number of modifications (“mods”), and the size of the change (“sloc”), in that priority order. This report addressed the following three types of trends:

1. Trends of reliability and risk factors: evaluate cumulative failures as a function of cumulative risk factors and vice versa.
2. Trend and shape metrics: evaluate product reliability and maintainability and the stability of the process that produces the product.
3. Trends in fault correction: evaluate trends in the numbers of corrected and remaining faults and trends in fault correction times.

INFORMATION SCIENCE

The purpose of these evaluations was to provide a comprehensive view of trends in reliability risk (i.e., risk of faults and failures induced by changes in requirements) that may be incurred by deficiencies in the process (e.g., lack of precision in requirements). With this comprehensive analysis in hand, the software manager would have valuable information for deciding whether the software is safe to deploy. Although this project used examples from the Space Shuttle, the approach is general and could be applied to any NASA application.

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Schneidewind, N.F., "Report on Results of Discriminant Analysis Experiment, 27 June 2002," NASA OSMA Software Assurance Symposium, Berkeley, WV, 6 September 2002.

Schneidewind, N.F., "Report on Results of Discriminant Analysis Experiment," 27th Annual NASA/IEEE Software Engineering Workshop, 5 December 2002.

CONTRIBUTION TO BOOK:

Schneidewind, N.F., "Chapter VII, Requirements Risk and Maintainability," *Advances in Software Maintenance Management: Techniques and Solutions*, pp. 182-200, Hershey, PA: Idea Group Publishing, Dr. Macario Polo, Dr. Mario Piattini and Dr. Francisco Ruiz (Eds.), 2002.

KEYWORDS: Software Reliability, Modeling

NAVAL POSTGRADUATE SCHOOL/HQ USPACOM LIAISON DESK FOR CALENDAR YEAR 2002

Brian D. Steckler, Lecturer

Department of Information Sciences

Sponsors: Headquarters U.S. Pacific Command, Naval Postgraduate School

OBJECTIVE: The Naval Postgraduate School (NPS) Desk Liaison was created to facilitate and fully immerse NPS faculty and students into Headquarters U.S. Pacific Command (HQ USPACOM) operational environment. Activities of the NPS Liaison Desk incumbent included coordinating various NPS/U.S. Pacific Command (USPACOM) research and projects, attending periodic liaison meetings at Headquarters U.S. Commander in Chief, Pacific (HQ USCINCPAC), participating in exercise planning meetings within the USPACOM Area of Responsibility (AOR), and participating in select HQ USCINCPAC exercises to gain insight into their operational environment.

INFORMATION SCIENCE

SUMMARY: Establishment of the NPS Desk has allowed HQ USPACOM organizations to obtain access to NPS student and faculty talent, research capabilities, and new technologies. Specific NPS Liaison Desk coordinating efforts for CY 02 (all with continuing work in CY 03) included:

Computer Network Vulnerability Team (CNVT) Augmentation. NPS students who augmented USPACOM J39 and NSA/CSS Pacific (NCPAC) CNVT missions during network vulnerability assessments to USS BLUERIDGE, HQ PACAF, and HQ CINCPACLT in support of exercise TERMINAL FURY '03. NPS assisted HQ USPACOM with CNVT tasking and activities for Exercise Cobra Gold '03 in Thailand. In addition, NPS provided valuable information and practical experience training to USPACOM personnel (while learning about how to conduct live assessment missions) on the latest wired and wireless network hacker tools and exploits.

Computer Network Vulnerability Team (CNVT) Business Process Reengineering (BPR) Study. Facilitated a team of NPS students and faculty doing a complete rapid BPR of the USPACOM / NCPAC CNVT organization. This BPR is ongoing and deliverables will include a working web-based model for baselining and streamlining the CNVT process as well as to increase productivity of the CNVT personnel. This BPR is being conducted with NPS students doing both thesis and class project work in CY 02 and 03.

WLAN Research. Provided subject matter expertise and presented results of recent NPS research on the operational and legal aspects of newly emerging 802.11x wireless (WLAN) vulnerabilities in a variety of forums. NPS, HQ USPACOM, and NSA Pacific continue to conduct coordinated research in CY 03 on monitoring in this new medium at the request of USPACOM customers. NPS Liaison Desk and HQ USPACOM J39 co-hosted a highly successful legal conference in Hawaii to discuss the legal aspects of WLAN vulnerability assessments.

Network Security Software. Coordinated NPS subject matter experts providing support and technical assistance with HQ USPACOM's installed version of THERMINATOR Patternless Network Intrusion Detection System (PIDS). NPS students and faculty co-wrote this software system with National Security Agency in CY 01. USPACOM has been, and continues to be, a live operational test bed environment for this program. NPS students and faculty are continuing research and improvement of this system.

Web Information Operations. Worked with USPACOM, JIOC, Thai and Singapore military to apply IO to the web during Exercise Cobra Gold '03. NPS providing coding for front end and back end database driven application for web site in multiple languages. Three NPS students doing a practicum in lieu of a thesis in support of this initiative, with scheduled completion March 2003.

PRESENTATIONS:

Steckler, B.D., "NPS Research for USPACOM," Cebrowski Institute Symposium, WLAN Vulnerabilities and Legal Aspects of WLAN's, Naval Postgraduate School, 7-9 August 2002.

Steckler, B.D., "Web Information Operations," Flag Officer Presentation, Web IO Brief to USPACOM Flag Officers, HQ USPACOM, Camp Smith, HI, 22 March 2002.

Steckler, B.D., "Web Information Operations," Web IO Brief to Joint Information Operations Command (JIOC) and Other Participants, OrgWar Seminar, Naval Postgraduate School, 8 April 2002.

Steckler, B.D., Buettner, R. and Jasper, S.J., "NPS Liaison Desk," Flag Officer Presentation, HQ USPACOM Flag Officers, USPACOM, Camp Smith, HI, 19 December 2002.

KEYWORDS: Web Information Operations Research, Computer Network Vulnerability Assessments and Research, Wireless Network Attack/Defense, Patternless Intrusion Detection Systems, Business Process Reengineering, Computer Network Attack, Computer Network Defense, Computer Network Exploitation

INFORMATION SCIENCE

UNITED STATES MARINE CORPS SPECIFIC SOFTWARE INTEGRATION REQUIREMENTS OF THE ADVANCED FIELD ARTILLERY TACTICAL DATA SYSTEM/TACTICAL COMBAT OPERATIONS SOFTWARE SUITES

Geoffrey D. Thome

Department of Information Science
Sponsor: U.S. Marine Corps – MCSC

OBJECTIVE: Investigate and recommend architectural frameworks for tactical C2 systems. Investigate software integration requirements between the AFATDS and TCO C2 systems.

KEYWORDS: Tactical C2 Systems, Software Integration, AFATDS, TCO C2 Systems

**DEPARTMENT OF
INFORMATION SCIENCE**

**2002
Faculty Publications
and Presentations**

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Thate, T., "Identifying Collaborative Tools for Combined Joint Task Force 'Focused Logistics' to Support 'Rapid Decisive Operations'," Fourth International Conference on Electronic Commerce Research (ICECR-4), Dallas, TX, 8-11 November 2001.

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Gaver, D.P., Jacobs, P.A., Pilnick, S.E. and Richards, F.R., "CROPDUSTER: A Model for Evaluating the 'Common Relevant Operational Picture (CROP)'," Naval Postgraduate School Technical Report, NPS-OR-02-004, July 2002.

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Irvine, N., "Analysis of the Objective Data from the Fleet Battle Exercise-Hotel," Institute for Joint Warfare Analysis Publication, IJWA-01-012, 2001.

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Schneidewind, N.F., "Chapter VII, Requirements Risk and Maintainability," *Advances in Software Maintenance Management: Techniques and Solutions*, pp. 182–200, Hershey, PA: Idea Group Publishing, Dr. Macario Polo, Dr. Mario Piattini and Dr. Francisco Ruiz (Eds.), 2002.

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Schneidewind, N.F., "Introduction to Software Reliability with Space Shuttle Example," IEEE Reliability Society Ottawa Chapter, Tutorial Notes, Ottawa, Canada, 20 July 2002.

**DEPARTMENT OF
OPERATIONS RESEARCH**

**JAMES EAGLE
CHAIR**

OPERATIONS RESEARCH

OVERVIEW:

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

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

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

The Department of Operations Research mission is:

- To educate analysts who are fully capable of conducting independent analytical studies of military problems, and have an educational basis for continued learning and development.
- To provide the United States government and our allies with military officers who have a comprehensive knowledge of military operations research, and who can perform and manage quantitative analysis of operational and other Defense problems.
- To provide operations research and general analysis support to 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 Math)
- 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

OPERATIONS RESEARCH

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:

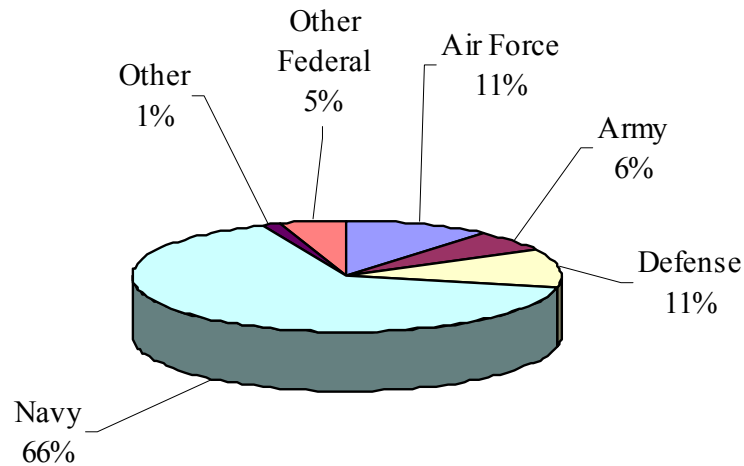
- Chair for Manpower Modeling
- Chair of Applied Systems Analysis
- Chair of Tactical Analysis

RESEARCH FACILITIES:

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

SPONSORED RESEARCH PROGRAMS (Research and Academic)-FY2002:

The Naval Postgraduate School's sponsored program exceeded \$61 million in FY2002. Sponsored programs include both research and educational activities funded from an external source. A profile of the sponsored program for the Department of Operations Research is provided below.



Size of Program: \$2,698K

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OPERATIONS RESEARCH

CHAIR OF APPLIED SYSTEMS ANALYSIS
CDR Matthew G. Boensel, USN, Military Instructor
Department of Operations Research

Sponsor: Chief of Naval Operations-Assessment Division (N81)

OBJECTIVE: In accordance with the current Memorandum of Understanding between the Superintendent, Naval Postgraduate School and N81 (dated 12 April 1993), funds will provide research support for analysis of issues of interest to the Navy. Research will provide professional development of NPS faculty and students.

SUMMARY: Specific elements of this project include:

- Support for student thesis tours, in association with the OA program office.
- Support for faculty development in applied systems analysis and faculty travel to DC in support of N81 activities.
- Support for student and faculty travel for thesis research projects.

PRESENTATIONS:

Boensel, M., "Spreadsheet Modeling for Military Operations Research," Ft. Leavenworth, KS, 18-19 June 2002.

Boensel, M., "Spreadsheet Modeling for Military Operations Research," Scott Air Force Base, 16 August 2002.

THESIS DIRECTED:

Cha, Y.K., "Analysis of Logistics Flow (Dry Cargo) in Japan in Support of Executing OPLAN 5027," Master's Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: Optimization, Operations Research, Combat Logistics

EXTENSIBLE OPTIMIZATION TOOLKIT FOR MILITARY PLANNING SYSTEMS

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

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

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

OPERATIONS RESEARCH

CONFERENCE PUBLICATIONS:

Buss, A.H., "Component Based Simulation Modeling with Simkit," *Proceedings of the 2002 Winter Simulation Conference*, E. Yücesan, C.-H. Chen, J.L. Snowdon and J.M. Charnes (Eds.), 2002.

Buss, A.H. and Sanchez, P.J., "Building Complex Models With Legos (Listener Event Graph Objects)," *Proceedings of the 2002 Winter Simulation Conference*, E. Yücesan, C.-H. Chen, J.L. Snowdon and J.M. Charnes (Eds.), 2002.

PRESENTATIONS:

Bradley, G., "Extensible Markup Language (XML) for Network Optimization," INFORMS Annual Meeting, San Jose, CA, 17-20 November 2002.

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

Bradley, G. and Buss, A.H., "Extensible Optimization Toolkit for Military Planning Systems," INFORMS Annual Meeting, San Jose, CA, 17-20 November 2002.

Buss, A.H., "Component Based Simulation Modeling with Simkit," WSC 02 Winter Simulation Conference, San Diego, CA, 8-11 December 2002.

Buss, A.H., "Discrete Event Modeling of Movement and Detection," INFORMS Annual Meeting, San Jose, CA, 17-20 November 2002.

Buss, A.H. and Sanchez, P.J., "Building Complex Models With Legos (Listener Event Graph Objects)," WSC 02 Winter Simulation Conference, San Diego, CA, 8-11 December 2002.

THESES DIRECTED:

Burger, J., "Real-time Engagement Area Development Program (READ Pro)," Master's Thesis, Naval Postgraduate School, June 2002.

Childs, M.D., "An Exploratory Analysis of Water Front Force Protection Measures Using Simulation," Master's Thesis, Naval Postgraduate School, March 2002.

Dickie, J.A., "Modeling Robot Swarms Using Agent-based Simulation," Master's Thesis, Naval Postgraduate School, June 2002.

Erlenbruch, T., "Agent-based Simulation of German Peacekeeping Operations for Units Up to Platoon Level," Master's Thesis, Naval Postgraduate School, March 2002.

Havens, M.E., "Dynamic Allocation of Fires and Sensors," Master's Thesis, Naval Postgraduate School, March 2002.

KEYWORDS: Dynamic Planning, Loosely Coupled Components, Platform Independent Software, Java

OPERATIONS RESEARCH

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

OBJECTIVE: Develop large-scale mathematical programming techniques to: (1) test a stochastic-programming model for planning sealift deployments subject to attack, (2) study neighborhood generation in local-search heuristics incorporating in a branch-and-bound solver for mixed-integer programming, and (3) extend the capabilities available in a prototype military planning system for dynamic operation over heterogeneous computer networks. This is a continuing research project.

SUMMARY: (1) Research on stochastic programming for sealift planning was completed and a paper submitted for review. Results indicate that substantial reductions in expected disruptions caused by enemy attacks at seaports of debarkation can be obtained through stochastic-programming methodologies. (2) Military capital planning applications modeled as large integer linear programs have been used to establish a number of techniques that improve solution quality and reduce solution time. Branch and bound enumeration is responsive to expressing the importance of decisions with respect to some datum in space or time. A new class of flow cover cuts induced by variable upper and variable lower bounds has yielded intuitive as well as numerical guidance about how and why to tighten constraints. (3) Another part of this research extended a toolkit of methods to quickly construct graph and network algorithms. The algorithms were integrated into a dynamic map-based military planning system that operates over heterogeneous computer networks. The system can download algorithms over a computer network and execute them to analyze operations. The design allows algorithms to be easily added to the planning system.

PUBLICATIONS:

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

Brown, G.G., Dell, R.F., Davis, R.L. and Duff, R.H., "Optimizing Plant-line Schedules and an Application at Hidden Valley Manufacturing Company," *INTERFACES*, 32, pp. 1-14, 2002.

Brown, G.G., Dell, R.F., Holtz, H. and Newman, A.M., "How Space Command Optimizes Long-Term Investment in Space Systems," *INTERFACES*, 2002, (to appear).

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

Israeli, E. and Wood, R.K., "Shortest-Path Network Interdiction," *Networks*, Vol. 40, pp. 97-111, 2002.

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

PRESENTATIONS:

Bradley, G., "Extensible Markup Language (XML) for Network Optimization," INFORMS Annual Meeting, San Jose, CA, 17-20 November 2002.

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

Bradley, G. and Buss, A.H., "Extensible Optimization Toolkit for Military Planning Systems," INFORMS Annual Meeting, San Jose, CA, 17-20 November 2002.

OPERATIONS RESEARCH

Brown, G. and Wood, K., "Outfitting and Pre-positioning Theater Ballistic Missile Defense AEGIS Battle Groups to Meet an Exigent Threat of Attack," INFORMS Annual Meeting, San Jose, CA, 17-20 November 2002.

Israeli, E. and Wood, K., "Trilevel System Defense Models," INFORMS Annual Meeting, San Jose, CA, 17-20 November 2002.

Salmeron, J., Brown, G.G., Dell, R.F. and Rowe, A., "CIPA: Capital Investment Planning Aid for the U.S. Navy," INFORMS Annual Meeting, San Jose, CA, 17-20 November 2002.

Sanchez, S. and Wood, K., "The BEST Algorithm to Solve Stochastic Integer Programs," INFORMS Annual Meeting, San Jose, CA, 17-20 November 2002.

Wood, K., "Network Interdiction," Workshop on Network Interdiction and Stochastic Integer Programming, University of California at Davis, Davis, CA, 15 March 2002.

Wood, K., "A Practical Algorithm for Enumerating Near-min s-t Cuts in a Graph," INFORMS Annual Meeting, San Jose, CA, 17-20 November 2002.

TECHNICAL REPORTS:

Brown, G.G., Newman, A.M., Rosenthal, R.E. and Rowe, A.A., "Optimizing Tomahawk Strikes," Naval Postgraduate School Technical Report, NPS-OR-01-001-PR, 2001.

Salmeron, J., Brown, G.G., Dell, R.F. and Rowe, A., "Capital Investment Planning Aid (CIPA)," Naval Postgraduate School Technical Report, NPS-OR-02-006, 2002.

THESES DIRECTED:

Bayram, V., "Optimizing the Capacity and Operation of U.S. Army Ammunition Production Facilities," Master's Thesis, Naval Postgraduate School, June 2002.

Burger, J., "Real-time Engagement Area Development Program (READ Pro)," Master's Thesis, Naval Postgraduate School, June 2002.

Castro, D.R., "Optimization Models for Allocation of Air Strike Assets with Persistence," Master's Thesis, Naval Postgraduate School, December 2002.

Culver, C.L., "MH-60s Helicopter and Pilots to Combat Support (HC) Squadrons," Master's Thesis, Naval Postgraduate School, March 2002.

Dickie, J.A., "Modeling Robot Swarms Using Agent-Based Simulation," Master's Thesis, Naval Postgraduate School, June 2002.

Enholm, J.C., "Marine Thirty-Year Plan," Master's Thesis, Naval Postgraduate School, March 2002.

Erken, Ö., "A Branch-and-Bound Algorithm for the Network Diversion Problem," Master's Thesis, Naval Postgraduate School, December 2002.

Givens, R.D., "A Comparison of the Operational Potential and Capability of Two Combat Logistics Force Alternatives," Master's Thesis, Naval Postgraduate School, September 2002.

Travers, C., "Optimizing Aimpoints for Multiple GPS Weapons Released Against a Single Target," Master's Thesis, Naval Postgraduate School, September 2002.

OPERATIONS RESEARCH

Uygun, A., "Network Interdiction by Lagrangian Relaxation and Branch-and-Bound," Master's Thesis, Naval Postgraduate School, June 2002.

KEYWORDS: Integer Programming, Stochastic Programming, Dynamic Planning

VERIFICATION, VALIDATION, AND ACCREDITATION OF THE DECISION SUPPORT TOOLBOX, VERSION 2

Gordon H. Bradley, Professor

Department of Operations Research

Sponsor: Space and Naval Warfare Command Systems Center - Charleston

OBJECTIVE: To perform a Verification, Validation, and Accreditation (VV&A) of specific components of Chi System's Decision Support Toolbox, version 2 that are being considered for integration into the Command and Control Personal Computer (C2PC).

SUMMARY: An informal VV&A was used to test the system components with a variety of inputs and to validate by code inspection the algorithms used by the system. Additional documentation was prepared to more fully describe the algorithms used in the system. The final report described seven main conclusions about the software. A list of recommendations for proposed features for future versions of the system was prepared.

THESIS DIRECTED:

Burger, J., "Real-time Engagement Area Development Program (READ Pro)," Master's Thesis, Naval Postgraduate School, June 2002.

KEYWORDS: Decision Support Tools, Terrain Analysis, Movement Analysis

LARGE-SCALE OPTIMIZATION

Gerald G. Brown, Distinguished Professor

R. Kevin Wood, Professor

Department of Operations Research

Sponsor: Air Force Office of Scientific Research

OBJECTIVE: This annual proposal for continued research in large-scale optimization includes two main short-term topics, (a) development of a fundamentally new stochastic-programming algorithm with applications to interdiction, and (b) the study of bilevel system-interdiction and system-defense models along with the production of a seminal reference for this field.

SUMMARY: To publish how the research results of this project have been motivated by and applied to USAF Space Systems and other long-term military capital planning of more than a trillion dollars in investments. To catalog a variety of military applications of attacking linear programs representing development of weapons of mass destruction, interdicting or delaying military movements, disrupting logistics flows of materiel, and even interfering with entire national economies. A research paper on a new Bound, Enumerate Screen and Test (BEST) algorithm for stochastic programming is nearly complete. The algorithm and results on a civilian problem were presented at the Annual INFORMS meeting. The algorithm was also presented as a technique for solving stochastic network-interdiction problems at an Army-sponsored workshop.

PUBLICATIONS:

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

OPERATIONS RESEARCH

Brown, G.G., Dell, R.F., Davis, R.L. and Duff, R.H., "Optimizing Plant-line Schedules and an Application at Hidden Valley Manufacturing Company," *INTERFACES*, 32, pp. 1-14, 2002.

Brown, G.G., Dell R.F., Holtz, H. and Newman, A.M, "How Space Command Optimizes Long-Term Investment in Space Systems," *INTERFACES*, 32, pp. 1-14, 2003.

Brown, G.G., Dell, R.F. and Newman, A.M., "Optimizing Military Capital Planning," *INTERFACES*, 32, pp. 1-14, 2003.

Israeli, E. and Wood, R.K., "Shortest-Path Network Interdiction," *Networks*, Vol. 40, pp. 97-111, 2002.

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

PRESENTATIONS:

Brown, G.G., "Top Ten Secrets in Optimization," Plenary Address, Military Operations Research Society, Ft. Leavenworth, KS, 18-20 June 2002.

Brown, G. and Wood, K., "Outfitting and Pre-positioning Theater Ballistic Missile Defense AEGIS Battle Groups to Meet an Exigent Threat of Attack," INFORMS Annual Meeting, San Jose, CA, 17-20 November 2002.

Israeli, E. and Wood, K., "Trilevel System Defense Models," INFORMS Annual Meeting, San Jose, CA, 17-20 November 2002.

Salmeron, J., Brown, G.G., Dell, R.F. and Rowe, A., "CIPA: Capital Investment Planning Aid for the U.S. Navy," National Meeting of the Institute for Operations Research and the Management Sciences, San Jose, CA, 17-20 November 2002.

Sanchez, S. and Wood, K., "The BEST Algorithm to Solve Stochastic Integer Programs," INFORMS Annual Meeting, San Jose, CA, 17-20 November 2002.

Wood, K., "Network Interdiction," Workshop on Network Interdiction and Stochastic Integer Programming, University of California at Davis, Davis, CA, 15 March 2002.

Wood, K., "A Practical Algorithm for Enumerating Near-min s-t Cuts in a Graph," INFORMS Annual Meeting, San Jose, CA, 17-20 November 2002.

TECHNICAL REPORT:

Salmeron, J., Brown, G.G., Dell, R.F. and Rowe, A., "Capital Investment Planning Aid (CIPA)," Naval Postgraduate School Technical Report, NPS-OR-02-006, 2002.

THESES DIRECTED:

Bayram, V., "Optimizing the Capacity and Operation of U.S. Army Ammunition Production Facilities," Master's Thesis, Naval Postgraduate School, June 2002.

Castro, D.R., "Optimization Models for Allocation of Air Strike Assets with Persistence," Master's Thesis, Naval Postgraduate School, December 2002.

Culver, C.L., "MH-60s Helicopter and Pilots to Combat Support (HC) Squadrons," Master's Thesis, Naval Postgraduate School, March 2002.

Enholm, J.C., "Marine Thirty-Year Plan," Master's Thesis, Naval Postgraduate School, March 2002.

OPERATIONS RESEARCH

Erken, Ö., “A Branch-and-Bound Algorithm for the Network Diversion Problem,” Master’s Thesis, Naval Postgraduate School, December 2002.

Givens, R.D., “A Comparison of the Operational Potential and Capability of Two Combat Logistics Force Alternatives,” Master’s Thesis, Naval Postgraduate School, September 2002.

Travers, C., “Optimizing Aimpoints for Multiple GPS Weapons Released Against a Single Target,” Master’s Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: Integer Programming, Stochastic Programming, Network Interdiction

MUNITIONS INVESTMENT MODELS

Gerald G. Brown, Distinguished Professor

Alan R. Washburn, Professor

Department of Operations Research

Sponsors: Naval Supply Systems Command, Naval Ammunition Logistics Center

OBJECTIVE: Review and extrapolate the current technology for planning large-scale weapons purchases through optimization.

SUMMARY: The Navy’s current Non Nuclear Ordnance Requirements (NNOR) process is not cost-constrained. As a result, it provides little guidance as to weapon purchases when budget constraints make it impossible to satisfy all of the requirements generated by NNOR. The purpose of this research was to construct a prototype of a multi-year investment model to recommend munitions purchases reflecting existing and predicted budget constraints. A draft structure for the Assessment and Investment Model (AIM) was developed that recognizes the principal uncertainty in any weapons planning study: the timing and scale of the war in which the weapons will be used. The structure is a large linear program. The required computations are extensive but can be accomplished in a reasonable amount of time. Subsequent work will determine whether the required data can be found or developed.

PRESENTATION:

Fahringer, P., “Ordnance Assessment and Investment Model (AIM),” Information Paper Presented by Naval Ammunition Logistics Center to the Naval Ordnance Readiness Improvement Process Executive Steering Group (ESG), 15 January 2003.

KEYWORDS: Optimization, Weapons, Munitions

OPTIMIZING NAVY PROGRAM PLANNING

Gerald G. Brown, Distinguished Professor

Robert F. Dell, Associate Professor

Anton Rowe, Research Associate

Javier Salmeron, Research Assistant Professor

Department of Operations Research

Sponsor: Chief of Naval Operations (N81)

OBJECTIVE: To provide Chief of Naval Operations Code N81 with a desktop, optimization-based decision-support tool to integrate, rationalize, and schedule the way in which and the rate at which Navy capital spending programs should be conducted over the next 25 years.

SUMMARY: A prototypic custom-built optimization-based decision-support system was developed, complete with graphical user interface and custom heuristic. The decision-support system prescribes complete scenarios that can follow all Navy guidelines, including details such as keeping shipyards efficiently employed, and meeting IWARS (Integrated Warfare Architecture) requirements. Without the

OPERATIONS RESEARCH

system, complete scenarios must be manually assembled, which is a slow, laborious task that can result in undetected errors.

PUBLICATION:

Brown, G.G., Dell, R.F. and Newman, A.M., "Optimizing Military Capital Planning," *INTERFACES*, 33, pp.1-14, 2003.

PRESENTATION:

Salmeron, J., Brown, G.G., Dell R.F. and Rowe, A., "CIPA: Capital Investment Planning Aid for the U.S. Navy," INFORMS Annual Meeting, San Jose, CA, 17-20 November 2002.

TECHNICAL REPORT:

Salmeron, J., Brown, G.G., Dell, R.F., and Rowe, A., "Capital Investment Planning Aid (CIPA)," Naval Postgraduate School Technical Report, 2002.

THESIS DIRECTED:

Aytekin, M., "Applying a Fix-and-Relax Heuristic to U.S. Navy Force Structure Planning," Master's Thesis, Naval Postgraduate School, December 2002.

OTHER:

Software: The following version of the decision-support system was delivered to N81.

Version	Delivered	Comments	Documentation
P.08.27	May 2002	Advanced Prototype. Interface partially operative and scalable. Heuristic solver.	Same as version P.07.04

KEYWORDS: Optimization, Large-scale Optimization, Program Planning, Budgeting, Capital Budgeting

APPLICABILITY ASSESSMENT FOR MARITIME OPERATIONS

Arnold H. Buss, Research Assistant Professor

Thomas E. Halwachs, Senior Lecturer

Department of Operations Research

Sponsor: U.S. Coast Guard Research and Development Center

OBJECTIVE: Assess Maritime Operations Simulation (MarOpsSim) as a modeling tool for U.S. Coast Guard demands, assets, and operating environments.

SUMMARY: The Maritime Operations Simulation (MarOpsSim) is a modern discrete event simulation being used by the U.S. Coast Guard. MarOpsSim was originally developed by the U.S. Coast Guard Research and Development Center to examine elements of the Search and Rescue and Law Enforcement missions. MarOpsSim is now being extended to encompass all 14 Deepwater missions to support the Deepwater Acquisition. This document reports the results of the Core Verification and Validation (Core V&V) effort conducted at the Naval Postgraduate School by the authors. Based on the analysis and assessment made so far, it can be concluded that MarOpsSim is a modeling tool that can be used to reasonably represent the characteristics and behavior of the Coast Guard against the demands of, and in the operations environments described in, the Modeling and Simulation Master Plan (MSMP). Furthermore, MarOpsSim produces output that can be summarized and analyzed to consistently generate Coast Guard system performance measures also described in the MSMP.

OPERATIONS RESEARCH

KEYWORDS: Discrete-event Simulation, United States Coast Guard, Deepwater Acquisition, Research and Development Center

TOOLKIT FOR EVALUATING ALGORITHMS FOR INTERNETTING OF FIRES

Arnold H. Buss, Research Assistant Professor
Modeling, Virtual Environments, and Simulation Institute
Sponsor: U.S. Army TRADOC Analysis Command

OBJECTIVE: To develop a decision-support algorithm that will dynamically allocate both sensor and weapons resources for use in future combat systems.

SUMMARY: In order to provide a testbed for evaluating proposed NETFIRES algorithms, a combat simulation environment, DAFS (Dynamic Allocation of Fires and Sensors) was developed to allow evaluation of different objective force configurations and demonstrate proof of concept for a field-level decision-support system. The software utilizes a combination of Simulation and Optimization, taking advantage of the distinct benefits of each discipline. The randomness and pseudo-realism of simulation were combined with algorithms that gather and evaluate the local operating environments and produce global employment policy. The simulation then adjudicated the resulting plan. DAFS facilitates exploring the effect of internetting of fires in scenarios with imperfect information as well as interactions between the design of proposed platforms and internetting of fires. The Simulation was implemented using Simkit, a Discrete Event Simulation (DES) toolkit written in Java by the principal investigator.

CONFERENCE PAPERS:

Buss, A.H., "Component Based Simulation Modeling with Simkit," *Proceedings of the 2002 Winter Simulation Conference*, E. Yücesan, C.-H. Chen, J.L. Snowdon and J.M. Charnes (Eds.), 2002.

Buss, A.H. and Sanchez, P.J., "Building Complex Models With Legos (Listener Event Graph Objects)," *Proceedings of the 2002 Winter Simulation Conference*, E. Yücesan, C.-H. Chen, J.L. Snowdon and J.M. Charnes (Eds.), 2002.

PRESENTATIONS:

Buss, A.H., "Component Based Simulation Modeling with Simkit," WSC 02 Winter Simulation Conference, San Diego, CA, 8-11 December 2002.

Buss, A.H., "Discrete Event Modeling of Movement and Detection," INFORMS Annual Meeting, San Jose, CA, 17-20 November 2002.

Buss, A.H. and Sanchez, P.J., "Building Complex Models With Legos (Listener Event Graph Objects)," WSC 02 Winter Simulation Conference, San Diego, CA, 8-11 December 2002.

SOFTWARE:

DAFS (Dynamic Allocation of Fires and Sensors)

THESIS DIRECTED:

Havens, M.E., "Dynamic Allocation of Fires and Sensors," Master's Thesis, Naval Postgraduate School, March 2002.

KEYWORDS: Future Combat Systems, Army Objective Force Concept, Decision Support Tools, Dynamic Allocation of Weapons Resources

OPERATIONS RESEARCH

OFFICER CANDIDATE SCHOOL DATA ANALYSIS STUDY

Samuel E. Buttrey, Associate Professor
Department of Operations Research

Sponsor: Marine Corps Recruiting Command

OBJECTIVE: To analyze data from a 67-question survey administered to recruits at the Marine Corps' Officer Candidate School (OCS) and build a statistical model to identify candidates at risk and/or demographic and other characteristics that are predictive of success at OCS. This will allow early intervention efforts at OCS in an attempt to retain high-risk candidates.

SUMMARY: Individual outcomes are highly uncertain because people are much more than a set of demographics and personal characteristics. The model produced a fairly high error rate when predicting success or failure of individuals. However, in groups of demographically similar recruits the predictions were highly accurate. This model will allow recruiters and OCS staffers to identify groups at high risk and target intervention efforts at members of those groups. The research showed that the different commissioning programs produce recruits with different aggregate probabilities of success. Recommendations for improving the data-collection process and the survey itself were included. Finally a spreadsheet model able to produce predicted probabilities of success was delivered. This tool could be used at OCS in order to identify candidates at high risk of failure, or by recruiters to identify specific behaviors of recruits that might be corrected before the start of OCS training.

THESIS DIRECTED:

McNeill, D.B., "An Analysis of Factors Predicting Success or Failure at United States Marine Corps Officer Candidate School," Master's Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: Manpower, Recruiting

OFFICER RECRUITING STRUCTURE II, TASK 2

Samuel E. Buttrey, Associate Professor
Department of Operations Research

Sponsor: Marine Corps Recruiting Command

OBJECTIVE: To complement a detailed examination of the validity and applicability of an April 2001 Center for Naval Analysis (CNA) study of the Marine Corps officer recruiting structure in relation to the qualified market. The qualified candidate population, or QCP, is defined as the mentally qualified males who graduated from four-year degree-granting institutions, with a male enrollment of 400 or greater, in only four years. This study's objective was to validate the CAN model if possible, and to determine how the Marine Corps might improve its officer recruiting through more accurate determination of the QCP.

SUMMARY: This project examined CNA predictions of the QCP from a given university. The CNA study could not be validated because the QCP cannot be counted directly. This study expanded the set of colleges considered and populated the database with Department of Education counts of enrollments and completions going back to 1996. Almost no information appeared to be available from any source about students who transfer from two-year to four-year schools. A number of colleges and universities were surveyed in an effort to learn about these students and about other relevant issues, and a survey of Officer Selection Officers (OSOs) was designed and administered. A spreadsheet was produced to enable planners to estimate the QCP at each of the 1,044 colleges in the database, for each of four ethnic groups and three recruiting programs. Shortcomings of the CNA model were exposed and described. For example, the CNA model tends to over-predict at the Historically Black Colleges and Universities, because of African-Americans' generally lower performance, as a group, on standardized tests. The CNA model does not consider Puerto Rican colleges and universities, which has the effect of omitting a large number of qualified Hispanic candidates. Furthermore the Marine Corps' qualification standards were inconsistent when the SAT and ACT marks were compared, and inclusion of candidates who require five years to graduate more closely reflect the OSO's working environment.

OPERATIONS RESEARCH

THESIS DIRECTED:

Hallahan, W.D., "Validation of the United States Marine Corps Qualified Candidate Population Model," Master's Thesis, Naval Postgraduate School, December 2002.

KEYWORDS: Manpower, Education, Recruiting

SENSOR MIX STUDY

W. Matthew Carlyle, Associate Professor

Department of Operations Research

Sponsor: U.S. Army TRADOC Analysis Command

OBJECTIVE: To develop optimization models for determining appropriate mix and usage of various sensor types organic to the objective force unit of action.

SUMMARY: New models based on simple stochastic optimization approaches, and clustering targets into named- and tactical-areas-of-interest, were developed and tested on simple data. A student is currently developing advanced versions of the cluster-based models, including packaging of sensors to allow for positive correlation between sensors of different types that would improve detection capabilities.

THESIS DIRECTED:

Tutton, S., "Optimization of Sensor Mix and Employment for the Objective Force Unit of Action," Master's Thesis, Naval Postgraduate School, June 2003.

KEYWORDS: Sensors, C4ISR, Objective Force, Optimization

LESSONS LEARNED FROM INFRASTRUCTURE

George W. Conner, Associate Provost for Strategic Planning

Robert F. Dell, Associate Professor

Julie Filizetti, Associate Provost for Academic Affairs

Department of Operations Research

Sponsor: Defense Logistics Agency

OBJECTIVE: The investigators will provide information about Department of Defense (DoD) Base Realignment and Closure (BRAC) processes and similar infrastructure efficiency initiatives; prepare a case self-study of Naval Postgraduate School (NPS) experiences in the BRAC process using a case study methodology developed by Rand; conduct an historical validation self-study for NPS of prototype decision support criteria developed by Rand; conduct a case study of another DoD educational institution that was involved in a BRAC process or similar infrastructure efficiency initiative; conduct an historical validation study for the DoD educational institution of prototype decision support criteria developed by Rand; and review draft research products developed by Rand and provide comments to Rand and the DoD office of the Chancellor for Education and Professional Development.

KEYWORDS: Base Realignment and Closure, Decision Support, Facilities Efficiency

OPERATIONS RESEARCH

OPTIMIZATION MODELS FOR INSTALLATION MANAGEMENT

Robert F. Dell, Associate Professor

Department of Operations Research

Sponsor: United States Army, Assistant Chief of Staff for Installation Management

OBJECTIVE: Develop optimization models to assist with installation management.

SUMMARY: This project, researches, supports, and develops optimization models to assist the Army's Assistant Chief of Staff for Installation Management. The primary effort in 2002 involved development of the integer-linear programs Optimal Stationing of Army Forces (OSAF) and Budget Allocation for Environmental Cleanup (BAEC). The Center for Army Analysis used OSAF for numerous stationing studies and the Army will use OSAF to help plan its 2005 base realignment and closures. The Army's Base Realignment and Closure Office used BAEC to help plan over \$350 million in environmental cleanups at over 400 sites on 41 current and former Army installations.

PUBLICATION:

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

THESES DIRECTED:

Bayram, V., "Optimizing the Capacity and Operation of U.S. Army Ammunition Production Facilities," Master's Thesis, Naval Postgraduate School, June 2002.

Dzwonchyk, J.D., "Optimal Allocation of Army Military Construction Projects," Master's Thesis, Naval Postgraduate School, June 2002.

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

NUCLEAR PROLIFERATION ASSESSMENT

James D. Eagle, Professor and Chair

Department of Operations Research

Sponsor: National Nuclear Security Administration

OBJECTIVE: Professor James Eagle, Chairman of the Operations Research Department at the Naval Postgraduate School will support the NNSA/NA-241 nuclear proliferation assessment methodologies (NPAM) project by participating in the working group consisting of U.S. National Laboratory and academic professionals. The working group will develop guidelines for the practical application of NPAM to address questions and issues related to the proliferation of nuclear weapons and weapons-useable materials and related technologies, as input to policy analysis.

KEYWORDS: Nuclear, Proliferation, Modeling

OPERATIONS RESEARCH

ANALYTICAL DECISION-SUPPORTING RESEARCH USING SYNTHESIZED ADAPTIVE-AGENT-BASED MODELING AND MATHEMATICAL MODELING

Donald P. Gaver, Distinguished Professor

Patricia A. Jacobs, Professor

Department of Operations Research

John Hiles, Research Professor

Modeling, Virtual Environments, and Simulation Institute

Sponsor: Chief of Naval Operations (N-6M)

OBJECTIVE: Purpose of the research is to formulate and study models for the adaptive scheduling of time critical tasks under imperfect information in joint warfare with a view towards guiding allocation of acquisition and eventually operational resources. The emphasis is on modeling the impact of information obtained from realistically imperfect sensor systems on interactive and joint conflicts. The purpose of the modeling and analysis is to explore the advantages of using Genetic Algorithms and other adaptive procedures in the adaptive scheduling of processing of time-critical tasks, with imperfectly known identity and arriving in random streams of "unknown," i.e. changing, properties. This is a generalization of the General Assignment Problem (GAP) treated (under assumptions of certainty) by mathematical programming. The models here are called the Generalized General Assignment Problem (GGAP).

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

PUBLICATIONS:

Andrade, S.T., Rowe, N.C., Gaver, D.P. and Jacobs, P.A., "Analysis of Shipboard Firefighting-team Efficiency Using Intelligent-agent Simulation," *Proceedings of the 2002 Command and Control Research and Technology Symposium*, Naval Postgraduate School, 11-13 June 2002.

Barkdoll, T.C., Gaver, D.P., Glazebrook, K.D., Jacobs, P.A. and Posadas, S., "Suppression of Enemy Air Defenses (SEAD) as an Information Duel," *Naval Research Logistics*, 49, pp. 723-742, 2002.

PRESENTATIONS:

Andrade, S.T., Rowe, N.C., Gaver, D.P. and Jacobs, P.A., "Analysis of Shipboard Firefighting-Team Efficiency Using Intelligent-agent Simulation," 2002 Command and Control Research and Technology Symposium, Naval Postgraduate School, 11-13 June 2002.

Gaver, D.P. and Jacobs, P.A., "Analytical Decision Support Using Agent-based and Mathematical Modeling," Modeling, Virtual Environments and Simulation Open House, 21 August 2002.

TECHNICAL REPORT:

Gaver, D.P. and Jacobs, P.A., "Battlespace/Information War (BAT/IW): A System-of-Systems Model of a Strike Operation," Naval Postgraduate School Technical Report, NPS-OR-02-005, August 2002.

OTHER:

Gaver, D.P., Jacobs, P.A., Hiles, J. and Takahara, G., "Modeling and Analysis of Uncertain Time-critical Tasking Problems (UTCTP)," (forthcoming).

KEYWORDS: Combat Models, Bayesian Perception Updating, Decision Analysis

OPERATIONS RESEARCH

JOINT EXPERIMENTATION HIGH-LEVEL-LOW-RESOLUTION MODELING

Donald P. Gaver, Distinguished Professor

Patricia A. Jacobs, Professor

Steven E. Pilnick, Associate Professor

Department of Operations Research

Sponsor: U.S. Joint Forces Command

OBJECTIVE: Purpose of the research is to formulate and study state space models for sensor-to-shooter operations in joint warfare with a view towards guiding allocation of acquisition and eventually operational resources. The emphasis is on modeling the impact of inter-service sharing of information obtained from realistically imperfect sensor systems on interactive and joint conflicts.

SUMMARY: High-level-low-resolution models for the study of effectiveness of the Common Relevant Operational Picture, (CROP), have been formulated, studied and used to provide insight of the benefits of the common relevant operational picture.

PRESENTATIONS:

Gaver, D.P., Jacobs, P.A. and Pilnick, S.E., "CROP DUSTER," presentation to MAJ Mackie, USAF, Joint Personnel Recovery Agency, 6 February 2002.

Gaver, D.P., Jacobs, P.A. and Pilnick, S.E., "CROP DUSTER," presentation to Dr. Yeoh, Singapore-CSO, 25 March 2002.

TECHNICAL REPORT:

Gaver, D.P., Jacobs, P.A. and Pilnick, S.E., "CROP DUSTER: A Model for Appreciating the Common Relevant Operational Picture (CROP)," Naval Postgraduate School Technical Report, NPS-OR-02-004, July 2002.

THESIS DIRECTED:

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

KEYWORDS: Combat Models, Bayesian Perception Updating, Decision Analysis

MODELING THE BENEFITS AND RISKS OF MINE AVOIDANCE

Donald P. Gaver, Distinguished Professor

Patricia A. Jacobs, Professor

Steven E. Pilnick, Associate Professor

Department of Operations Research

Sponsor: Naval Postgraduate School

OBJECTIVE: Purpose of the research is to formulate and study models to investigate the benefits and risks of mine avoidance, without object classification capability, under circumstances that include imperfect sensors and false targets.

SUMMARY: Simulation and analytical Models for object avoidance using imperfect sensors have been formulated and studied.

THESIS DIRECTED:

Kim, C., "The Effect of Sensor Performance on Safe Minefield Transit," Master's Thesis, Naval Postgraduate School, December 2002.

OPERATIONS RESEARCH

KEYWORDS: Mine Avoidance, Decision Analysis

MODELS FOR LIVER INSULT AND RECOVERY

Donald P. Gaver, Distinguished Professor

Patricia A. Jacobs, Professor

Department of Operations Research

Sponsor: Naval Health Research Center Detachment-Toxicology

OBJECTIVE: Use mathematical computer-based modeling and statistical methods to quantify the effects of a toxin on the liver.

SUMMARY: Mechanistic models for the effect of a toxic substance on the liver have been developed and experimental data have been analyzed.

PRESENTATION:

Gaver, D.P., Jacobs, P.A., Carpenter, R.L. and Bobb, A., "Cellular Response Modeling," Theories and Practices in Toxicology and Risk Assessment, Cincinnati, OH, 15-18 April 2002.

OTHER:

Carpenter, R.L., Gaver, D.P., Jacobs, P.A., Narayanan, T.K., Jung, A. and Bobb, A., "A Mechanistic Mathematical Model of Cell Toxicity from APAP," (forthcoming).

Carpenter, R.L., Gaver, D.P., Jacobs, P.A., Robinson, P. and Bobb, A., "Towards a Model of Liver Insult and Recovery After Insult by Xenobiotic Chemicals," Poster Session, 40th Annual Meeting, Society of Toxicology, San Francisco, CA, March 24-29, 2001

Bobb, A., Carpenter, R.L., Gaver, D.P. and Jacobs, P.A., "High Dosage Model for the Effect of APAP on Liver Cells," (forthcoming).

KEYWORDS: PBPK/PD Compartment Modeling, Predictive Toxicology

TRAINING AND RESEARCH SUPPORT FOR DIRECTOR, OPERATIONAL TEST AND EVALUATION

Donald P. Gaver, Distinguished Professor

Patricia A. Jacobs, Professor

Department of Operations Research

Sponsor: Director, Operational Test and Evaluation, Naval Postgraduate School

OBJECTIVE: The purpose of the research is to develop new methodology for operational testing utilization (addressing the general question "How much testing is enough") with emphasis on modeling and simulation applied to test design rehearsal, and to investigate the effectiveness of the classification principle to be used by a kill vehicle in national missile defense. An additional purpose is to create training and reference material, to be presented on a web site.

SUMMARY: A number of models for system reliability growth via failure mode removal have been formulated and studied. Materials for an operational test and evaluation web site have been developed and put in place; see <http://www.nps.navy.mil/or/testeval/index.htm>. An investigation of the classification principle to be used by a kill vehicle in National Missile Defense (NMD) has been undertaken; is a Dempster-Shafer (DS), or an adapted Bayes procedure preferable? Two conferences were conducted on this topic: one in Santa Fe, New Mexico, and one at Lincoln Labs, Lincoln, Massachusetts. Investigation of approaches to the classification problem will continue in collaboration with the inventor of DS, Professor Arthur Dempster.

OPERATIONS RESEARCH

PUBLICATION:

Gaver, D.P., Jacobs, P.A. and Seglie, E., "Balancing 'Test-Fix-Test' and Released System Reliability Under a Fixed Budget," *Communications of the Third International Conference on Mathematical Methods in Reliability*, pp. 251-254, Norwegian University of Science and Technology, Trondheim, Norway, H. Langseth and B. Lindqvist (Eds.), 17-20 June 2002.

PRESENTATIONS:

Gaver, D.P., Jacobs, P.A. and Seglie, E., "Balancing 'Test-Fix-Test' and Released System Reliability Under a Fixed Budget," Third International Conference on Mathematical Methods in Reliability, Trondheim, Norway, 17-20 June 2002, (invited).

Gaver, D.P., Jacobs, P.A. and Seglie, E., "Stochastic Models for System Design Fault Removal in Support of Operational Test (OT) Planning," 2002 Spring Research Conference on Statistics in Industry and Technology, Ann Arbor, MI, 20-22 May 2002, (invited).

OTHER:

Gaver, D.P., "Operational Test and Evaluation Web Site," <http://www.nps.navy.mil/or//testeval/index.htm>

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

DEVELOPMENT OF JOINT EXPERIMENTATION METHODOLOGY, COURSEWARE AND HANDBOOK

**Thomas H. Hoivik, CAPT, USN (Ret.), Senior Lecturer
Department of Operations Research
Sponsor: U.S. Joint Forces Command**

OBJECTIVE: To develop a step-by-step joint experimentation planning and design methodology for U.S. Joint Forces Command to use for planning and analysis of major Joint Experiments.

SUMMARY: Joint and Service Experiments present a great opportunity for experimenting with new initiatives, which may include a variety of concepts, processes, or systems (CPS). A great deal of knowledge and insight can be obtained about military initiatives, tactics, doctrine, and organizational processes. However, there are mixed opinions about the value and validity of information obtained during these past complex experiments. As a result, U.S. Joint Forces Command (J9) requested guidance on how to better plan, conduct and analyze complex joint experiments including the development of an experimentation handbook and courseware for training of participants. The research investigated and developed a detailed joint experimentation methodology including methods for identifying and fully defining concept, process or system issues and evaluation measures to gain insight into initiative effectiveness. The joint experimentation handbook and courseware introduces tools and techniques for better analysis, utilizing workshops, simulations and limited objective experiments, before large-scale wargames and complex joint and service experiments are conducted. The handbook will be used as a base reference and guide for future joint experimentation.

PUBLICATION:

Hoivik, T.H., "Fundamental of Joint Experimentation Planning and Design," U.S. Joint Forces Command (J9) Distribution, February 2002.

KEYWORDS: Joint Experimentation, Joint Forces Command, Joint Warfare

OPERATIONS RESEARCH

DATA QUALITY ASSURANCE TO SUPPORT NAVSUP LOGISTICS

Robert A. Koyak, Assistant Professor
Samuel E. Buttrey, Associate Professor
Department of Operations Research
Sponsor: Naval Supply Systems Command

OBJECTIVE: To initiate research into data quality issues at the Naval Inventory Control Points in Mechanicsburg and Philadelphia, Pennsylvania. Areas in which data quality shortfalls are addressable with statistical techniques were identified as the basis for follow-on research.

SUMMARY: This research effort arose from data quality shortfalls that were recognized at the two Naval Inventory Control Points. Further shortfalls were identified in a series of reports issued by the General Accounting Office. Many of these shortfalls are amenable to improvement by adopting a systematic data quality effort. The time for undertaking such a project was opportune, as Naval Supply Systems Command (NAVSUP) was at the beginning of replacing its legacy inventory management systems with an Enterprise Resource Planning (ERP) solution. In May 2002 Professor Buttrey attended the Data Management Association (DAMA) International Symposium in San Antonio, Texas, to become acquainted with the latest development in data quality management. In August 2002 Professor Koyak visited Naval Inventory Control Point-Philadelphia for one week to learn first-hand about data quality problems at that location. An extensive program for follow-on research to improve data quality through statistical analysis was developed as a result of this effort. Two NPS graduate students, LCDR Gerald Burch and LCDR Patrick Burson, have undertaken NAVSUP-sponsored thesis research in data quality under the advisorship of Professor Koyak.

THESES DIRECTED:

Burch, G.F., "The Cost of Maintaining a Naval Inventory System with Inaccurate Records," Master's Thesis, Naval Postgraduate School, March 2003.

Burson, P., "An Analysis of the Impact of Data Errors on Backorder Rates in the F404 Engine System," Master's Thesis, Naval Postgraduate School, March 2003.

KEYWORDS: Inventory, Data Quality, Simulation

JOINT INTEROPERABILITY TESTING OF AIR AND SPACE SURVEILLANCE SYSTEMS

Robert A. Koyak, Assistant Professor
Department of Operations Research
Sponsor: Defense Information Systems Agency, Joint Interoperability Test Command

OBJECTIVE: To develop statistical testing methodologies for evaluating the performance of joint air surveillance, in particular with respect to joint interoperability testing and certification.

SUMMARY: The investigation considered how track information that is communicated between sensor platforms during joint air and space surveillance can be used in joint interoperability testing. Interoperability depends on the transmission of track quality (TQ) numbers, from which reporting responsibility is determined. If TQ numbers are reported inaccurately, interoperability can be adversely affected. The investigation considered how statistical tests can be developed, based on reported TQ numbers, to determine if systems are either under- or over-reporting their accuracy. Integration of the "truth space" into the investigation was also considered.

THESES DIRECTED:

Gulick, J.S., "Statistical Validation of Air Surveillance Track Quality Numbers for Joint Interoperability Testing," Master's Thesis, Naval Postgraduate School, June 2002.

OPERATIONS RESEARCH

Smith, G.K., "A Methodology for Evaluating the Truth Space in Testing for the Single Integrated Air Picture," Master's Thesis, Naval Postgraduate School, June 2002.

KEYWORDS: Sensors, Tracking, Surveillance

CNET: JOINT COMBAT MODELING

Thomas W. Lucas, Associate Professor

Department of Operations Research

Curtis L. Blais, Research Associate

Modeling, Virtual Environments, and Simulation Institute

Sponsor: Chief of Naval Education and Training

OBJECTIVE: Develop material for an online version of Joint Combat Modeling.

SUMMARY: Material was developed for an interactive online version of the Joint Combat Modeling course. This includes learning modules consisting of PowerPoint slides, reading material, interactive applets, discussion boards, and assignments—using the framework of the Blackboard CourseInfo™ tool adopted by the Naval Postgraduate School for its distance learning classes—sufficient to cover equivalent material to what is delivered in the resident version. The course was designed to be taken by several students in synchronization with the active participation of a professor.

KEYWORDS: Distributed Learning, Web-based Learning, Distance Learning, Combat Modeling

THE VALUE OF INFORMATION AND ANALYSIS OF COMBAT DATA

Thomas W. Lucas, Associate Professor

Department of Operations Research

Sponsor: Naval Postgraduate School

OBJECTIVE: Attempt to validate models and look for invariant trends in data sets on historical battles. Use simple models and exploratory analysis to search for insights on the value of information.

SUMMARY: This research explored the validation of Lanchester equations as models of the attrition process for the Battle of Kursk in World War II. Also, the Center for Army Analysis' CDB90G data set, which contains about 140 attributes on nearly 660 land battles was used to investigate which factors, over time, are associated with victory. Finally, simple models were used to determine the effects of varying levels of information.

PUBLICATIONS:

Lucas, T.W., "How Damage Functions Affect Estimates of Fratricide and Collateral Damage," *Naval Research Logistics*, 2002, (revised and accepted for publication).

Lucas, T.W. and McGunnigle, J., "When is Model Complexity Too Much? Illustrating the Benefits of Simple Models with Hughes' Salvo Equations," *Naval Research Logistics*, 2002.

Lucas, T.W. and Turkes, T., "Fitting Lanchester Equations to the Battle of Kursk," 2002, (revised and resubmitted).

THESES DIRECTED:

Ipekci, A., "How Agent Based Models Can Be Utilized to Explore and Exploit Non-linearity and Intangibles Inherent in Guerrilla Warfare," Master's Thesis, Naval Postgraduate School, June 2002.

OPERATIONS RESEARCH

McIntosh, G., "Information Superiority and Game Theory: The Value of Varying Levels of Information," Master's Thesis, Naval Postgraduate School, March 2002.

Pee, E.Y., "An Exploratory Analysis on the Effects of Information Superiority on Battle Outcomes," Master's Thesis, Naval Postgraduate School, March 2002.

KEYWORDS: Modeling and Simulation, Combat Analysis

THE EFFECTS OF REVERSING SLEEP-WAKE CYCLES ON SLEEP AND FATIGUE ON THE CREW OF USS *JOHN C. STENNIS*

**Nita Lewis Miller, Research Assistant Professor
Department of Operations Research
Department of Systems Engineering**

Sponsor: Naval Submarine Medical Research Laboratory

OBJECTIVE: The purpose of this study is to determine the quality and quantity of sleep in U.S. Navy Sailors working night shifts aboard the USS STENNIS during combat operations.

SUMMARY: This study explores the effects of reversing the work-sleep schedules of the crew aboard the USS JOHN C. STENNIS. It also reviews current research in the field of sleep deprivation and the resultant performance decrements in humans. The results of the study indicate that a significant number of sailors have difficulty adjusting to working nights and sleeping days. Additionally, the study finds that individuals working topside have greater difficulty adjusting to the reversed schedule than do their counterparts who work belowdecks. Using a validated model of human performance and fatigue, this study demonstrates that the level of fatigue and sleep deprivation observed in this population significantly reduce individual effectiveness. The study includes recommendations that address the need for educating military personnel on the subject of fatigue and sleep logistics, possible fatigue countermeasures, and the need for further research on this topic.

THESIS DIRECTED:

Nguyen, J., "The Effects of Reversing Sleep-Wake Cycles on Sleep and Fatigue on the Crew of *USS John C. Stennis*," Master's Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: Sleep Deprivation, Human Performance, Carrier Operations During Combat, Night Shiftwork, Melatonin, Light Exposure

FATIGUE EFFECTS ON TEAM PERFORMANCE

**Nita Lewis Miller, Visiting Assistant Professor
Department of Operations Research
Department of Systems Engineering**

Sponsor: Air Force Research Laboratory

OBJECTIVE: This project will evaluate team performance in war gaming scenarios and assess changes that occur with fatigue such as that which is experienced in continuous operations or long-duration missions.

KEYWORDS: Fatigue, Team Performance, Human Factors, Sustained Operations, Continuous Operations

OPERATIONS RESEARCH

MODELING HUMAN ELEMENTS OF DECISION MAKING

Nita Lewis Miller, Research Assistant Professor
Department of Operations Research
Department of Systems Engineering
Sponsor: U.S. Army TRAC-Monterey

OBJECTIVE: The development of combat models and combat simulations do not accurately represent human factors and the impact that they have on combat operations. It is well understood that human behavior representation is a complex and challenging task for military combat modelers. The process of decision-making during combat is one of the most problematic modeling challenges. This study explores these concepts more fully.

SUMMARY: Combat models attempt to represent the various factors that can influence combat outcomes. The most difficult of these factors to define and represent are the purely human inputs into the combat equation. These include factors such as personality, emotion, and level of expertise, which vary from individual to individual. The process of decision-making during combat is one of the most problematic modeling challenges. Traditional models of human decision-making do not adequately address the factors listed above. This study addresses this issue by proposing an influence diagram, which builds on traditional utility theory to include the human element in combat decision-making.

In the near future, commanders and their respective staffs will interact with subordinate and opposing forces whose physical and cognitive behaviors are represented in software and simulation. This model presents human factors and environmental variables that influence stress and risk assessment. These variables contribute to situational awareness. Leaders integrate information from various sources. These sources range from observations, training, orders, and reports and use this knowledge with doctrine and tactics to develop an understanding of the situation. This paper describes a Bayesian network model of the variables associated with risk assessment and stress in combat scenarios. The level of situational awareness is determined by what the commander knows about the unit and the surrounding conditions. This model lends structure to the environment and enables a probabilistic interpretation of risk and stress levels. This model is applicable to various combat scenarios ranging from brief engagements to sustained operations.

THESES DIRECTED:

Barsnick, A., "Modeling Human Elements in Decision Making," Master's Thesis, Naval Postgraduate School, June 2002.

Therrien, S., "A Bayesian Model to Incorporate Human Factors in Commander's Decision Making," Master's Thesis, Naval Postgraduate School, June 2002.

KEYWORDS: Human Behavior Representation, Human Factors and Human Performance, Bayesian Networks, Military Combat Models, Decision Making

NETFIRES DYNAMIC ALLOCATION OF WEAPONS EFFECTS

Nita Lewis Miller, Visiting Assistant Professor
Department of Operations Research
Department of Systems Engineering
Sponsor: TRADOC Analysis Command

OBJECTIVE: The objective of this project is to develop a Bayesian network which will represent human factors and the impact they have on combat operations. The model will enhance decision making capability, and will be especially relevant to issues of operational tempo and risk which are force protection issues.

KEYWORDS: Human Performance, Decision Making, Decision Support Tools, Bayesian Networks, Modeling and Simulation

OPERATIONS RESEARCH

SLEEP PATTERNS IN U.S. NAVY RECRUITS: AN ASSESSMENT OF THE IMPACT OF CHANGING SLEEP REGIMENS

**Nita Lewis Miller, Research Assistant Professor
Department of Operations Research
Department of Systems Engineering
Sponsor: Walter Reed Army Institute of Research**

OBJECTIVE: The purpose of this study is to determine the quality and quantity of sleep in U.S. Navy recruits. An examination of the activity level (actigraphy) data will show how much sleep recruits actually receive versus what they are expected to get. This study will also examine two sleep regimes (2100 to 0500 and 2200 to 0600) to determine if recruit sleep differs due to bedtime.

SUMMARY: United States Navy recruits are trained at the Recruit Training Command (RTC) in Great Lakes, Illinois. Basic training, or Boot Camp, lasts approximately 63 days and encompasses many areas of military training. The schedules of the recruits are closely managed, and this includes the time allocated for their sleep. Within recent years, the designated sleep amounts and bed times for recruits have changed considerably. As recently as 2001, recruits were allowed to sleep for only 6 hours per night from 2200 to 0400. This sleep regime changed in December, 2001 to 7 hours and then again in May, 2002 to 8 hours, for a sleep schedule of 2100 to 0500. Currently, U.S. Navy recruits are allowed to sleep for 8 hours from 2200 to 0600. This study assesses the amount and quality of sleep received by recruits in these two 8 hour conditions; 2100 to 0500 and 2200 to 0600.

PRESENTATION:

Coard, H.F., Dyche, J., Carr, W. and Miller, N.L., "Sleep Changes for Basic Military Training in the Navy," Recruit and Trainee Healthcare Symposium, Baltimore, MD, 2002.

THESIS DIRECTED:

Baldus, B.R., "Sleep Patterns in U.S. Navy Recruits: An Assessment of the Impact of Changing Sleep Regimens," Master's Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: Sleep Deprivation, Human Performance, Adolescent and Young Adult Sleep Patterns, Recruit Training

SLEEP PATTERNS OF U.S. NAVY SUBMARINERS

**Nita Lewis Miller, Research Assistant Professor
Department of Operations Research
Department of Systems Engineering
Sponsor: Naval Submarine Medical Research Laboratory**

OBJECTIVE: The purpose of this study is to determine the quality and quantity of sleep in U.S. Navy Submariners when deployed as compared to shore duties.

SUMMARY: Access to the results from this study are restricted but are available at the NPS Library.

Follow-on Work: At-sea trial of an experimental 24-hour watchstanding schedule.

THESIS DIRECTED:

Gamboa, D.S., "An Analysis of the Effects of Environment and Career Longevity on the Sleep Patterns of Enlisted U.S. Navy Submariners," Master's Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: Sleep Deprivation, Human Performance, Submariner Operations

OPERATIONS RESEARCH

LINES OF COMMUNICATION AND AGENT-BASED SYSTEMS

Peter Purdue, Professor

Department of Operations Research

John Hiles, Research Professor

Modeling, Virtual Environments, and Simulation Institute

Sponsor: Joint Warfare Analysis Center

OBJECTIVE: To examine the feasibility of using agent-based systems to study the movement of material through a road network. Where feasible, the results of the agent-based model will be compared with known results using optimization techniques.

SUMMARY: A student from the Modeling, Virtual Environments and Simulation Institute (MOVES) curriculum has undertaken to examine the feasibility of using agent-based systems to study the movement of material through a road network. He has created the basic agent-based model and designed the appropriate agents and their communications capabilities. Purdue and Hiles will explore with the sponsor the application of the results to classified problems.

PUBLICATION:

A preliminary report on progress has been presented to the sponsor.

KEYWORDS: Complex Adaptive Systems, Agent-based Models, Communications

SUPPORT FOR THE JOINT STAFF FORCE STRUCTURE, RESOURCES AND ASSESSMENT DIRECTORATE

Peter Purdue, Professor

Department of Operations Research

Sponsor: Joint Staff (J8)

OBJECTIVE: To support activities outlined in the Memorandum of Understanding between the Naval Postgraduate School (NPS) and the Joint Staff (JCS) by sponsoring general research in joint analysis and educational activities in joint warfighting and analyses, with continuing emphasis on the role of Complexity.

SUMMARY: The main goal of the project was educational: to create the outline of a short course on Complexity and National Security for use by analysts and managers. A secondary goal was to support development of a workshop in support of the main goal. The workshop will be held later this year and is to be managed by Alidade Consulting. A comprehensive review of the academic and military literature on complexity was carried out and the results incorporated into the course outline.

PRESENTATIONS:

Purdue, P. and Gaver, D., "Complexity and National Security," Technical Cooperation Program Conference on Complexity and Open Systems, Defence Technology Agency, Auckland, New Zealand, 18-21 March 2002.

Purdue, P. and Gaver, D., "Complexity and National Security," 19th ISMOR Conference, Oxford, UK, 26-30 August 2002.

KEYWORDS: Joint Warfare, Wargaming and Analysis, Combat Models, Joint Warfighting Capabilities Assessments, Model Evaluation, Complexity

OPERATIONS RESEARCH

DYNAMIC ALLOCATION OF STRIKE FORCE ASSET

Richard E. Rosenthal, Professor

Javier Salmeron, Research Assistant Professor

Department of Operations Research

Sponsor: Space and Naval Warfare Systems -San Diego

OBJECTIVE: The Space and Naval Warfare Systems Center (SPAWAR) is developing the real-time execution decision support system (REDS). Within the system, SPAWAR envisions a mathematical model for composing strike packages from available assets and allocating those packages to targets. This research will develop optimization modeling and solution technology to be used for designing and assigning strike packages in this context. This study's approach will aim for solution times that are fast enough for dynamic allocation, and it will contain a persistence feature to encourage optimal solutions to conform to recommendations made in previous runs of the model.

KEYWORDS: Strike Planning, Force Allocation, Optimization, Modeling

OPTIMIZATION MODELING FOR PLANNING INVESTMENTS IN AIRLIFT INFRASTRUCTURE AND TANKER FLEET

Richard E. Rosenthal, Professor

Laura M. Williams, Research Assistant Professor

Department of Operations Research

Lt.Col. Steven F. Baker, U.S. Air Force Academy

Department of Operations Research

Sponsor: Office of Secretary of Defense, Program Analysis and Evaluation

OBJECTIVE: This ongoing effort aids in the Program Objectives Memorandum (POM) process with respect to military airlift. Using the Naval Postgraduate School/RAND Mobility Optimization (NRMO) and possibly other optimization modeling approaches, this study continues the tanker requirements study of the past two years and begins the analysis of airlift infrastructure

SUMMARY: During this year, this study analyzed tanker support for fighter drags. The results of the fighter drag analysis were validated by manually reviewing the output of the model used by Air Mobility Command (AMC) for operational planning of tanker sorties (CMARPS). Although AMC claimed that the result (the number of tankers required to perform the fighter drag) was too low by an order of 2.5, this research found that the number of tanker sorties prescribed by their model (CMARPS) was almost exactly the same as the number determined by this analysis.

The objective of the airlift infrastructure analysis is to determine which airfields become necessary when certain countries deny access to our forces. This analysis has just begun and will continue into next year. Current work involves preparing new scenarios for use in the optimization model.

PUBLICATIONS:

Baker, S.F., Morton, D.P., Rosenthal, R.E. and Williams, L.M., "Optimizing Military Airlift," *Operations Research*, Vol. 50, No. 4, pp. 582-602, 2002.

Baker, S.F., Rosenthal, R.E. and Williams, L.M., "Tanker Requirements Study 2005: The Use of Tankers for Fighter Deployment," Operations Research Department, Naval Postgraduate School, November 2001.

Baker, S.F., Rosenthal, R.E. and Williams, L.M., "Optimal Tanker Usage for Aircraft Deployment: TRS-05 and the Future," Operations Research Department, Naval Postgraduate School, January 2002.

KEYWORDS: Air Mobility, Aerial Refueling, Tankers, Mobilization

OPERATIONS RESEARCH

OPTIMIZING TOMAHAWK LAND ATTACK PREDESIGNATION

Richard E. Rosenthal, Professor

Department of Operations Research

Sponsor: Naval Surface Warfare Center, Dahlgren Division

OBJECTIVE: Goal is to improve the design and develop prototypes for a set of procedures with which the fleet can allocate tasks requiring land attack missiles to specific surface ships and submarines.

KEYWORDS: Heuristics, Land Attack, Surface Warfare Operations, Benchmarking

HOMELAND SECURITY RESEARCH AND TECHNOLOGY PROPOSAL (OPTIMIZING ELECTRIC GRID DESIGN UNDER ASYMMETRIC THREAT)

Javier Salmeron, Research Assistant Professor

R. Kevin Wood, Professor

Department of Operations Research

Sponsor: U.S. Department of Justice

OBJECTIVE: Develop new optimization models and methods for planning expansion of electrical generation, transmission and distribution systems that are robust to potential disruptions caused by natural causes, sabotage and, especially, terrorist attacks. The proposed research is intended as the start of an effort spanning at least two years.

SUMMARY: A new model based on network-interdiction and electrical power-flow models has been developed for identifying critical system components (e.g., generators, transformers, transmission lines) in an electric power grid. A decomposition-based solution algorithm has been designed for solving the model approximately. Preliminary testing on medium-sized, IEEE benchmark networks shows the model can be solved efficiently and accurately.

KEYWORDS: Optimization, Homeland Security, Electric Power Grid, Network Interdiction

ADAPTIVE EXPLORATION OF AGENT-BASED COMMAND AND CONTROL SIMULATIONS

Susan Sanchez, Professor

Thomas W. Lucas, Associate Professor

Department of Operations Research

Sponsor: U.S. Marine Corps Combat Development Command

OBJECTIVE: Develop a framework that facilitates high-dimensional explorations of Agent-Based Command and Control Simulations.

SUMMARY: Analysts use combat models to provide information to decision-makers who must make and justify decisions involving billions of dollars and impacting many lives. This research continues a multi-year effort to define, test, and implement a new set of high-dimensional search strategies for use in exploring agent-based simulations. The prototype approaches that were developed automatically look across a breadth of factors and adaptively focus sampling efforts on the “interesting” effects and interactions. The efficiency of the search strategies under a variety of scenarios was examined with computational experiments. These experiments were conducted on a variety of agent-based simulations involving peace enforcement and guerilla combat scenarios.

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Kleijnen, J.P.C., Sanchez, S.M., Lucas, T.W. and Cioppa, T.M., “A User’s Guide to the Brave New World of Designing Simulation Experiments,” *Discussion Paper 1, 2003*, Tilburg University, Center for Economic Research.

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Lucas, T., Sanchez, S., Brown, L. and Vinyard, W., "Better Designs for High-Dimensional Explorations of Distillations," *Maneuver Warfare Science 2002*, United States Marine Corp Project Albert, Quantico, VA, pp. 17-46, 2002.

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Vinyard, B. and Lucas, T., "Exploring Combat Models for Non-monotonicities and Remedies," *Phalanx*, Vol. 35, No. 1, pp. 19, 36-38, March 2002.

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Lucas, T.W., "Some Prototype Agent-based Simulation Studies," DSO National Laboratories Seminar, Singapore, 31 October 2002.

Sanchez, S.M. and Lucas, T.W., "Exploring the World of Agent-Based Simulations: Simple Models, Complex Analyses," Winter Simulation Conference, San Diego, CA, 8-11 December 2002.

Sanchez, S.M. and Lucas, T.W., "Getting the Most From Our Models: Efficient High-dimensional Explorations," 5th Project Albert International Workshop, Uberlingen, Germany, 1-5 July 2002.

Vinyard, W. and Lucas, T.W., "Reducing Non-monotonicities in Combat Models," Military Operations Research Society Symposium, Fort Leavenworth, KS, 18-20 June 2002.

THESES DIRECTED:

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Pee, E.Y., "An Exploratory Analysis on the Effects of Information Superiority on Battle Outcomes," Master's Thesis, Naval Postgraduate School, March 2002.

Wan, S.C., "An Exploratory Analysis on the Effects of Human Factors on Combat Outcomes," Master's Thesis, Naval Postgraduate School, March 2002.

Wu, H.-F., "Spectral Analysis and Sonification of Simulation Data Generated in a Frequency Domain Experiment," Master's Thesis, Naval Postgraduate School, September 2002

KEYWORDS: Modeling and Simulation, Design of Experiments, Agent-based Models, Command, Control and Communications

OPERATIONS RESEARCH

GROUND LOGISTICS COMMAND AND CONTROL

David A. Schrady, Professor
Department of Operations Research
Sponsor: Office of Naval Research

OBJECTIVE: The objective was to support Lockheed Martin, Naval Electronics and Surveillance Systems (NE&SS), in their performance of modeling and engineering development of a system for ground logistics command and control in Expeditionary Maneuver Warfare, an element of the Future Naval Capabilities (FNC) Program of the Office of Naval Research.

SUMMARY: The project involved a team consisting of Lockheed Martin (LM), NE&SS and Advanced Technology Laboratory (ATL), Penn State University Applied Research Laboratory (ARL), Metron, Incorporated, and NPS. ARL and LM-ATL were responsible for autonomic logistics and instrumented a Marine Corps Light Assault Vehicle (LAV) to demonstrate this capability. Demonstration parameters monitored on the LAV included fuel level, battery state, alternator output, engine oil pressure, and engine coolant temperature. Their work included communications architecture with spoken language recognition system and distributed intelligent agents for logistics software components. LM-NE&SS addressed the Shared Data Environment architecture and structuring issues. Metron was responsible for logistics modeling and simulation and for incorporating expeditionary warfare and expeditionary logistics in the Naval Simulation System. LM-NE&SS, Metron, and NPS provided integration and overall project management. Project reviews with the Office of Naval Research and Marine Corps representatives were held June 25-26 June at Penn State ARL, State College, PA, September 17-18 at Metron, Solano Beach, CA, and 12 December at LM World Vision Center in Crystal City, VA.

KEYWORDS: Sea Basing, Logistics Command and Control, Autonomic Logistics

MODELING AND SIMULATION ANALYSIS FOR EXPEDITIONARY LOGISTICS

David A. Schrady, Professor
Department of Operations Research
Sponsor: Office of Naval Research

OBJECTIVE: The objective is to support Metron, Inc. and Lockheed Martin, Advanced Technology Laboratory, who separately hold contracts for modeling and simulation of expeditionary logistics in support of the Future Naval Capabilities program of the Office of Naval Research.

SUMMARY: The effort has consisted of support and analyses defining and documenting logistics command and control, modeling and simulation, database, planning, and user interface requirements responsive to the Office of Naval Research (ONR) Future Naval Capabilities Expeditionary Logistics vision. It has further involved determination of the logistics representation enhancements needed in the Naval Simulation System in order to meet these requirements. Monthly activity reports were provided to both contractors for inclusion in their monthly reports to ONR.

CONFERENCE PUBLICATION:

Schrady, D.A., "Sea-Based Logistics and Lessons from the Falklands," *Proceedings of the USMC/NAVSEA Naval Expeditionary Sea Base Sustainment Conference*, Naval Surface Warfare Center, Port Hueneme, CA, 29-31 January 2002.

TECHNICAL REPORT:

"Expeditionary Logistics Modeling and Simulation Support to the Future Naval Capability (FNC) Program, Phase I Part 1 Report," Metron, Incorporated, 22 January 2002.

KEYWORDS: Sustainability, Sea-based Logistics, Expeditionary Logistics, Expeditionary Maneuver Warfare

OPERATIONS RESEARCH

RESEARCH ON AGGREGATED COMBAT MODELS II - METHODOLOGY FOR THE COMPARATIVE EVALUATION OF MODELS

James G. Taylor, Professor
Department of Operations Research
Sponsor: U.S. Center for Army Analysis

KEYWORDS: Combat Models, Evaluation of Combat Models, Attrition Methodologies

LINEAR PROGRAM/PARTIALLY OBSERVABLE MARKOV DECISION PROCESSES INFORMATION OPTIMIZATION METHODOLOGY

Alan R. Washburn, Professor
Department of Operations Research
Sponsor: Air Force Office of Scientific Research

OBJECTIVE: Develop and test an optimization method for jointly assigning sensor assets and firepower assets to a target set. The method will employ linear programming in a master problem that utilizes partially observable Markov decision processes to generate policies for joint, sequential assignments.

KEYWORDS: Information Warfare

TARGETING OPTIMIZATION

Alan R. Washburn, Professor
David H. Olwell, Senior Lecturer
Department of Operations Research
Sponsor: Director, U.S. Army TRADOC Analysis Center

OBJECTIVE: Create software for optimally aiming a weapon set at a target set. The main purpose of the software is to enable studies of the value of global versus local information in making optimal weapon assignments, in the context of network-centric warfare. A subsidiary purpose is to illuminate tradeoffs between information and firepower.

SUMMARY: The main accomplishment was to provide the sponsor with computer code in the form of a WINDOWS dll-file (*SIMPLL.dll*) that approximately solves the weapons targeting problem (WTP). Given collections of weapons and targets, the WTP problem is to assign weapons to targets, possibly many-to-one, in a manner that maximizes the expected value of the total target value killed. The sponsor was also provided with an Excel workbook *NetFire.xls* that illustrates how *SIMPLL.dll* is called, and that compares the results of assigning weapons optimally with the results of assigning weapons using various suboptimal heuristics. Results sometimes differ strongly, and sometimes not, depending on circumstances. Important factors are the degree to which targets differ from one another (optimality being important when differences between targets are strong), and the overall correlation of forces (optimality being important when the weapon set is neither too large nor too small for the target set). The workbook includes facilities for manipulating these factors in order to see the impact on operations, as well as facilities for uploading realistic kill probability data from the JANUS wargame.

CONFERENCE PUBLICATION:

Olwell, D. and Washburn A., "Fast Optimal Target Allocation, Interneted Fires, and the Value of Information," *71st Military Operations Research Society Symposium*, Quantico, VA, 10-12 June 2003

PROJECT REPORT:

Olwell, D. and Washburn, A., "Interneting of Fires," Naval Postgraduate School Project Report, NPS-OR-02-003-PR, June 2002.

OPERATIONS RESEARCH

KEYWORDS: Targeting, Networking, WTP

A COMPARISON OF TWO METHODS OF SCORING IMPACT LOCATIONS

Lyn R. Whitaker, Associate Professor
Department of Operations Research
Sponsor: Yuma Proving Ground

OBJECTIVE: To provide statistical support to investigate a new method of scoring the location of projectile impact at the Yuma Proving Grounds. Specifically, we will compare a new overhead scoring technique with the current more labor-intensive method of physically locating the impact at the test site. The comparison will be based on test results where impacts are scored using both methods.

KEYWORDS: Reliability, Test and Evaluation

NAVAL POSTGRADUATE SCHOOL/RAND MOBILITY OPTIMIZER MODEL SUPPORT

Laura M. Williams, Research Assistant Professor
Department of Operations Research
Sponsor: Lockheed Martin Corp

OBJECTIVE: The primary objective is to provide training and support to Lockheed Martin personnel in the use of the Naval Postgraduate School/Rand Mobility Optimizer (NRMO) model developed by the principal investigators. On-site training, and ongoing telephone and email support will be provided as well as limited modeling support for Lockheed Martin analyses.

KEYWORDS: Optimization, Air Mobility, Mobility

SUMMER PROGRAM IN OPERATIONS RESEARCH TECHNOLOGY, DISTINGUISHED VISITING PROFESSORS

Laura M. Williams, Research Assistant Professor
R. Kevin Wood, Professor
Department of Operations Research
Sponsor: National Security Agency

OBJECTIVE: Provide leadership and technical guidance to graduate students in National Security Agency's (NSA) Summer Program for Operations Research Technology.

SUMMARY: Combined, Professors Williams and Wood spent approximately three months with NSA's Operations Research Group in Columbia, Maryland guiding graduate students in their analysis of some emergent OR problems at NSA. These problems included:

- The reformulation of a linear program used for allocation of resources to projects in a static environment to one in a dynamic environment. The original model performed a one-time allocation of funds and personnel to projects.
- The creation of a discrete-event simulation to model the generation of events that need to be stored in an information database. The simulation will be used to determine how a graph-based information structure grows over time compared to the growth of a standard database structure.
- The use of space-filling curves to map a route through a city.
- The use of data-mining techniques to sort relevant from non-relevant data.
- The creation of Visual Basic software to display relationships between objects on a map.

These projects are all classified, preventing more detailed descriptions here. Classified project summaries were provided to NSA management upon completion of all projects.

KEYWORDS: Optimization, Data Mining, Discrete-event Simulation

OPERATIONS RESEARCH

LARGE-SCALE MIXED INTEGER PROGRAMMING

R. Kevin Wood, Professor

Department of Operations Research

Sponsor: Joint Warfare Analysis Center

OBJECTIVE: Develop integer-programming methods, including decomposition, for solving interdiction problems under uncertainty.

SUMMARY: Available from sponsor.

PRESENTATION:

Sanchez, S. and Wood, K., "The BEST Algorithm to Solve Stochastic Integer Programs," INFORMS Annual Meeting, San Jose, CA, 17-20 November 2002.

THESIS DIRECTED:

Erken, Ö., "A Branch-and-Bound Algorithm for the Network Diversion Problem," Master's Thesis, Naval Postgraduate School, December 2002.

KEYWORDS: Optimization

LARGE-SCALE NETWORK ALGORITHMS

R. Kevin Wood, Professor

Department of Operations Research

Sponsor: National Security Agency

PARALLEL COMPUTING FOR THE NPS OPTIMIZATION LAB

R. Kevin Wood, Professor

Department of Operations Research

Sponsor: Defense University Research Instrumentation Program (ONR)

OBJECTIVE: This proposal to the Defense University Research Instrumentation Program seeks funds to upgrade the single-processor RS/6000 workstations in the Naval Postgraduate School (NPS) Optimization Laboratory with a multi-node, multi-processor RS/6000 system. The proposed system will improve computational power by at least 2,000%.

SUMMARY: A grant was obtained and an IBM p690 Regatta computer purchased along with a tape backup. This computer has eight processors, eight gigabytes of RAM and is set up with three logical partitions, i.e., three separate machines.

KEYWORDS: Optimization, Stochastic Programming, Parallel Computing

SUPPORT FOR THE CENTER FOR OPERATIONS RESEARCH, NATIONAL SECURITY AGENCY

R. Kevin Wood, Professor

Department of Operations Research

Sponsor: National Security Agency

OBJECTIVE: Provide on-call analytical support to the National Security Agency.

SUMMARY: Available from sponsor.

THESIS DIRECTED:

Erken, Ö., "A Branch-and-Bound Algorithm for the Network Diversion Problem," Master's Thesis, Naval Postgraduate School, December 2002.

KEYWORDS: Optimization

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OPERATIONS RESEARCH**

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Faculty Publications
and Presentations**

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**GRADUATE SCHOOL OF
ENGINEERING AND
APPLIED SCIENCES**

**RUDOLF PANHOLZER
DEAN**

**DEPARTMENT OF
AERONAUTICS AND
ASTRONAUTICS**

**MAX PLATZER
CHAIR**

AERONAUTICS AND ASTRONAUTICS

OVERVIEW:

The Department of Aeronautics and Astronautics is an integral part of the Graduate School of Engineering and Applied Sciences. Aero/Astro faculty members conduct research and teach courses covering air and space vehicles, missiles, propulsion, aerodynamics, avionics, control systems, structures, turbomachinery, computational and experimental methods, orbital mechanics and combat survivability that emphasize total systems design. The uniqueness of this approach is that air and space vehicles are considered part of a larger combat system that includes all aspects of warfighting.

Navy and Marine Corps aircraft are designed to operate aboard ships as part of a larger battle group. Challenges normally not considered by aircraft operating from land bases become design constraints for shipboard compatibility. By working in a Total System Design Group, Aero/Astro faculty and students are exposed to the constraints of shipbuilding, software development and weapons compatibility. Additional issues such as acquisition methods, analysis of alternatives, and order of battle scenarios can be explored by working with the Graduate School of Business and Public Policy, the Graduate School of Operations and Information Sciences, and the School of International Graduate Studies. Aero/Astro faculty and students are exposed to a wide variety of disciplines to develop capable runway-independent aircraft and robust space systems.

CURRICULA SERVED:

- Aeronautical Engineering (Curriculum 610)
- Engineering/Avionics (Curriculum 611)
- NPS-TPS Cooperative Program (Curriculum 612)
- Space Systems Engineering (Curriculum 591)

DEGREES GRANTED:

- Master of Science in Aeronautical Engineering
- Master of Science in Engineering Science
- Master of Science in Astronautical Engineering
- Aeronautical and Astronautical Engineer
- Doctor of Engineering

RESEARCH THRUSTS:

- Aerospace Vehicle Design
- Aerodynamics, Aeroelasticity, V/STOL Aircraft Technology
- Flight Mechanics and Controls
- Structures, Structural Dynamics, Composite Mechanics, Fracture and Fatigue
- Propulsion and Gas Dynamics
- Avionics
- Rotary Wing Aircraft Technology
- Aircraft Combat Survivability
- Spacecraft Systems, Attitude Control and Smart Structures
- Spacecraft Guidance, Control and Optimization

RESEARCH FACILITIES:

- Aeronautical Engineering Laboratories:
 - Aerodynamics Laboratory
 - Gas Dynamics Laboratory
 - Combustion Laboratory

AERONAUTICS AND ASTRONAUTICS

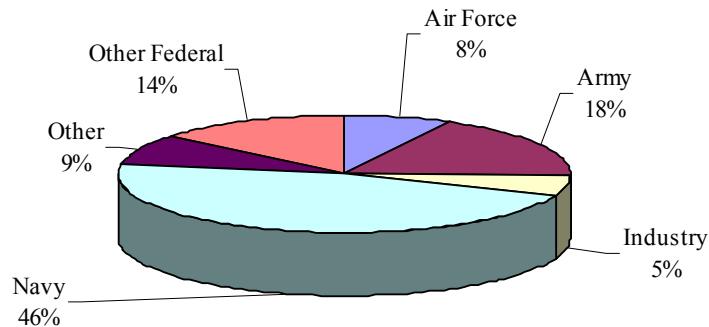
- Turbo-Propulsion Laboratory
- Computation Laboratory
- Flight Mechanics Laboratory
- Structures and Composite Laboratory
- Controls Laboratory
- Avionics Laboratory
- Survivability and Lethality Assessment Laboratory
- Rotorcraft Laboratory
- Aeronautics Design Laboratory
- Spacecraft Laboratories:
 - FLTSATCOM Laboratory
 - Spacecraft Test Laboratory
 - Spacecraft Attitude Dynamics Laboratory
 - Spacecraft Design Laboratory

RESEARCH CENTERS:

- Navy-NASA Joint Institute of Aeronautics
- Spacecraft Research and Design Center
- Turbo-Propulsion Laboratory
- Vertical Flight Technology Center
- Aerodynamics Decelerator Systems Center

SPONSORED RESEARCH PROGRAMS (Research and Academic)-FY2002:

The Naval Postgraduate School's sponsored program exceeded \$61 million in FY2002. Sponsored programs included both research and educational activities funded from an external source. A profile of the sponsored program for the Department of Aeronautics and Astronautics is provided below:



Size of Program: \$3,112K

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ACTIVE LAUNCH VIBRATION ISOLATION

Brij N. Agrawal, Professor
Department of Aeronautics and Astronautics
Sponsor: National Reconnaissance Office

OBJECTIVE: The purpose of this research was to generate and assess different concepts and approaches for actively isolating spacecraft and payloads from vibration loads experienced during launch. Major approaches, including single or multiple axis shock and vibration isolation with the payload adaptor fitting and structural-acoustic control for fairings, were considered. The most promising approaches were recommended for further investigation and technology demonstration. The ultimate benefit of this effort can be a significant reduction in spacecraft BAS and payload structural mass and the elimination or substantial reduction in vibration testing and its associated costs and schedule impacts.

KEYWORDS: Satellites

ANGULAR RATE ESTIMATION BY DYNAMIC GYRO FOR SPACECRAFT ATTITUDE CONTROL

Brij N. Agrawal, Professor
Department of Aeronautics and Astronautics
Sponsor: National Reconnaissance Office

OBJECTIVE: Unpredictable rate gyroscope degradation/failures have impacted National Aeronautics and Space Administration (NASA) spacecraft missions such as Skylab and Hubble Space Telescope as well as several Department of Defense (DoD) and European Space Agency (ESA) satellites. An alternative source of angular rate information, dynamic gyro, is based on software implemented real time dynamic model of the spacecraft. In 2001, at the Naval Postgraduate School (NPS), research was performed to determine the effectiveness of dynamic gyros. The assumed error sources were introduced in the dynamic model to the spacecraft inertia, appendages angular position and angular rates, reaction wheel speed measurements, dynamic modeling, and un-modeled disturbance torques. In 2002, the objective was to determine the error sources in real spacecraft hardware and their impact on the performance of the dynamic gyro. In addition, the dynamic model developed by the spacecraft contractor(s) was compared with that at NPS for dynamic gyro.

KEYWORDS: Attitude Rate Estimation, Rate Gyros, Kalman Filtering

BIFOCAL RELAY MIRROR TECHNOLOGY DEVELOPMENT

Brij N. Agrawal, Professor
Department of Aeronautics and Astronautics
Sponsor: National Reconnaissance Office

DUAL LINE OF SIGHT CONTROL

Brij N. Agrawal, Professor
Department of Aeronautics and Astronautics
Sponsor: Space Missile Command

OBJECTIVE: The objective of this project was to develop a bifocal relay mirror test bed, with single access rotation between the apertures, to investigate dual line of sight control issues. Using analytical simulations and experiments on the test bed, improved integrated beam control and attitude control techniques were developed and demonstrated.

KEYWORDS: Relay Mirror Spacecraft, Beam Control, Attitude Control

MULTI-BODY FLEXIBLE DYNAMICS AND CONTROL MODELS

Brij N. Agrawal, Professor
Department of Aeronautics and Astronautics
Sponsor: National Reconnaissance Office

OBJECTIVE: The objective of the proposed research was to evaluate different techniques for the multi-body flexible dynamic and control models and associated off-the-shelf software packages. The key factors in the evaluation for the software are accuracy of prediction, processing requirements, run time, overall algorithmic robustness and software reusability. The goal was to improve accuracy of analytical prediction of spacecraft attitude dynamic and control performance and to develop “industry standard” models and associated software packages.

KEYWORDS: Satellites, Computers

RELAY MIRROR TESTBED

Brij N. Agrawal, Professor
Department of Aeronautics and Astronautics
Sponsor: Air Force Research Laboratory

OBJECTIVE: The objective of this project was to develop a bifocal relay mirror test bed, with single access of rotation between the apertures, to investigate dual line of sight control issues. Using analytical simulations and experiments on the test bed, improved integrated beam control and attitude control techniques were developed and demonstrated. The emphasis on this project was on the optical payload and beam control for the test bed.

KEYWORDS: Relay Mirror Spacecraft, Beam Control, Attitude Control

SATELLITE SERVICING LABORATORY

Brij N. Agrawal, Professor
Department of Aeronautics and Astronautics
Sponsor: Air Force Research Laboratory

OBJECTIVE: The objective of this research was to develop an autonomous servicing spacecraft simulator and test-bed. The simulator was used for the development and validation of autonomous, neural network based control algorithms as well as various hardware elements necessary for autonomous rendezvous and docking, space manipulator control and satellite servicing operations.

KEYWORDS: Satellite Servicing, Autonomous Control, Neural Networks, Free-Flying Satellites

SPACECRAFT SYSTEMS

Brij N. Agrawal, Professor
Department of Aeronautics and Astronautics
Sponsor: National Reconnaissance Office

OBJECTIVE: The objective of this project was to develop and operate spacecraft laboratories to provide noteworthy improvements to the Space Engineering Curriculum.

KEYWORDS: Spacecraft Design, Automated Design, Spacecraft Attitude Control

AERONAUTICS AND ASTRONAUTICS

SWARM-FORMATION SATELLITE SYSTEM DESIGN

Brij N. Agrawal, Professor
Department of Aeronautics and Astronautics
Sponsor: National Reconnaissance Office

OBJECTIVE: The objective of this project was to participate with the University Team, MIT, Stanford, and Caltech on the design of swarm-formation satellite system. The emphasis by the Naval Postgraduate School (NPS) team was on the mission and payload definition. The application of spacecraft design tools at the NPS Spacecraft Design Center for use by distributed collaborative design teams was also evaluated.

KEYWORDS: Spacecraft Design, Automated Design, Distributed Design

VIBRATION SUPPRESSION AND ISOLATION IN THE IMAGING SPACECRAFT

Brij N. Agrawal, Professor
Department of Aeronautics and Astronautics
Sponsor: Secretary of the Air Force

OBJECTIVE: For an imaging satellite, vibration isolation of the imaging sensor is a critical requirement to meet its performance. For future imaging satellites with higher performance requirements, vibration isolation becomes even more critical. The objective of this project was to assess vibration suppression and isolation technologies develop of vibration isolation concept for a recommended spacecraft configuration and demonstrate by a laboratory experiment the concept and recommend the optimum concept including control laws, sensors and actuators.

ADVANCED MATERIAL AND COOLING SYSTEMS FOR LIQUID ROCKET ENGINE COMPONENTS

Christopher Brophy, Research Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: Air Force Research Laboratory

OBJECTIVE: To determine the benefits of transpiration cooled engine segments compared to convention film-cooled geometries. Prototype copper engine spool segments with 10 micron diameter perforated walls were evaluated for both the combustion chamber walls as well as the converging/diverging nozzle section.

KEYWORDS: Rocket Engines, Film Cooling, Materials

A DIAGNOSTICALLY ENHANCED SIX DOF THRUST STAND FOR PULSE DETONATION ENGINE TESTING

Christopher Brophy, Research Assistant Professor
David W. Netzer, Distinguished Professor
Department of Aeronautics and Astronautics
Sponsor: Office of Naval Research

OBJECTIVE: To accurately measure the performance of a multi-tube air-breathing pulse detonation engine and compare to predicted values. The proposed system will also have the capability to characterize the temporal flow field of the engine in order to determine reasons for the observed performance gains/deficits.

KEYWORDS: Pulse Detonation Engine, Thrust Measurements, Diode Laser Diagnostics

AERONAUTICS AND ASTRONAUTICS

THE EFFECTS OF ROCKET MOTOR OPERATING CONDITIONS ON EXHAUST PLUME SOOT CONCENTRATIONS AND IR SIGNATURE

Christopher Brophy, Research Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: Air Force Research Laboratory

OBJECTIVE: To experimentally determine the effects of rocket motor operating conditions, fuel composition, and film cooling geometry on the exhaust plume soot characteristics and plume signature of gaseous oxygen/liquid-fuel rocket motors.

KEYWORDS: Rocket Engines, Plumes, Soot

IDENTIFICATION AND CHARACTERIZATION OF CRITICAL ISSUES FOR PULSE DETONATION ENGINE DEVELOPMENT

Christopher Brophy, Research Assistant Professor
David W. Netzer, Distinguished Professor
Department of Aeronautics and Astronautics
Sponsor: Office of Naval Research

OBJECTIVE: Characterize physical and operational requirements for the cyclical detonation of a liquid fuel aerosol for pulse detonation engine applications. The investigation explored valving, fuel injection and timing requirements as well as the necessary physical properties such as minimum droplet size, fuel distribution and ignition energy.

KEYWORDS: Pulse Detonation Engines, Detonation, Liquid Fuel

LIQUID ROCKET ENGINE SIGNATURE STUDIES

Christopher Brophy, Research Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: Air Force Research Laboratory

OBJECTIVE: Characterize the spatial distribution and mass concentration of soot in a liquid rocket engine exhaust plume for both well mixed and film cooled geometries. Multiwavelength transmission measurements, planar imaging, and tomography will be applied to specified motor geometrics and conditions. Modeling of the heat transfer processes were also compared to experimental results.

KEYWORDS: Rocket Engines, IR Signature, Tomography

PULSE DETONATION TECHNOLOGY DEVELOPMENT

Christopher Brophy, Research Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: General Electric Aircraft Engines

OBJECTIVE: The Naval Postgraduate School (NPS) and General Electric Aircraft Engines (GEAE) performed cooperative research in developing pulse detonation (PD) technology. NPS conducted analysis and testing of GEAE specified PD tasks. The program advanced the state of PD technology using liquid fuels. The NPS PD research program will benefit from the new technologies provided and from the expansion of current programs to include other liquid fuels. GEAE will benefit from the existing liquid fuel PD capabilities at NPS which, together with the proposed effort, will provide advancement in GEAE's capabilities for applications to commercial and military applications.

AERONAUTICS AND ASTRONAUTICS

UNSTEADY FUEL INJECTION STUDIES
Christopher Brophy, Research Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: Arnold Engineering Development Center

OBJECTIVE: Operate a liquid fuel rocket engine in an unsteady manner for diagnostic purposes. Temporal soot loading was monitored by Naval Postgraduate School (NPS) personnel and additional diagnostics were determined and provided by sponsor during site visit.

KEYWORDS: Rocket Engines, Unsteady

EXPERIMENTAL STUDIES OF COMPRESSIBLE DYNAMIC STALL CONTROL
Muguru S. Chandrasekhara, Research Professor
Department of Aeronautics and Astronautics
Sponsor: Army Aviation and Troop Command

OBJECTIVE: To continue ongoing studies of dynamic stall control using different approaches.

SUMMARY: Two different compressible dynamic stall control methods were studied in this, of which the oscillatory blowing technique was decided to be only partially effective. The other, the variable droop leading edge (VDLE) airfoil method was found to be successful in mitigating many of the undesirable effects of dynamic stall. In this, a 6 in chord, VR-12 airfoil was tested in the compressible dynamic stall facility (CDSF) at conditions enveloping a helicopter rotor flow. Both point diffraction interferometry and unsteady absolute fluctuations data were obtained for many different Mach numbers and reduced frequencies for various airfoil droops and the special case of continuously variable droop. These situations can be simulated in the CDSF by a design that uses only slightly different mounting of and locking schemes for, the associated linkages of the drive system. Large, up to 75%, reductions of airfoil drag, and dramatic reductions in the airfoil pitching moment coefficient, with positive damping were obtained when the airfoil was dynamically varied. This later result makes the approach especially noteworthy, since it is the pitching moment and the negative damping that are most destructive for a helicopter if it ever encounters dynamic stall. Further studies are underway.

PUBLICATIONS:

Chandrasekhara, M.S. and Tung, C., "An Exploratory Investigation of Pulsatile Blowing to Control Compressible Dynamic Stall over an Oscillating NACA 00125 Airfoil," *NASA/AFDD TM*, (being reformatted).

PRESENTATION:

Tung, C., AFDD, Regarding the status of the project, U.S. Army/Israel MOA Meeting.

Tung, C. and Chandrasekhara, M.S., "Review of Compressible Dynamic Stall Control Methods," AHS Heli Japan Conference, Tochigi, Japan, 13-15 November 2002.

KEYWORDS: Flow Control, Helicopter Blade Stall, Smart Materials, Synthetic Jets

AERONAUTICS AND ASTRONAUTICS

A FUNDAMENTAL STUDY OF COMPRESSIBLE DYNAMIC STALL AND ITS CONTROL OVER A VARIABLE DROOP LEADING EDGE AIRFOIL

Muguru S. Chandrasekhara, Research Professor

Department of Aeronautics and Astronautics

Sponsor: U.S. Army Research Office

OBJECTIVE: To investigate basic vorticity dynamics issues of compressible dynamic stall control using a Variable Droop Leading Edge (VDLE) airfoil.

SUMMARY: The effort was initiated in September 2002. In an attempt to meet the US Army TDA, a new way of controlling dynamic stall that can exploit the progress in smart materials, the concept of drooping an airfoil leading edge steadily as it pitches up to high angles of attack was tested in this project. The goal of the project was to identify the fundamental fluid mechanics issues associated with dynamically drooping the airfoil leading edge as a means to control dynamic stall. It is well documented that large amounts of vorticity are produced in the flow experiencing dynamic stall, whose coalescence is to be avoided through proper management if control is to be successful. This requires development of a detailed understanding of the fluid mechanics involved. It is proposed to use the point diffraction interferometry images and the measured pressure distributions to “fill in the gaps” where optical access is not available to aid in this effort.

PUBLICATION:

Chandrasekhara, M.S., Martin, P.B. and Tung, C., “Compressible Dynamic Stall Control Using a Variable Droop Leading Edge Airfoil,” AIAA 41st Aerospace Sciences Meeting and Exhibit, AIAA Paper No. 2003-0048, Reno, NV, 6-9 January 2003, (to be presented).

KEYWORDS: Variable Geometry Airfoils, Dynamic Stall, Rotor Blade Flow Control

STEADY AND UNSTEADY FLOW CONTROL FOR DYNAMIC STALL AND HUB-DRAG REDUCTION

Muguru S. Chandrasekhara, Research Professor

Department of Aeronautics and Astronautics

Sponsor: Army Aviation and Troop Command

OBJECTIVE: To conduct hub-drag reduction studies using synthetic jet blowing and also, to study the Variable Droop Leading Edge (VDLE) airfoil flow for dynamic stall control.

SUMMARY: This is a combination of two tasks, but the majority of the effort was devoted to the hub-drag reduction aspects, since the Variable Droop Leading Edge (VDLE) airfoil is being studied and reported separately. It is well known that as much as 35% of the total helicopter drag is due to that on the hub and other closely located components. In this study, it is attempted to reduce this component using synthetic blowing. The study consisted of two phases. In one, a 2 ft chord, NACA 0036 airfoil was fabricated and tested in the FML 4 ft x 5 ft wind tunnel. Oil flow visualization using a fluorescent dye was conducted to identify regions of flow separation for different conditions. Subsequently, a new model was fabricated with movable slot locations where synthetic jet blowing can be introduced. The actuators for these were supplied under a proprietary contract by a vendor. Tests were conducted using smoke flow visualization and detailed wake surveys using automated experiment control software. Results indicated that synthetic blowing produced 30% to 40% reductions in drag and also, reduced the extent of separation. More studies are planned to obtain velocity data in this flow.

PUBLICATION:

Martin, P.B., Tung, C., Chandrasekhara, M.S. and Arad, E., “Active Separation Control Measurements and Computations for a NACA 0036 Airfoil,” *AIAA 21st Applied Aerodynamic Conference*, Orlando, FL, June 2003, (to be presented).

PRESENTATION:

Martin, P.B., AFDD, Regarding the status of the project, U.S. Army/Israel MOA Meeting.

KEYWORDS: Flow Control, Helicopter Hub-Drag, Synthetic jets

**SUPPORT OF FSU/FAMU EXPERIMENTAL STUDIES OF COMPRESSIBLE DYNAMIC
STALL CONTROL**

**Muguru S. Chandrasekhara, Research Professor
Department of Aeronautics and Astronautics
Sponsor: Florida A&M University**

OBJECTIVE: To investigate compressible dynamic stall control using supersonic micro-jets.

SUMMARY: Florida State university researchers are now attempting to use microjet blowing to control compressible dynamic stall. For verifying this concept, the National Aeronautics and Space Administration (NASA)/FML Compressible Dynamic Stall Facility is being used. In the first series of tests, a 6 in chord NACA 0015 airfoil, with 540 microjets each 400 μm in diameter was tested. The blowing velocities were supersonic. Point diffraction interferometry data showed noticeable delay of dynamic stall onset angle and also, the absence of the concomitant vortex. However, the large number of jets and the mass flow through these was found to be somewhat excessive. Hence, these holes were filled and new 200 μm holes were drilled in the model, before testing again. The results were found to be acceptable, but not as convincing as the first series of tests due to insufficient penetration of the jets into the airfoil vorticity layer to favorably affect the flow. To reduce the mass flow, yet attain this penetration, it is now proposed to use the larger jets, reduce their number and alter their spatial distribution. More testing is planned subject to funding availability. These will include some pressure measurements also.

PUBLICATION:

Shih, C., Beahn, J., Krothapalli, A. and Chandrasekhara, M.S., "Control of Compressible Dynamic Stall Using Microjets," *ASME Fluids Engineering Meeting*, Honolulu, HI, June 2003, (to be presented).

KEYWORDS: Micro-jet blowing, Dynamic Stall, Rotor Blade Flow Control

**AIRCRAFT COMBAT SURVIVABILITY, RELIABILITY AND SYSTEM SAFETY
ENGINEERING**

**CDR Mark A. Couch, USN, Military Instructor
Department of Aeronautics and Astronautics
Sponsor: Various**

OBJECTIVE: To provide education in the disciplines of aircraft combat survivability, reliability and system safety engineering to engineers, analysts and contractor support personnel at various Department of Defense (DoD) activities. This distance learning course will be taught concurrently with the in-resident portion of AA 4251. Funds received from contractor students will be used to cover fixed VTC costs, travel and improvements to the course, of which some of the travel and improvements will be executed in FY2003.

KEYWORDS: Combat Survivability, Susceptibility, Vulnerability, Reliability, System Safety

AERONAUTICS AND ASTRONAUTICS

F/A-18 C/D AVIONICS ARCHITECTURE STUDY

Russell W. Duren, Associate Professor

Department of Aeronautics and Astronautics

Sponsor: Naval Air Warfare Center -Weapons Division

OBJECTIVE: Work with F/A-18 advanced weapons laboratory personnel to develop a system-wide assessment of the F/A-18 C/D avionics system. Identify growth requirements and factors limiting growth over the next 20 to 30 years. Develop a list of potential solutions identifying costs and benefits associated with each solution. Identify best solution(s) and develop a funding schedule for implementation.

KEYWORDS: Avionics, Avionics Data Bus, Legacy Upgrades, MIL-STD-1553

UHF ELECTRICALLY SCANNED ARRAY (UESA) STUDY

Russell W. Duren, Associate Professor

Department of Aeronautics and Astronautics

Sponsor: Naval Air Systems Command

OBJECTIVE: The objective of this proposal was to investigate computer architecture and processing issues related to the development and testing of a UHF electrically scanned array (UESA).

KEYWORDS: Airborne Early Warning, Avionics, Computer Architecture, Cooperative Engagement Capabil, Electrically Scanned Array

CASCADE VORTEX SHEDDING STUDY

Garth V. Hobson, Professor

Department of Aeronautics and Astronautics

Sponsor: National Aeronautics and Space Administration Glenn Research Center

OBJECTIVE: This research investigated the conditions under which vortex shedding occurs in the present cascade tunnel. Experimental laser Doppler velocimetry measurements were performed in the tunnel under the most favorable vortex shedding conditions.

KEYWORDS: Vortex Shedding, Laser Doppler Velocimetry, Turbulence

MODELING AND INSTRUMENTATION FOR PRECISION AIRDROP GUIDANCE, NAVIGATION, AND CONTROL FOR PRECISION AIRDROP

Richard M. Howard, Associate Professor

Department of Aeronautics and Astronautics

Sponsors: U.S. Army Yuma Proving Ground, Naval Postgraduate School

OBJECTIVE: To develop, test, and demonstrate an onboard sensor and data collection package for personnel parachute systems; and to develop aerodynamic models for high-glide parachute systems for simulation and modeling for guidance, navigation and control development. The work was part of related continuing projects.

SUMMARY: A six-degree-of-freedom model for a parafoil was developed. Simulation software was programmed in MATLAB. Initial trials indicate reasonable model fidelity, with model-tuning to follow. A prototype personnel parachute instrumentation package was delivered to a chosen vender as a model for future production.

AERONAUTICS AND ASTRONAUTICS

THESIS DIRECTED:

Mortaloni, Paul M., "High Glide Parachute Aerodynamics Modeling," Master's Thesis, Naval Postgraduate School, December 2002.

KEYWORDS: Modeling, Instrumentation, Parachute, Parafoil, Sensors

CONTINUED DEVELOPMENT OF THE AFFORDABLE GUIDED AIRDROP SYSTEM

Isaac I. Kaminer, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: U.S. Army Yuma Proving Ground

OBJECTIVE: To continue efforts in the development of a low-cost guidance, navigation, and control system for airdrop leading to the demonstration of autonomous guidance of a flat-circular parachute; to support this effort with simulation, hardware development, model development, instrumentation development, and assistance with data analysis, test planning, and system demonstration.

KEYWORDS: Airdrop, Parachute, Autonomous Guidance, Modeling

INTEGRATION AND FLIGHT TEST OF UCLA'S NAVIGATION COMPUTER ON NPS'S UAV FROG

Isaac I. Kaminer, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: National Aeronautics and Space Administration - Goddard

OBJECTIVE: To test the University of California, Los Angeles' (UCLA) navigation computers on the Naval Postgraduate School's (NPS) Frog unmanned aerial vehicle (UAV).

KEYWORDS: Unmanned Air Vehicles, Flight Test

COMPETENCY EDUCATION PACKAGE FOR AIRCRAFT STRUCTURES

Ramesh Kolar, Research Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Warfare Center -Aircraft Division

OBJECTIVE: To develop and teach courses in aircraft fracture and fatigue, aircraft practical stress analysis, and aircraft ground loads for NAVAIR engineers in structures competency.

KEYWORDS: Stress Analysis, Aircraft Fatigue, Fracture Mechanics, Crack Propagation, Metal Fatigue

FINITE ELEMENT MULTI-DISCIPLINARY ANALYSIS OF FLIGHT VEHICLES

Ramesh Kolar, Research Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: National Aeronautics and Space Administration

OBJECTIVE: The purpose of this research was to identify the development and integration of finite element multidisciplinary analysis (FEMA) and to design flight vehicles. An existing Computational Fluid Dynamics (CFD) code was used to couple structural, aerodynamic and flight controls interaction in an efficient and robust manner. In Phase I, criteria will be established for critical performance and operation bounds, basic principles and concepts, spatial and temporal discretization and related methods of solution. The performance of FEMA tools will be evaluated with other available solutions. A pilot code that simulates CFD-structure-control integration to depict the effectiveness of the presently developed algorithm

AERONAUTICS AND ASTRONAUTICS

will be developed. Several algorithms for design optimization for integration into FEMA tools will be identified. Flight control systems integration will be evaluated and proposed for implementation. Improvements and integration of advanced flight control systems structures will be evaluated. In particular, the feasibility of integrating nonlinear control laws as well as specific control design methods into multiobjective optimization software will be investigated.

KEYWORDS: Flight Vehicles, Computational Fluid Dynamics, Flight Control Systems

AERONAUTICAL ENGINEERING CURRICULUM SUPPORT

Max F. Platzer, Distinguished Professor and Chair

CDR Mark Rhoades, USN, Assistant Professor

Department of Aeronautics and Astronautics

Sponsor: Naval Air Warfare Center -Aircraft Division

OBJECTIVE: To provide support for the development of state-of-the-art design tools and to enhance the interaction between the Naval Air Systems Command (NAVAIR) and students and faculty in the Department of Aeronautics and Astronautics.

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

Max F. Platzer, Distinguished Professor and Chair

Department of Aeronautics and Astronautics

Sponsor: University of Kentucky

OBJECTIVE: The overall objectives of this research were to obtain data that are appropriate for advancing the state of turbomachine flutter and dynamic response prediction, evaluation of the capability of current state-of-the-art unsteady aerodynamic models including the evaluation of transition models, and assessment of three-dimensional effects for separated flow and the influence of linear cascade side walls on unsteady aerodynamic response.

CROSS-FLOW FAN FOR VTOL AIRPLANE

Max F. Platzer, Distinguished Professor and Chair

Department of Aeronautics and Astronautics

Sponsor: National Aeronautics and Space Administration Glenn Research Center

OBJECTIVE: The goal of this research was to assess the feasibility of using cross-flow fans (CFF) as additional lift generators for the propulsion of personal air vehicles capable of vertical take-off and landing (VTOL).

SUMMARY: The proposed design retains the desirable features from both conventional aircraft and current designs of VTOL vehicles that utilize ducted fans for thrust generation. The innovative aspects of the proposed design were that it used CFFs for thrust augmentation during VTOL while it retained features of a fixed wing aircraft configuration in order to achieve high efficiency in cruise flight. Extensive studies by LTV Aerospace Corporation, concluded in 1975, demonstrated the potential advantages of CFF as a thrusting device although because of the Navy's loss of interest in V/STOL aircraft, the CFF technology has been overlooked and no further testing and development has been performed for the past quarter century. Recent advances in Wankel-type rotary engines make possible low weight, low volume packaging of CFFs in conventional aircraft with little or no increase in vehicle drag. Therefore, the CFF technology offers ample opportunities for further development using the most recent advances in new materials, computational fluid dynamics, experimental techniques and advanced measurement methods. The purpose of this research was to further prove and develop the CFF concept and examine whether its application could revolutionize air travel and develop personal air vehicles or converticars that use ultralight CFFs.

AERONAUTICS AND ASTRONAUTICS

DEVELOPMENT OF MICRO AIR VEHICLE

Max F. Platzer, Distinguished Professor and Chair
Department of Aeronautics and Astronautics
Sponsor: Naval Research Laboratory

OBJECTIVE: The purpose of this project was to modify the current micro-air vehicle to demonstrate free-flight in the hovering mode. The modification will include further weight minimization and flapping wing optimization as well as a center-of-gravity shift to obtain a statically stable vehicle. The feasibility of sustained forward flight by adding fixed wings to provide lift and volume and by using flapping wings for propulsion and control was explored using a second MAV configuration.

IMPROVEMENT OF IFLOW

Max F. Platzer, Distinguished Professor and Chair
Department of Aeronautics and Astronautics
Sponsor: Naval Surface Warfare Center, Carderock Division

OBJECTIVE: The purpose of this work was to collaborate with the National Aeronautics and Space Administration (NASA) Ames Research Center (ARC) in developing a parallel version of Incompressible Navier-Stokes Solver in General 3D Coordinates (INS3D) for the Navy's computing environment.

KEYWORDS: NASA, INS3D

NPS/CIRPAS SUPPORT OF ONR AIRBORNE RESEARCH OBJECTIVES

Max F. Platzer, Distinguished Professor and Chair
Department of Aeronautics and Astronautics
Sponsor: National Oceanic and Atmospheric Administration

EVALUATION OF A NEW APPROACH TO EFFICIENT TRAJECTORY OPTIMIZATION

Michael Ross, Associate Professor
Department of Aeronautics and Astronautics
Fariba Fahroo, Associate Professor
Department of Mathematics
Sponsor: Draper Laboratory

OBJECTIVE: Complex trajectory optimization problems are generally described as multiphase optimization problems. Over each of these phases, the vehicle may be governed by different dynamics. The presence of these phases naturally partitions the time interval into smaller domains. In many problems, state or control discontinuities occur across these phases. An effective numerical trajectory optimization method should be able to handle these problems in an accurate and efficient manner. This project tested domain decomposition techniques to handle both continuous and discontinuous dynamics.

EVALUATION OF A PREDICTIVE METHOD FOR NEAR-OPTIMAL GUIDANCE

Michael Ross, Associate Professor
Department of Aeronautics and Astronautics
Fariba Fahroo, Associate Professor
Department of Mathematics
Sponsor: Draper Laboratory

OBJECTIVE: The goal of this research was to evaluate the capability of solving linear-time-varying quadratic optimal control problems without the aid of differential Riccati equations.

AERONAUTICS AND ASTRONAUTICS

SUMMARY: Linear time-varying systems with quadratic cost arise quite frequently in the design of guidance and control systems. In particular, they facilitate the notion of neighboring optimal control laws. For predictive control methods to work efficiently, it is necessary to avoid solving Riccati equations online. In this project a new method developed at NPS was evaluated for on-line (i.e. real-time) implementation. This method does not use Riccati methods but solves the accessory minimum problem using an indirect Legendre pseudospectral method. The evaluation process demonstrated that the new method was capable of solving such problems on line without incurring loss in accuracy employed in the approximation.

KEYWORDS: Guidance and Control, Symplectic Boundary Value Problems, Riccati Methods

ADVANCED FAN AND COMPRESSOR DEVELOPMENT STUDIES

Raymond P. Shreeve, Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Warfare Center

OBJECTIVE: To develop or validate tools for the design of advanced compression systems for Navy engines: (i) to obtain experimental measurements and observations of CD blade stall for CFD code validation; (ii) to develop a geometry package geared to the design (by CFD analysis) of swept transonic blading; (iii) to install and test an advanced transonic axial stage and thereby establish the means to economically evaluate more advanced designs; (iv) to develop advanced measurement capability.

KEYWORDS: Fan and Compressor Stall, Cascade Measurements, Transonic Fan and Compressor Design, Swept Blading Design

HCF/SPIN TEST RESEARCH

Raymond P. Shreeve, Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Warfare Center -Aircraft Division

OBJECTIVE: To develop high-cycle fatigue (HCF) spin-test techniques. Following the successful implementation of air-jet excitation (AJE), oil-jet excitation (OJE) and eddy-current excitation (ECE) techniques using two small rotors, this period's goals were to apply similar techniques in TST to full-scale engine rotors, and to perform tests to evaluate damping techniques. Program was conducted in close association with the Naval Air Warfare Center Aircraft Division (NAWCAD), and with the participation of Hood Technology Corporation, jointly funded by the Air Force.

KEYWORDS: High-cycle Fatigue, HCF, Spin-pit facility, Spin Testing

RESEARCH IN THE ACOUSTIC DETECTION OF THE RAH-66 COMANCHE HELICOPTER

E. Roberts Wood, Professor
Department of Aeronautics and Astronautics
Sponsor: Comanche Program Office

OBJECTIVE: Continued work in support of ongoing development of the Army's RAH-66 Comanche helicopter. This phase of the Naval Postgraduate School (NPS) work relates to development of a new acoustic code for the Army for prediction of helicopter noise detection. The first phase of the work required that code Ichin be modified from Fortran 77 to the more flexible and user-friendly code, MATLAB. The second phase of the effort required that the army code Scape be coupled with Ichin such that Scape can support Ichin as an independent computer program or as integrated code. The third phase of this effort called for verifying the new Ichin code against actual one-third octave band noise measurements taken of the Comanche helicopter.

KEYWORDS: Helicopter, Rotorcraft, Noise, Acoustic Detection, Ichin

RESEARCH IN DAMPER FREE ROTOR DESIGN BASED ON MAPLE GENERATED NON-LINEAR SIMULATION

E. Roberts Wood, Professor
Department of Aeronautics and Astronautics
Sponsor: U.S. Army Research Office

OBJECTIVE: The purpose of this research was to derive the full non-linear lead-lag equation of motion for a multi-blade helicopter rotor. MAPLE and SIMULINK were incorporated in the derivation. This new expanded analysis was applied in two areas with high potential for eliminating reliance on mechanical damping in helicopters. These were by introduction of structural tailoring to provide nonlinear hingeless rotor lead/lag characteristics; and by swashplate feedback for increased lead/lag stability.

KEYWORDS: Rotorcraft, Helicopter, Ground/Air Resonance, Damperless, VTOL/MAPLE/SIMULINK

RESEARCH IN THE STRUCTURAL DYNAMIC RESPONSE OF THE RAH-66 COMANCHE HELICOPTER

E. Roberts Wood, Professor
Department of Aeronautics and Astronautics
Sponsor: Comanche Program Office

OBJECTIVE: The present task calls for structural optimization of the Comanche tailcone against 23-mm HEI threat. There are two phases to this work. One phase consists of correlation of our dystran simulation with results of live fire tests conducted at Aberdeen Proving Ground on the tailcone fabrication under the STA (Static Test Article) phase of the program. The second phase consists of exploring the integrity of the EMD design of the RAH-66 to the 23-mm HEI threat. In effect, the STA phase serves as verification of dytran modeling compared to real world firing tests. The EMD phase is being conducted to improve the design strength of the tailcone.

KEYWORDS: Helicopter, Rotorcraft, Dynamics, Structures, NASTRAN/DTRAN

**DEPARTMENT OF
AERONAUTICS AND
ASTRONAUTICS**

**2002
Faculty Publications
and Presentations**

CONFERENCE PAPERS

Chandrasekhara, M.S. and Wilder, M.C., "Heat Flux Gage Measurements of Compressible Dynamic Stall," 40th Aerospace Sciences Meeting, AIAA Paper 2002-0293, Reno, NV, 7-10 January 2002.

Howard, R.M., DeMoss, T.R., Lack, D.D. and Caldwell, Jr., R.B., "Tumbling Susceptibility of a Tailless Unmanned Air Vehicle," AIAA Flight Mechanics Conference, AIAA-2002-4615, Monterey, CA, 5-8 August 2002.

Tung, C., and Chandrasekhara, M.S., "Review of Compressible Dynamic Stall Control Methods," AHS Heli Japan Conference, Tochigi, Japan, 13-15 November 2002.

**DEPARTMENT OF
ELECTRICAL AND COMPUTER
ENGINEERING**

**JEFFREY B. KNORR
CHAIR**

ELECTRICAL AND COMPUTER ENGINEERING

OVERVIEW:

The Department of Electrical and Computer Engineering (ECE) has a broad research program, reflecting the variety of skills and interests of the faculty. ECE faculty research projects are supported by systems commands, warfare centers, the services, basic research agencies, other universities, and industry. These research projects can be grouped into ten major research thrust areas that support the curricula serviced by the Department as well as the several DoD Plans. Unique to the Department and the Naval Postgraduate School is the ability of faculty and students to perform military relevant classified research at all levels. The Department's research program ensures that our graduate students will have a creative and meaningful thesis experience, that our curricula and courses will remain at the cutting edge, that we can recruit and retain quality faculty, and that we can provide our sponsors with cutting edge solutions to their problems.

CURRICULA SERVED:

- Electronic Systems Engineering
- Information Warfare
- Electronic Warfare
- Space Systems Operations
- Space Systems Engineering
- Undersea Warfare
- Joint C4I Systems
- Information Technology Management
- Aeronautical Engineering

DEGREES GRANTED:

- Master of Science in Electrical Engineering
- Master of Science in Engineering Science
- Electrical Engineer
- Doctor of Philosophy

RESEARCH THRUSTS:

- Communication Systems:
Professor Tri Ha, Professor R. Clark Robertson
- Communication Networks:
Assistant Professor John McEachen, Professor Murali Tummala, Military Assistant Professor Robert Ives, Associate Professor Xiaoping Yun
- Computer/Information Systems:
Professor Jon Butler, Associate Professor Douglas Fouts, Professor Herschel Loomis, Visiting Instructor Randy Wight
- Electromagnetic Systems:
Professor Jeffrey Knorr, Research Associate Professor Richard Adler, Associate Professor David Jenn, Professor Michael Morgan, Research Associate Andrew Parker, Research Associate Professor Ray Vincent, Visiting Associate Professor Jovan Lebaric
- Infra-Red and Electro-Optics:
Distinguished Professor John Powers, Professor Phillip Pace, Visiting Associate Professor Ron Pieper
- Guidance, Control and Navigation Systems:
Associate Professor Roberto Cristi, Associate Professor Gary Hutchins, Associate Professor Xiaoping Yun
- Power Electronics, Electric Machines and Distribution:
Associate Professor Robert Ashton, Associate Professor John Ciezki

ELECTRICAL AND COMPUTER ENGINEERING

- 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

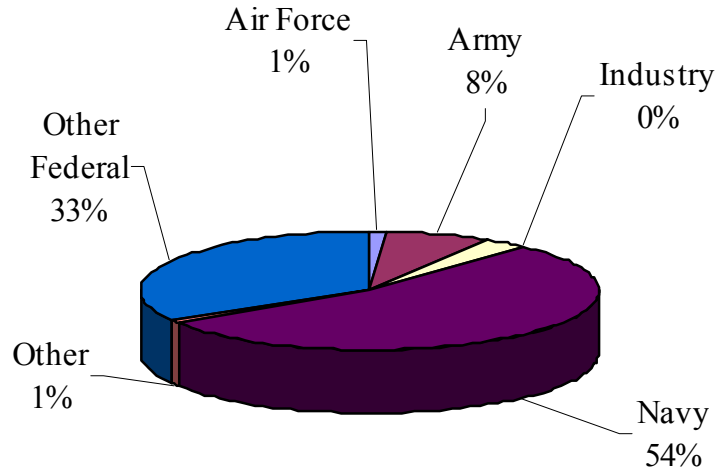
RESEARCH CHAIR:

- National Security Agency Cryptologic Chair

ELECTRICAL AND COMPUTER ENGINEERING

SPONSORED RESEARCH PROGRAMS (Research and Academic)-FY2002:

The Naval Postgraduate School's sponsored program exceeded \$61 million in FY2002. Sponsored programs included both research and educational activities funded from an external source. A profile of the sponsored program for the Department of Electrical and Computer Engineering is provided below:



Size of Program: \$3,517K

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ELECTRICAL AND COMPUTER ENGINEERING

ARCTIC ANTENNA SITE EVALUATION

Richard W. Adler, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Space and Naval Warfare Systems Center San Diego

OBJECTIVE: This is a program to evaluate the suitability of a remote arctic antenna site for use in a high frequency radio system transmission and reception experiment.

KEYWORDS: Antennas, Ground Characteristics

NOISE AND INTERFERENCE AFFECTING THE PERFORMANCE OF EXISTING AND PROPOSED COMMUNICATION SYSTEMS

Richard W. Adler, Research Associate Professor
Andrew Parker, Research Associate
Department of Electrical and Computer Engineering
Sponsor: Federal Communications Commission

OBJECTIVE: This proposal defines a research program to assess and report to the Federal Communications Commissions (FCC) the current state of knowledge about electromagnetic noise and interference that affects the performance of existing and future wireless communications systems. An initial effort is described to address radio noise and interference problems pertinent to the allocation and assignment of spectrum space to new classes of users by the FCC. These problems have been examined by the FCC Technical Advisory Council (TAC) with the conclusion that additional technical assistance is needed to identify, define and resolve important questions about noise and interference.

KEYWORDS: Noise, Interference, Communications System Performance

INTEGRATED FIGHT-THROUGH POWER AND ADVANCED POWER CONVERTER MODULES

Robert W. Ashton, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Surface Warfare Center, Carderock Division

OBJECTIVE: This research effort will provide support for the interface working groups and integrated fight-through power (IFTP). This task will require the investigation of available power converter design options. Additionally, assistance in the design and development of advanced reconfigurable zonal electric distribution system hardware will be provided in the form of testing, debugging and documentation. Support includes conducting appropriate tests, analyze/evaluating technical documentations/data, and providing comments. The Principal Investigator shall attend technical meetings, as required, and provide monthly status reports. Travel to CDNSWC-SSES Philadelphia shall be required to implement the above objectives.

KEYWORDS: Power System, DC Distribution, Zonal Architecture, DC-DC Converter

ELECTRICAL AND COMPUTER ENGINEERING

BEOWULF SYSTEMS DISTRIBUTED NETWORK OPERATIONS RESEARCH

Randy Borchardt, Research Associate
Department of Electrical and Computer Engineering
Sponsor: Space and Naval Warfare Systems Center-San Diego

OBJECTIVE: The research is focused on expanding password security based on a Beowulf system.

KEYWORDS: Beowulf, Password, Security, Computers

FY02 SUPPORT FOR THE COMPUTER NETWORK RESEARCH LABORATORY AND THESIS RESEARCH

LCDR Christopher Eagle, USN, Department of Computer Science
Randy Borchardt, Research Associate
Department of Electrical and Computer Engineering
Sponsor: National Security Agency

OBJECTIVE: This proposal for computer network research laboratory projects expenditures over the next three years and specifically requests FY02 funding for lab research support and required equipment upgrades.

KEYWORDS: Network, Security, Computer, Software, Information Operations

INVESTIGATION IN DISPARATE SENSOR INTEGRATION FOR THE EARLY WARNING OF BIOLOGICAL AND CHEMICAL THREATS

Monique P. Fargues, Associate Professor
Department of Electrical and Computer Engineering
Sponsors: United States Army Soldier - Biological Chemical Compound Command, Edgewood Chemical Biological Center

OBJECTIVE: Analyze collected field tests conducted to evaluate whether various types of sensors may be used to discriminate between biochemical warheads and high energy, explosive rounds. Evaluate military sensors and their potential for battlefield use, develop algorithms that can distinguish between high energy and biochemical rounds, and determine effects of burst altitude, range and environment on burst identification.

KEYWORDS: Chemical and Biological Detect, Discrimination, Classification

DETECTION, CLASSIFICATION, AND PROCESSING OF WIRELESS LOCAL AREA NETWORK SIGNALS

Tri T. Ha, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Information Warfare Activity

OBJECTIVE: Develop a prototype using commercially available low cost hardware and software solutions to detect, classify and process a wireless IEEE 802.11b DSSS compliant network signal.

KEYWORDS: IEEE 802.11b/DSSS/WLAN/OSI, Detection/Recognition, Protect/Network Security, Computer/Software, Communications/Networking

ELECTRICAL AND COMPUTER ENGINEERING

NSA/ATD CRYPTOLOGIC RESEARCH LAB AND THESIS RESEARCH SUPPORT

Tri T. Ha, Professor

Department of Electrical and Computer Engineering

Sponsor: National Security Agency

OBJECTIVE: Support for the cryptologic research laboratory, under the auspices of the Cryptologic Research Center, at the Naval Postgraduate School wherein graduate students and faculty perform research in support of NSA's Applied Technology Division.

KEYWORDS: COMINT/Bleeper/VSAT/OSI/TCP/IP, Modulation, Cyclostationary, Detection, Recognition

EFFECTIVENESS OF BROADBAND ANTENNA DESIGNS

David C. Jenn, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: QRC, Inc.

OBJECTIVE: The objective is to design and demonstrate a wideband antenna that can be used in ground penetrating radar applications. The antenna design tradeoff study will be performed using computational electromagnetics codes. Critical aspects of the candidate designs may be demonstrated in the laboratory by measurements on scaled or full scale models if deemed necessary.

SUMMARY: This program was primarily an investigation into the effectiveness of several broadband antenna designs for use in ground penetrating radar applications. The antennas must be capable of operating over an extremely wide frequency range (10 MHz to 1 Ghz). The antenna must illuminate a spot on the ground a distance of several meters from the antenna. A well defined compact spot must be maintained over the entire range of frequencies.

Two antenna types that have the potential to achieve the bandwidth are the contra-wound quadrafil helix and contra-wound conical spiral. Previous designs of these antennas have demonstrated bandwidths up to a decade, with well behaved input impedance characteristics.

The various aspects of the program include analysis and design of the antennas, simulation of their input and radiation characteristics using computational electromagnetics codes, and development of prototype hardware.

KEYWORDS: Antenna, Radar Application

FEASIBILITY STUDY ON APPLICATIONS OF UV FILAMENTS TO SURFACE WAVE PROPAGATION

David C. Jenn, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Air Warfare Center - Weapons Division

OBJECTIVE: To conduct a feasibility study on the application of UV laser atmospheric filaments to microwave propagation along the conductive path.

KEYWORDS: UV Filaments, Surface Waves, Microwave

ELECTRICAL AND COMPUTER ENGINEERING

VULNERABILITY OF WIRELESS NETWORKS IN INDOOR AND URBAN ENVIRONMENTS

David C. Jenn, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: U.S. Department of Justice

OBJECTIVE: The signals from wireless communications systems and local area networks radiate in free space and therefore can be intercepted by terrorist operatives. Hidden receivers can be placed in public areas such as lobbies and parking lots outside of buildings, and signals intercepted or injected into the wireless systems to jam or deceive. This project investigates the propagation of wireless signals in indoor and urban environments using computational electromagnetic codes available in the ECE Department's microwave and antenna laboratory. The software will be used to examine the vulnerability of these wireless systems and identify simple measures that can be taken to increase the system's security.

KEYWORDS: Wireless Networks, Antennas, Propagation, Computational Electromagnetics

ANTENNA DEVELOPMENT FOR MAN-PACK TACTICAL RADIOS

Jovan E. Lebaric, Visiting Associate Professor
Richard W. Adler, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: United States Army Soldier - Biological Chemical Compound Command

OBJECTIVE: This proposal addresses research and development tasks to improve and design a conformal, wearable RF vest antenna for low VHF use by optimizing the feed region shape and by adding commercially available cladding material in the feed region and integrating the RF vest with the Kevlar flak vest. A second task is to design a ship-replacement antenna for a compact field radio operating in the 30 to 88 MHz band.

KEYWORDS: Communications, Antennas

CONCEALED WEAPONS DETECTION

Jovan E. Lebaric, Visiting Associate Professor
Richard W. Adler, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: U.S. Department of Justice

OBJECTIVE: This research addresses the development and design of a concealed weapons detection system using non-intrusive impulse electromagnetic wave illumination.

KEYWORDS: Weapons Detection

DESIGN AND PROTOTYPE OF WIDEBAND USQ-113 ANTENNAS FOR EA-6B

Jovan E. Lebaric, Visiting Associate Professor
Richard W. Adler, Research Associate Professor
Andrew Parker, Research Associate
Department of Electrical and Computer Engineering
Sponsor: Naval Air Systems Command

OBJECTIVE: The proposed research is for the design and prototyping of two wideband antennas for the USQ-113 system onboard EA6-B aircraft. One of the proposed antennas is an evolution (reduced size) of the "Bell" antenna design testbed at NPS in FY99 while the other is a new low-profile design conformal to the aircraft "skin." The proposed research includes computer modeling and simulation, prototyping, and electrical performance verification via measurements.

ELECTRICAL AND COMPUTER ENGINEERING

KEYWORDS: Antennas, Computational Electromagnetics

ULTRAWIDEBAND ANTENNA FOR THE USQ-146 INSTALLATION IN THE H-60 HELICOPTER

Jovan E. Lebaric, Visiting Associate Professor
Richard W. Adler, Research Associate Professor
Andrew Parker, Research Associate
Department of Electrical and Computer Engineering
Sponsor: Naval Information Warfare Activity

OBJECTIVE: The Naval Postgraduate School will design, fabricate, and test an ultra-wideband transmit antenna for the USQ-146 Rubicon system for use in an H-60 helicopter. The platform operational restrictions on landing and take-off will restrict the design to a retractable radiator, unless the operational requirements permit a larger surface area to be used for the antenna than is currently available for antenna mounting.

KEYWORDS: Information Warfare, Jamming, Antennas

USQ-146 LOW-PROFILE OMNI-DIRECTIONAL ULTRA-WIDEBAND ANTENNA FOR SHIPBOARD AND VEHICULAR USE

Jovan E. Lebaric, Visiting Associate Professor
Richard W. Adler, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Information Warfare Activity

OBJECTIVE: This research addresses the design of a low-profile omni-directional ultra-wideband transmit antenna for the USQ-146 system to be installed on land-based vehicles or onboard ships.

KEYWORDS: Information Warfare, Jamming, Antennas

USQ-146 LOW-PROFILE QUADRANT-SWITCHABLE-BEAM ULTRA-WIDEBAND ANTENNA FOR SHIPBOARD AND VEHICULAR USE

Jovan E. Lebaric, Visiting Associate Professor
Richard W. Adler, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Information Warfare Activity

OBJECTIVE: This research is directed at the design of a low-profile ultra-wideband transmit antenna with steerable beams for the USQ-146 Rubicon system for use in a shipboard environment or on a land-based vehicle.

KEYWORDS: Information Warfare, Jamming, Antennas

CNSG 04/05 MID-CAREER TECHNICAL UPDATE

Herschel H. Loomis, Jr., Professor
John W. Van Hise, Jr., Research Associate
Department of Electrical and Computer Engineering
Sponsor: Naval Security Group Command

OBJECTIVE: To provide a tailored technical update to the 04/05 mid-career CNSG course to meet schedule and educational requirements of cryptologists.

ELECTRICAL AND COMPUTER ENGINEERING

KEYWORDS: SIGINT/ELINT, Detection/Recognition/Protect, Exploitation/Network Security, Computer/Software/Sensors, Communications/Networking

PROJECT GUSTY ORIOLE
Herschel H. Loomis, Jr., Professor
Department of Electrical and Computer Engineering
Sponsor: National Reconnaissance Office

OBJECTIVE: To conduct research into architectures and algorithms for the acquisition, processing and communication of tactical information. To provide support for the course Space Systems 3001, Military Applications of Space and SS4051, Military Space Systems and Technologies.

SUMMARY: Completed work on the following: (1) developed plans for a satellite communications system, (2) designed a triple-modular-redundancy computer for 64-bit microprocessor and for DSP COTS ASIC. Continued service on Ph.D. committee for NRL code 8000 employee on modeling of behavior of microprocessors in single event effect environment, (3) began book *Emitter Geolocation* with Dr. Michael Price.

KEYWORDS: Military Space, Computer Architectures, Situational Awareness, Space Vehicles

TRIPLE-MODULAR-REDUNDANT ARCHITECTURES FOR RELIABLE SPACE-BASED COMPUTING

Herschel H. Loomis, Jr., Professor
Department of Electrical and Computer Engineering
Sponsor: National Reconnaissance Office

OBJECTIVE: This project will produce a prototype design of a reconfigurable triple-modular-redundant computer system imbedded in a XYLINX Virtex field programmable gate array.

KEYWORDS: Single Event Upsets, Computer Architectures, Reliable Computing

TIMING-BASED COMMUNICATION CHANNELS

John McEachen, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: National Security Agency

OBJECTIVE: Develop tools for empirical observation of delay artifacts in network-based timing channels, support thesis requirements of two NPS students, model and simulate effects of noise on timing-based communications channels.

KEYWORDS: Timing Channels, Communications, Computer Networks

WIRELESS NETWORKING PROTOCOL VULNERABILITY ASSESSMENT

John McEachen, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Engineering Logistics Office

OBJECTIVE: Design a system for analysis and processing of contemporary, standardized wireless computer communications systems. Evaluate security aspects associated with Palm OS use of Mobitex, 802.11a, and 802.11b. Evaluate the interface of wireless with traditional guided medium networks. Upgrade existing advanced networking laboratory facilities.

KEYWORDS: Wireless Networking, Wireless LAN, WLAN, Mobitex IT-21, Information Operations, Wireless ATM

RADIATION TOLERANT ASIC AND PHOTOVOLTAIC DEVICES FOR SPACE-BASED SYSTEMS

**Sherif Michael, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: National Reconnaissance Office**

OBJECTIVE: In this research, a high performance digitally programmable VLSI network for space-based system is proposed. The design is based on a technique that was developed earlier by the proposer, and has shown excellent sensitivity performance. The mixed model signal circuit, using BiCMOS techniques is currently under development. Previously fabricated VLSI ASIC chips will also be irradiated using the NPS LINAC for testing its performance under radiation environment. Past experimental results using this technique have shown great improvements in the circuits radiation performance. Research in developing advanced models of multi-junction solar cells, along with study of their radiation environment performances is also proposed.

KEYWORDS: Space Radiation Effects, Satellites, Simulation, Radiation Hardened

RADIATION TOLERANT ASIC AND VLSI DEVICES FOR SPACE-BASED SYSTEMS

**Sherif Michael, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: National Reconnaissance Office**

OBJECTIVE: In this research, a general purpose digitally programmable VLSI network for space-based system is proposed. The design is based on a technique that was developed earlier by the proposer, and has shown excellent radiation sensitivity performance. The mixed mode signal circuit, using BiCMOS techniques is currently under development. Previously fabricated VLSI ASIC chips will also be irradiated using the NPS LINAC for testing its performance under radiation environment. Past experimental results using this technique have shown great improvements in the circuits radiation performance. Research in incorporating these designs using SOI fabrication techniques will also be considered.

KEYWORDS: Space Radiation Effects, Satellites, Simulation, Radiation Tolerant ASIC Device

GUSTY YEARLING, TASK A

**Michael A. Morgan, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Engineering Logistics Office**

OBJECTIVE: Research in radiation and propagation will be performed to support project Gusty Yearling.

KEYWORDS: Antennas, Propagation, Impulse Radiation

MAGNETIC FIELD SENSOR PLACEMENT AND TIME-REVERSED EM IMAGING STUDIES

**Michael A. Morgan, Professor
Department of Electrical and Computer Engineering
Sponsor: Office of Naval Research**

OBJECTIVE: 1) Optimization of sensor placements will be investigated to increase measurement accuracy of magnetostatic near-fields surround ferromagnetic objects. 2) Time-reversed wave equation solutions in acoustics will be extended to electromagnetics and considered for application to radar imaging.

KEYWORDS: Magnetostatic Measurements, Time-reversed Acoustics, Radar Imaging

OPTIMIZATION OF MAGNETIC FIELD SENSOR PLACEMENTS USING A GENETIC ALGORITHM

Michael A. Morgan, Professor
Department of Electrical and Computer Engineering
Sponsor: Office of Naval Research

OBJECTIVE: Implement search strategies for optimizing sensor placements near to a ferromagnetic object using a genetic algorithm to minimize errors in predicting off-board magnetic field signatures.

KEYWORDS: Magnetostatic Signatures, Sensor Placement, Optimization, Genetic Algorithm

SYSTEM VULNERABILITY AND SHIELDING EFFECTIVENESS STUDY: TASK F1947

Michael A. Morgan, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Surface Warfare Center, Dahlgren Division

OBJECTIVE: Assorted tasks will be performed to support efforts in assessing shielding effectiveness of structures against impulsive and CW sources.

KEYWORDS: Systems Vulnerability, Shielding Effectiveness

SYSTEM VULNERABILITY STUDY: TASK F1947

Michael A. Morgan, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Surface Warfare Center, Dahlgren Division

OBJECTIVE: Initial site visit will be undertaken to examine system and gather information.

KEYWORDS: System Vulnerability

AEA SOFTWARE SUPPORT ACTIVITY AND SEAD ANALYSIS

Phillip E. Pace, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Air Systems Command

OBJECTIVE: Performing the necessary tasks to enable the NPS Center for Joint Services Electronic Warfare to act as the PMA-234, Airborne Electronic Attack (AEA) Software Support Activity (SSA) is proposed.

KEYWORDS: Network-centric Warfare, EA-6B, UAVs, Stand-in Sensors, ARA, AOA

ELECTRICAL AND COMPUTER ENGINEERING

DIGITAL TARGET IMAGING ARCHITECTURE FOR MULTIPLE LARGE TARGET GENERATION

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

OBJECTIVE: The technical objective of this research is twofold. The first objective is to qualify the system-level implementation tradeoffs of a digital, programmable imaging architecture to generate realistic false target signatures against high resolution imaging radars, including synthetic aperture radar (SAR) and Inverse SAR (ISAR), using ALLL-Digital techniques and modern digital radio frequency memory (DRFM) technology. The second objective is to design, fabricate and test an all digital target imaging device capable of generating large false targets using wideband CHIRP signals of any duration to provide a new, superior radio frequency (RF) decoy capability.

KEYWORDS: Digital Target Imaging, Image Synthesizer, AN/SLY-2, AIEWS, Inverse Synthetic Aperature

NAVY SURFACE ANTI-SHIP CRUISE MISSILE THREAT SIMULATOR VALIDATION WORKING GROUP

Phillip E. Pace, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Research Laboratory

OBJECTIVE: The objective of this proposal is to provide technical leadership to the Navy Surface Anti-ship Cruise Missile Threat Simulator Validation Working Group. 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.

KEYWORDS: Anti-ship Cruise Missiles, Simulator Technology, Hardware-in-the-Loop Simulation

OPEN LOOP ANALYSIS AND CRUISE SIMULATION STUDIES OF DTIB RESULTS

Phillip E. Pace, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Research Laboratory

OBJECTIVE: The objective of this proposal is to provide a threat time line analysis of the Nulka DTIB open loop field test results and study the correlation of the discrete seeker events with cruise model simulations.

KEYWORDS: Anti-ship, Cruise Missile, Simulator Technology, Cruise Model, Open-loop

INTEGRATED SENSING AND PROCESSING

Charles W. Therrien, Professor
Department of Electrical and Computer Engineering
Sponsors: Air Force Office of Scientific Research and Defense Advanced Research Projects Agency

OBJECTIVE: DARPA DSO/ACMP has plans to initiate a new program in integrated sensing and processing (ISP). A central idea of this program is to provide a two-way flow of information both from the sensor to the user (perhaps an analyst or a battle commander) as well as from the user to the sensor.

KEYWORDS: Sensors, Fusion, Signal Processing

ELECTRICAL AND COMPUTER ENGINEERING

JSIPS-N COMMUNICATIONS, MODEL AND SIMULATION RESEARCH PROJECT

Murali Tummala, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Aviation Depot

OBJECTIVE: To develop a simulation model for JSIPS-N packet switched communications network, including local area and wide area segments and other network components. Issues to be addressed in this effort are performance indicators, assessment of alternate network topologies and system constraints in terms of capacity limitations and maximum number of sites supportable.

KEYWORDS: Wide Area Networks, Local Area Networks, Modeling, Simulation

MODELING AND SIMULATION OF JSIPS-N COMMUNICATIONS ARCHITECTURE (JCA)

Murali Tummala, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Aviation Depot

OBJECTIVE: To continue the modeling and simulation effort of JSIPS-N Concentrator Architecture (JCA) for transmission of imagery over packet switched communications networks-local area and wide area segments-that was initiated during FY2001. Issues to be addressed in this effort are network performance indicators, assessments of alternate network topologies, and system constraints in terms of capacity limitations and the number of nodes supportable.

KEYWORDS: Wide Area Networks, Local Area Networks, Modeling and Simulation

SILVACO TOOLS DEVELOPMENT

Todd Weatherford, Assistant Professor
Andrew Parker, Research Associate
Department of Electrical and Computer Engineering
Sponsor: Naval Surface Warfare Center, Crane Division

OBJECTIVE: To utilize TCAD tools to study radiation effects in various integrated circuits.

KEYWORDS: Total Dose, Charge Collection, Oxide Charge Trapping, Radiation Hardened, Integrated Circuits

ADVANCED RF RECEIVER SYSTEM ARCHITECTURES

Lonnie Wilson, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Engineering Ordnance Technical Division

OBJECTIVE: The basic objective is to develop advanced RF receiver system architectures for new threat applications.

KEYWORDS: Electromagnetic, RF, IW

ELECTRICAL AND COMPUTER ENGINEERING

ELECTROMAGNETIC SUSCEPTIBILITY AND ANALYSIS OF CRITICAL INFRASTRUCTURE SYSTEMS

Lonnie Wilson, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Engineering Logistics Office

OBJECTIVE: The basic objective is to research the electromagnetic susceptibility of critical infrastructure systems.

KEYWORDS: Electromagnetic, Radar, Electronic Warfare, IW

GREEN ACRES PROJECT

Lonnie Wilson, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Space and Naval Warfare Systems Center-San Diego

OBJECTIVE: The basic objective is to initiate the Green Acres Project development for unique EW and IO applications against high performance weapons systems containing modern radar emitters, computer based C3, and high performance missile threats.

KEYWORDS: Radar, Electronic Warfare, IW, Information Warfare

HIGH PERFORMANCE DEINTERLEAVER USING MOP PARAMETERS

Lonnie Wilson, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Information Support Center

OBJECTIVE: The basic objective is to develop, evaluate and demonstrate a high performance deinterleaver using MOP parameters and preliminary screening using selected classical parameters. This development builds on FY2001 deinterleaver development efforts and previous high performance SEI processor developments and demonstrations.

KEYWORDS: Radar, DSP, Elint, Deinterleaver

PRELIMINARY INVESTIGATION AT DESERT FACILITY

Lonnie Wilson, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Surface Warfare Center, Dahlgren Division

OBJECTIVE: The basic objective is to perform a preliminary field investigation at a desert facility.

KEYWORDS: Electromagnetic, IW

REDUCED CREW SIZE METROLOGY USING WIRELESS LANS AND WEARABLE PCS

Xiaoping Yun, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Surface Warfare Center, Corona Division

OBJECTIVE: The objective of this project is to specifically 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 NPS and MSD to further collaborate and initiate studies and activities to further the objectives of both activities.

KEYWORDS: Metrology, Wireless LANS, Wearable Computers

SUBMARINE WIRELESS LOCAL AREA NETWORKING

Xiaoping Yun, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Sea Systems Command

OBJECTIVE: To conduct assessment of new wireless LAN technologies and standards and to test and evaluate the IEEE 802.11a compliant wireless LAN components as they become available on the market and to continue the investigation of wireless LAN EMC issues and to study wireless LAN security issues.

KEYWORDS: Wireless LANs, Damage Control, Local Area Network

COMPUTER AIDED DETECTION FOR SYNTHETIC APERATURE SONAR SYSTEM

Lawrence J. Ziomek, Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Sea Systems Command

OBJECTIVE: Derive accurate equations that will allow one to compute the probability of detecting a mine-like object (MLO) for a given probability of false alarm (False-alarm Rate) for a given ocean environment. Work will begin on deriving an expression for the Signal-to-Interference Power Ratio (SIR) at the output of a correlator receiver that will take into account the propagation in the ocean medium of an acoustic signal from the transmit array to the target, and from the target back to the receiver array. The probability of detection can be related to both the probability of false alarm and the SIR. Efforts will be made to express the SIR in terms of the complex scattering amplitude functions of different types of mines and ocean bottoms, and in terms of “target” and “reverberation” ambiguity functions.

KEYWORDS: Detecting Mine-like Objects, Signal-to-Interference Power, Target/Reverberation

**DEPARTMENT OF
MATHEMATICS**

**MICHAEL S. MORGAN
CHAIR**

MATHEMATICS

OVERVIEW:

The NPS Mathematics Department is committed to excellence. Our purpose is to provide an exceptional mathematical education focused on the unique needs of our students, to produce relevant research for our sponsors, and to provide quality service to the community. We further are committed to maintenance of a well-designed curriculum and a supportive environment for our students.

CURRICULA SUPPORTED:

- The majority of the departmental effort is devoted to the service courses offered which support a variety of curricula.

DEGREES GRANTED:

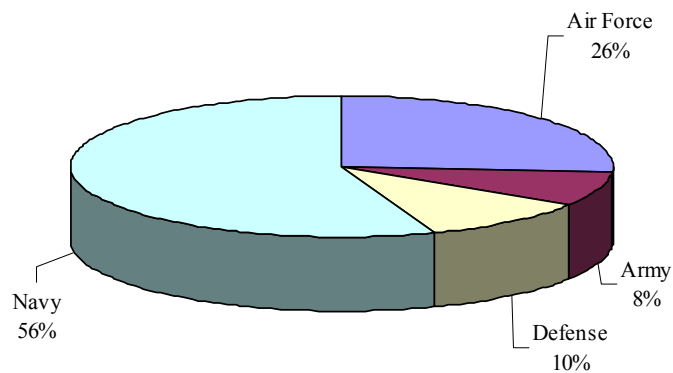
- Master of Science in Applied Mathematics
- Doctor of Philosophy

RESEARCH THRUSTS:

- Scientific Computation
- Control Theory
- Approximation
- Numerical Modeling

SPONSORED RESEARCH PROGRAMS (Research and Academic)-FY2002:

The Naval Postgraduate School's sponsored program exceeded \$61 million in FY2002. Sponsored programs include both research and educational activities funded from an external source. A profile of the sponsored program for the Department of Mathematics is provided below.



Size of Program: \$401K

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APPLIED MATHEMATICS

TOTAL LEAST SQUARES FITTING OF ORDERED DATA WITH POLYNOMIAL SPLINES

Carlos F. Borges, Associate Professor

Department of Mathematics

Sponsor: Unfunded

OBJECTIVE: To develop fast and numerically stable algorithms for fitting polynomial splines to ordered data with minimal error in the total least-squares sense.

SUMMARY: This unfunded effort is a continuing research project. The idea is to fit parametric polynomial spline curves to ordered data to get the best possible fit. Unlike traditional least-squares methods, it is assumed that errors may occur in both the x and y directions. Moreover, the data is allowed to be completely general - in particular, it does not have to be functional in nature, it may overlap itself or change directions without restriction. All that is required is an ordered set of points in the plane. A variety of different approaches have been investigated and some very fast and robust algorithms for solving the problem for a single Bezier curve have been developed. These algorithms have been extended to work with B-spline curves with general knot sequences.

PUBLICATION:

Borges, C.F. and Pastva, T.A., "Total Least Squares Fitting of Bezier and B-Spline Curves to Ordered Data," *Computer Aided Geometric Design*, Vol. 19, No. 4, pp. 275-289, 2002.

KEYWORDS: Curve Fitting, Data Compression, Approximation Theory

MODELING THE SPREAD OF BIOLOGICAL INFECTIONS IN A FUNCTIONING MILITARY UNIT

Carlos F. Borges, Associate Professor

Department of Mathematics

Sponsor: Unfunded

OBJECTIVE: To develop models that can be used to study the spread of biological infections in functioning military units. To use these models to better understand the implications of a bio-warfare attack on a forward operating military unit, and to develop strategies for minimizing the effects of such attacks.

SUMMARY: This unfunded effort is a continuing research project. U.S. Marine Corps CAPT Ryan Paterson's master's thesis work centered on various methods investigated by Professor Borges for modeling the spread of biological infections in functioning military units. He implemented a computer model that allows one to investigate the impact of a biological warfare attack on a single Marine battalion operating in a combat area. This model is quite general and it was used to further investigate vaccination and quarantine strategies and other aspects critical to operating in a bio-warfare environment where the specific agents can generate contagious illnesses (secondary infections). This is the first model of its kind.

THESIS ADVISED:

Paterson, R., "Modeling Man-made Epidemics," Master's Thesis, Naval Postgraduate School, March 2002.

KEYWORDS: Biological Warfare, Biological Terrorism

THERMOCAPILLARY EFFECTS IN WELDING

D. Canright, Associate Professor

Department of Mathematics

Sponsor: Unfunded

OBJECTIVE: To analyze the thermocapillary feedback mechanism in the “cold corner” region of weld pools, and to develop an accurate model of this process for numerical simulation of welding.

SUMMARY: This unfunded project extends previously funded work. At the edge of a weld pool, where hot liquid meets relatively cool solid, thermocapillary effects may locally dominate the flow of fluid and of heat, which can affect the quality of the resulting weld. In this case, the length scales of this concentrated flow are extremely small relative to the pool size, imposing severe resolution constraints for numerical simulations. The current work uses our earlier scaling analysis to develop a boundary-layer model that exploits the even smaller length scales of viscous boundary layers in the corner. The resulting corner model compares well with careful numerical simulations, and can be integrated into a global simulation to relieve the severe resolution constraints. This year resulted in one journal article and two conference presentations.

PUBLICATIONS:

Canright, D. and Huber, M., “A Boundary-layer Model of Thermocapillary Flow in a Cold Corner,” *Physics of Fluids*, 14(9):3272-3279, 2002.

Canright, D. and Huber, M., “Thermocapillary Feedback Near a Cold Wall: A Boundary-layer Model, 55th Annual Meeting of the Division of Fluid Dynamics of the American Physical Society, Dallas, TX, 24-26 November 2002,” *Bulletin of the American Physical Society*, 47(10):197, 2002.

PRESENTATIONS:

Canright, D. and Huber, M., “Boundary-layer Model for Thermocapillary Feedback Near a Cold Wall,” SIAM 50th Anniversary and 2002 Annual Meeting, Philadelphia, PA, 8-12 July 2002.

Canright, D. and Huber, M., “Thermocapillary Feedback Near a Cold Wall: A Boundary-layer Model,” 55th Annual Meeting of the Division of Fluid Dynamics of the American Physical Society, Dallas, TX, 24-26 November 2002.

KEYWORDS: Thermocapillary Flow, Materials Processing, Boundary-layer Theory

BUCKLING OF SHIP GRILLAGES WITH BULB FLAT STIFFENERS

Donald A. Danielson, Professor

Department of Mathematics

Sponsor: Naval Surface Warfare Center

OBJECTIVE: In earlier work, analytical formulas and finite element models have been developed for predicting the buckling loads of commonly used plate structures having thin-walled stiffeners. Now there is great interest in bulb flat stiffeners, whose unique shape distributes steel to maximize the resistance to buckling.

SUMMARY: In 2002, Professor Danielson extended earlier analytical formulas to apply to stiffeners of arbitrary cross section. As part of his PhD thesis work, LTC Archie Wilmer developed analytical models for needed cross section properties, and compared the predictions with a finite element code.

KEYWORDS: Structure, Ship, Grillage, Stiffener, Buckling

APPLIED MATHEMATICS

GUIDANCE AND CONTROL ALGORITHMS FOR HYPERSONIC AND REUSABLE LAUNCH VEHICLES

Fariba Fahroo, Associate Professor

Department of Mathematics

Sponsor: Air Force Research Laboratory

OBJECTIVE: To develop a fast and accurate methods for determining the largest reachable set (footprint) for a reusable launch vehicle.

SUMMARY: The ultimate goals of this research are to develop advanced guidance and control algorithms for hypersonic and reusable launch vehicles. One application is in the area of determining reachable regions by a reentry or un-powered hypersonic vehicle experiencing control effector failures. This problem was formulated as a parameter dependent optimal control problem and was solved using a numerical package developed at NPS by (Mike Ross and the PI). Future goals of the project will involve designing an adaptive reconfigurable control system for the X-40A vehicle to support a flight-test demonstration of an integrated adaptive guidance and control system.

PUBLICATIONS:

Two conference papers were submitted (one to the 2003 IEEE aerospace conference (March 2003) and the other to the 2003 American Conference in Control (June 2003)). They are both accepted to appear in 2003.

TRAJECTORY GUIDANCE USING A SPECTRAL METHOD

Fariba Fahroo, Associate Professor

Department of Mathematics

Sponsor: Draper Labs

OBJECTIVE: To develop a real-time non-linear guidance algorithm based on the pseudo-spectral methods for reusable launch vehicles.

SUMMARY: This research project is the continuation of a multi-year contract with Draper labs on developing and analysis of algorithms for solving complex trajectory optimization problems. The ultimate goal is to develop solutions methods for the inner (fast) and outer (slow) guidance loops for launch vehicles. In conjunction with developing efficient and accurate solution technique based on pseudo-spectral numerical methods for the outer loop, a guidance algorithm based on the pseudo-spectral methods was developed. This algorithm solved the main boundary-value problem in an efficient manner and was tested on a Low Thrust Orbit Transfer Problem. Currently the goal is to extend the result to guidance for a re-entry launch vehicle.

PUBLICATION:

Fahroo, F. and Ross, I.M., "Direct Trajectory Optimization by a Chebyshev Pseudo-spectral Method," *Journal of Guidance, Control and Dynamics*, Vol. 25, No. 1, pp. 160-166, 2002.

CONFERENCE PAPERS:

Ross, I.M. and Fahroo, F., "A Direct Method for Solving Nonsmooth Optimal Control Problems," *Proceedings of the 2002 IFAC World Conference*, Barcelona, Spain, July 2002.

Ross, I.M. and Fahroo, F., "A Perspective on Methods for Trajectory Optimization," *Proceedings of the AIAA/AAS Astrodynamics Conference*, Monterey, CA, 5-8 August 2002.

Ross, I.M. and Fahroo, F., "Pseudo-spectral Methods for Optimal Motion Planning of Differentially Flat Systems," *Proceedings of the 41st Conference on Decision and Control*, Las Vegas, NV, December 2002.

APPLIED MATHEMATICS

Ross, I.M., King, J.T. and Fahroo, F., "Designing Optimal Spacecraft Formations," *Proceedings of the AIAA/AAS Astrodynamics Conference*, Monterey, CA, 5-8 August 2002.

Ross, I.M., Rea, J. and Fahroo, F., "Exploiting Higher-order Derivatives in Computational Optimal Control," *Proceedings of the 2002 IEEE Mediterranean Conference*, Lisbon, Portugal, July 2002.

Strizzi, J., Ross, I.M. and Fahroo, F., "Towards Real-time Computation of Optimal Controls for Nonlinear Systems," *Proceedings of the AIAA Guidance, Navigation and Control Conference*, Monterey, CA, 5-8 August 2002.

Yan, H., Fahroo, F. and Ross, I.M., "Real-time Computation of Neighboring Optimal Guidance," *Proceedings of the AIAA Guidance, Navigation and Control Conference*, Monterey, CA, 5-8 August 2002.

KEYWORDS: Trajectory Optimization, Guidance, Pseudo-spectral Methods

VISITING PROFESSOR AT U. S. MILITARY ACADEMY

H.M. Fredricksen, Professor
Department of Mathematics
Sponsor: U. S. Military Academy

OBJECTIVE: To continue the relationship which exists between the Mathematics Departments at USMA and NPS and to find areas for future development.

SUMMARY: The Mathematics Department at USMA sponsors a Visiting Professor activity to provide an enrichment environment for their (primarily) military faculty. This is accomplished by bringing in senior faculty to interact, conduct research and teach cadets. Experiences shared will provide benefit to the individual and his home University, as well as that enjoyed by the faculty at USMA. Ultimately, the relationships between the two institutions will be enhanced and continued student enrollments at NPS will be the natural result.

KEYWORDS: Education

ASPECTS OF THE STATISTICAL THEORY OF SHAPE

C.L. Frenzen, Associate Professor
Department of Mathematics
Sponsor: Unfunded

OBJECTIVE: Representing the shape of a data set as a point on a manifold allows shape to be studied in a manner susceptible to mathematical and statistical analysis. This is key to comparing data sets. A central problem of shape theory is that it is not possible to represent the full range of shapes of an object in a Euclidean space without losing the ability to distinguish quantitatively between different shapes. This forces one to consider real and complex projective manifolds as shape spaces. The objective here is to understand and describe the topological and geometric properties of these new shape spaces, so that classical statistical methods can be adapted to work on them.

SUMMARY: When information in a data set about its location, scale, and orientation is removed, what remains is called the shape of the data. In the last two decades, it has been known that shapes could be represented as points in a so-called shape manifold. To compare shapes we must define a metric, and this metric defines a geometric structure on the manifold. These geometric structures are difficult to interpret and visualize, and finding concrete and simple representations for them is an important goal. Some preliminary results have been obtained along these lines.

KEYWORDS: Shape, Statistical Analysis

**CONVERGENCE OF THE SHIFTED QR ALGORITHM FOR UNITARY HESSENBERG
MATRICES**

**William B. Gragg, Professor
Department of Mathematics
Sponsor: Unfunded**

OBJECTIVE: To establish the global, and the cubic speed of, convergence of the unitary Hessenberg QR algorithm with Wilkinson's shift. The process is a fast, $O(n^2)$, process for solving such problems, which are of fundamental importance for signal processing.

SUMMARY: This paper shows that for unitary Hessenberg matrices the QR algorithm with the Wilkinson shift gives global convergence. Moreover the asymptotic rate of convergence is at least cubic, higher than that which is only quadratic for Hermitian tridiagonal matrices. A general mixed shift strategy with global convergence and cubic rate is also presented.

PUBLICATION:

Wang, T.-L. and Gragg, W.B., "Convergence of the Shifted QR Algorithm for Unitary Hessenberg Matrices," *Mathematics of Computation*, Vol. 71, No. 240, pp. 1473-1496, 2002.

**CONVERGENCE OF THE UNITARY QR ALGORITHM WITH A UNIMODULAR WILKINSON
SHIFT**

**William B. Gragg, Professor
Department of Mathematics
Sponsor: Unfunded**

OBJECTIVE: To find a better shift strategy for the uhqr algorithm, one that makes the algorithm practically faster and more numerically stable.

SUMMARY: In applying the QR algorithm to compute the eigenvalues of a unitary Hessenberg matrix, a projected Wilkinson shift of unit modulus is proposed and proved to give global convergence with (at least) a quadratic asymptotic rate for the QR iteration. Experimental testing demonstrates that the unimodular shift produces more efficient numerical convergence.

PUBLICATION:

Gragg, W.B., "Convergence of the Unitary QR Algorithm with a Unimodular Wilkinson Shift," *Mathematics of Computation*, Vol. 72, No. 241, 2003, 25 June 2002, (published electronically).

INFORMATION SYSTEM CERTIFIER EDUCATION

**Cynthia E. Irvine, Associate Professor
Department of Computer Science
Craig Rasmussen, Associate Professor
Department of Mathematics
Sponsor: Space and Naval Warfare Systems Command**

OBJECTIVE: Develop a curriculum for the purpose of educating U.S. Navy information system certifiers, and prepare introductory materials to facilitate familiarization of certifiers-to-be with the requisite knowledge and skills.

SUMMARY: This is an ongoing project. The Navy has a critical shortage of information system certifiers in uniform, and the NPS Cebrowski Institute is uniquely well qualified to address this problem. Under contract to PMW161, we are developing an educational program for new certifiers. An outline for the course and a bibliography of applicable Government documents were developed, and development of the

APPLIED MATHEMATICS

course material was initiated. Students in the program will be of two types: short course students and resident graduate students. Short course students will be individuals who may already be working in the area of certification and accreditation or those who are moving into this field. The short Certifier Education program students will spend approximately eight weeks in formal courses over a period of from eighteen months to two years. The courses will be of short duration and high intensity; with eight hours devoted to class and laboratory exercises each day. The intervening periods between visits to school will be spent in the field, where students acquire essential experience. Resident students will include certifier courses as electives as part of their graduate program, which depending upon student background, validation of prerequisites, and other factors can last between 12 and 24 months. A prerequisite for all students is an undergraduate degree in computer science or closely related engineering field. With two exceptions, the curriculum comprises courses already in the catalogue. The exceptions are the newly designed CS4680 (Introduction to Certification and Accreditation) and CS4685 (Case Studies in Certification).

A CD-ROM was also prepared containing an overview of the Certification and Accreditation process specifically targeted at students entering the program. Because of unusual attributes of Naval systems and procedures, PMW161 requested an introduction that was Navy-specific. Accordingly, dozens of DoD and DoN documents on certification and accreditation were digested, and researchers met with personnel from PMW161, the result being a product that would introduce the prospective Navy certifier to the responsibilities, skill sets, and requisite knowledge associated with the job.

PRESENTATIONS:

Dinolt, G., "The Navy Certifier Program," Cebrowski Institute Symposium, Naval Postgraduate School, 30 July 2002.

Rasmussen, C., "A Program for Education in Certification and Accreditation," WISE 3/WECS 5, Monterey, CA, 26-28 June 2003.

OTHER:

"The System Certification and Accreditation Process," CD-ROM introduction to certification and accreditation for prospective Navy certifiers.

KEYWORDS: Information Assurance, Computer Security, Certification and Accreditation

ANALYSIS OF DATA FROM THE MULTI-CENTER VALIDATION PROJECT

Toke Jayachandran, Professor

Department of Mathematics

Sponsor: Defense Intelligence Agency Central MASINT Organization

OBJECTIVE: To perform statistical analyses of data collected by the Armed Forces Institute of Pathology (AFIP) on behalf of the Central MASINT organization. The goal was to assess the effectiveness of the RAPID thermal cyclers in detecting the presence of biological/chemical agents such as anthrax and other agents, and to set standards and guidelines for laboratory analyses of samples containing suspect material.

SUMMARY: AFIP provided the raw data collected from the primary experiment using synthesized samples contaminated with differing levels of anthrax and analyzed at seven different laboratories. After several extensive discussions with the scientists at AFIP, the data was reformatted so as to be amenable to statistical analyses. Several statistical procedures were applied to determine the threshold level of the contaminant that has high probability of detection and also to identify the performance differences in the laboratories participating in the experiment. AFIP suggested that it would be useful to generate ROC curves for the data (Receiver Operating Characteristic Curves); ROC curves are often used by drug companies in support of new drugs for which FDA approval is being sought. Relevant information on the procedure for generating ROC curves was collected through an Internet search and applied to the AFIP data. Because of

the fact that the data did not report any false positive results (necessary for generating a meaningful ROC curve) the resulting graphs turned out to be straight lines, primarily.

An informal report on the results of the analysis was submitted to both AFIP and the sponsor. AFIP is continuing the experiment with several other chemical/biological threat agents and agreed to provide the new data in a format ready for statistical analysis; the project has been on hold pending the arrival of the data.

OTHER:

Jayachandran, Toke, "Statistical Analysis of AFIP Data," an informal report sent to AFIP and the sponsor.

INTEGRATED COOPERATIVE CONTROL OF SATELLITE FORMATIONS

Wei Kang, Associate Professor

Department of Mathematics

Sponsor: Air Force Research Laboratory

OBJECTIVE: The objectives of the project are (a) Coordinated formation control in the presence of J2 and other disturbances. (b) Attitude control when a satellite flies on an orbit under J2 and other disturbances. (c) Coordination strategy in an integrated controller with both relative attitude control and relative position control. (d) Simulations to test the proposed feedback design.

SUMMARY: Attitude tracking with almost disturbance decoupling is developed for rigid bodies. For multi-satellite systems, the multiple tracking controllers are integrated together in a perceptive frame to track a moving target. The coordinated controller does not assume the desired attitude as a priori information. Instead, the on-line sensor information of the satellite and the target position are used to control the attitude. As a result, the controller is robust under orbital uncertainties such as J2 perturbation in a multi-satellite system.

PUBLICATIONS:

Hamzi, B. and Kang, W., "Resonant Terms and Bifurcations of Nonlinear Control Systems with One Uncontrollable Mode," *Systems and Control Letters*, (to appear).

Hamzi, B., Kang, W. and Barbot, J.-P., "Analysis and Control of Hopf Bifurcations," *SIAM Journal on Control and Optimization*, (to appear).

Kang, W. and Papoulias, F.A., "Bifurcation and Control of Submersible Vehicles with Dive Plane Reversal," *Latin American Applied Research-An International Journal*, (to appear).

Kang, W. and Yeh, H.-H., "Coordinated Attitude Control of Multi-Satellite Systems," *International Journal of Robust and Nonlinear Control*, Vol. 12, pp. 185-205, 2002.

Krener, A.J. and Kang, W., "Locally Convergent Nonlinear Observers," *SIAM Journal on Control and Optimization*, (to appear).

Krener, A.J., Kang, W. and Chang, D., "Control Bifurcations," *IEEE Transactions on Automatic Control*, (to appear).

CONFERENCE PAPERS:

Kang, W. and Sparks, A., "Coordinated Attitude and Formation Control of Multi-satellite Systems," *Proceedings of the AIAA Guidance, Navigation, and Control Conference*, Monterey, CA, August 2002.

Kang, W., Xi, N., Zhao, Y., Tan, J. and Wang, Y., "Formation Control of Multiple Autonomous Vehicles: Theory and Experimentation," *Proceedings of the IFAC World Congress*, Barcelona, Spain, July 2002.

APPLIED MATHEMATICS

Kang, W. and Xiao, M., "Controllable or Uncontrollable? - A Bifurcation Point of View," *Proceedings of the IEEE Conference on Decision and Control*, Las Vegas, NV, December 2002.

KEYWORDS: Formation Control, Satellites, Bifurcation Control

NEW TRENDS IN NONLINEAR DYNAMICS AND CONTROL AND THEIR APPLICATIONS

Wei Kang, Associate Professor
Carlos F. Borges, Associate Professor
Department of Mathematics

Sponsor: Air Force Office of Scientific Research

OBJECTIVE: To organize a two-day symposium "New Trends in Nonlinear Dynamics and Control, and Their Applications" at NPS.

SUMMARY: The Symposium on New Trends in Nonlinear Dynamics and Control, and their Applications was held October 18-19, 2002, at the Naval Postgraduate School (NPS) in Monterey, California. The symposium was organized in conjunction with the 60th birthday of Professor Arthur J. Krener, a pioneer in nonlinear control theory and its applications for the last three decades. Leading researchers in nonlinear control attended the conference.

PUBLICATIONS:

Articles about the conference have been published in the Newsletters of UC Davis, NPS, SIU, and will appear in IEEE Control Magazine. Springer will publish a book based on the conference proceedings.

KEYWORDS: Nonlinear Dynamics, Control Theory

GALERKIN SPECTRAL SYNTHESIS METHODS

B. Neta, Professor
Department of Mathematics
Sponsor: Unfunded

OBJECTIVE: To develop existence and uniqueness theory for the energy dependent, steady state neutron diffusion equation with inhomogeneous oblique boundary conditions imposed. Also develop a convergence theory for the Galerkin Spectral Synthesis Approximations.

SUMMARY: An existence and uniqueness theory is developed for the energy dependent, steady state neutron diffusion equation with inhomogeneous oblique boundary conditions imposed. Also, a convergence theory is developed for the Galerkin Spectral Synthesis Approximations, which arise when trial functions depending only on energy are utilized. The diffusion coefficient, the total and scattering cross-sectional data are all assumed to be both spatially and energy dependent. Interior interfaces defined by spatial discontinuities in the cross-section data are assumed present. Our estimates are in a Sobolev-type norm, and our results show that the spectral synthesis approximations are optimal in the sense of being of the same order as the error generated by the best approximation to the actual solution from the subspace to which the spectral synthesis approximations belong.

PUBLICATION:

Neta, B., Reich, S. and Victory, H.D., "Galerkin Spectral Synthesis Methods for Diffusion Equations with General Boundary Conditions," *Annals of Nuclear Energy*, Vol. 29, pp. 913-927, 2002.

KEYWORDS: Galerkin, Spectral Synthesis, Diffusion

**A STUDY OF LATERAL BOUNDARY CONDITIONS FOR THE NRL'S COUPLED
OCEAN/ATMOSPHERE MESOSCALE PREDICTION SYSTEM (COAMPS)**

B. Neta, Professor

Department of Mathematics

Sponsor: Office of Naval Research

OBJECTIVE: The treatment of lateral boundaries in regional models has been a perennial problem since the early days of numerical weather prediction. In a limited-area model the lateral edges are not physical boundaries of the flow but constitute artificial constraints imposed by computational considerations. Hence they do not have a physical counterpart. Conditions must be imposed at these artificial boundaries in order to solve the problem in an efficient and accurate manner.

It is proposed here to continue work on high order non-reflecting boundary conditions for the dispersive Klein-Gordon equation and intend to extend new schemes to the nonlinear shallow water equations.

PUBLICATIONS:

Givoli, D. and Neta, B., "High-Order Non-Reflecting Boundary Conditions for Dispersive Waves," *Wave Motion*, (accepted).

Givoli, D. and Neta, B., "High-Order Non-Reflecting Boundary Conditions for Dispersive Wave Problems," *Journal of Computational and Applied Mathematics*, (accepted).

Givoli, D. and Neta, B., "High-Order Non-Reflecting Boundary Scheme for Time-Dependent Waves," *Journal of Computational Physics*, (accepted).

Givoli, D., Neta, B. and Patlashenko, I., "Finite Element Analysis of Time-dependent Semi-infinite Waveguides with High-order Boundary Treatment," (accepted).

Neta, B., Reich, S. and Victory, H.D., "Galerkin Spectral Synthesis Methods for Diffusion Equations with General Boundary Conditions," *Annals of Nuclear Energy*, Vol. 29, pp. 913-927, 2002.

CONFERENCE PAPERS:

Givoli, D. and Neta, B., "High-Order Non-Reflecting Boundary Conditions for Dispersive Wave Problems," *Proceeding of the International Conference on Computational and Mathematical Methods in Science and Engineering*, Alicante, Spain, 20-25 September 2002.

van Joolen, V., Neta, B. and Givoli, D., "High-Order Non-Reflecting Boundary Conditions for Dispersive Wave Problems in Stratified Media," *Proceedings of 2003 Coastal Engineering*, Cadiz, Spain, 23-26 June 2003, (accepted).

TECHNICAL REPORT:

Givoli, D. and Neta, B., "High-Order Higdon Non-Reflecting Boundary Conditions for the Shallow Water Equations," Naval Postgraduate School Technical Report, NPS-MA-02-001, 2002.

CONTRIBUTION TO BOOK:

Alfriend, K.T., Neta, B., Luu, K. and Walker, C.A.H., "Spaceflight Mechanics 2002," *Advances in the Astronautical Sciences*, Vol. 112, Univelt, Inc.: San Diego, 2002, (2-volume book).

KEYWORDS: Mesoscale, Limited-area Model, Perfectly Matched Layers, COAMPS

APPLIED MATHEMATICS

MODELS OF ENDOGENOUS FORMATION OF COALITIONS

Guillermo Owen, Professor
Department of Mathematics
Sponsor: Unfunded

OBJECTIVE: To develop models of coalition formation and the corresponding power and payoffs.

SUMMARY: In this project, attractive models of coalition formation have been studied. A study of coalitions within the European Union (European Parliament, European Central Bank, Council of Ministers) is underway.

PUBLICATION:

Gambarelli, G. and Owen, G., "Power in Political and Business Structures," *Power and Fairness*, Jahrbuch für neue politische Ökonomie, Mohr Siebeck, Tübingen, pp. 57-68, M.J. Holler, H. Kliemt, D. Schmidtchen and M.E. Streit (Eds.), 2002.

KEYWORDS: Bargaining, Coalitions, Power Indices

STABILITY IN SITUATIONS OF SHIFTING BALANCE OF POWER

Guillermo Owen, Professor
Department of Mathematics
Gordon McCormick, Professor
Department of Defense Analysis
Sponsor: Special Operations Command

OBJECTIVE: To study the way in which a shifting balance of power will cause instability in international relations.

SUMMARY: Models have been developed that show how the shifting balance of power can lead both to preventive wars and to wars of adjustment. Regions of stability and instability, depending both on the current balance of power and on the speed with which this balance is shifting, have been mapped.

Under a previous portion of this contract, methods of bargaining between states and sub-state entities were developed.

PUBLICATIONS:

Owen, G. and McCormick, G., "Factionalism, Bargaining, and Violence in Civil Wars," (submitted).

Owen, G. and McCormick, G., "War and the Shifting Distribution of Power," (pending publication).

KEYWORDS: Bargaining, Conflict, Terrorism, Preventive War

ACOUSTIC RADIATION AND SCATTERING FROM SUBMERGED STRUCTURES

C. Scandrett, Professor
Department of Mathematics
Sponsor: IHPC Singapore

OBJECTIVE: To analyze and numerically model the effects of applying active and passive acoustic layers for the purpose of reducing radiated and scattered signals from fluid-loaded structures.

SUMMARY: The final report on this project was delivered to the sponsors that included summaries of the work that had been conducted over the past few years. Topics included numerical modeling (using FDM and FEM) of layered materials. Structures considered were, Alberich coatings, multi-layered elastic/visco-

APPLIED MATHEMATICS

elastic coatings, and piezo-electric layers. The final report included applications of the T-matrix method for use in decomposing more complicated structures in an effort to ascertain their acoustic properties. Subsequently, there were over this year a number of revisions made on a paper submitted to the Journal of Sound and Vibration that is expected to be accepted for publication in 2003.

PUBLICATIONS:

Scandrett, C., "Scattering and Active Acoustic Control from a Submerged Spherical Shell," *Journal of the Acoustical Society of America*, 111(2), pp. 893-907, 2002.

Scandrett, C., Shin, Y.S., Hung, K.C., Khan, M.S., Lim, C.K. and Lilian, C.C., "Cancellation Techniques in Underwater Scattering of Acoustic Signals," *Journal of Sound and Vibration*, (revisions submitted).

KEYWORDS: Acoustic Scattering, Active Acoustic Control, Underwater Acoustics

FIFTH INTERNATIONAL SYMPOSIUM

C. Scandrett, Professor

Department of Mathematics

Sponsors: Office of Naval Research and Defense Advanced Research Projects Agency

OBJECTIVE: The purpose of these funds is to help support the planning and execution of a technical symposium on mines. The purpose of the symposium is to continue the examination of the potentials of emergent technologies to enhance the capabilities of the U. S. and its allies in mining, mine countermeasures, and humanitarian demining that includes area remediation. This symposium is a joint undertaking of several U. S. government agencies.

SUMMARY: The 5th International Symposium on Technology and the Mine Problem, was held at NPS in April. Three hundred scientists, engineers, military and civilian deminers, and program sponsors from the international communities in Europe and the Pacific and from the U.S. Army, U.S. Marine Corps, and U.S. Navy met in Monterey to share recent results and advances in the technologies that support future countermeasures systems development.

PUBLICATION:

Proceedings of the Fifth International Symposium have been produced, and will be distributed in 2003.

KEYWORDS: Mines, Mining, Undersea Warfare

FINITE ELEMENT MODELING OF HIGH FREQUENCY ACOUSTICS

C. Scandrett, Professor

Department of Mathematics

Sponsor: Office of Naval Research

OBJECTIVE: Perform research and development of the FE code ProPHLEX for use in numerical modeling of acoustic propagation in ocean sediments. The work includes collaboration with researchers at SACLANTCEN, and members of an experimental research team working on SAX04 in FY04.

SUMMARY: This project was started late this past year. The 80K funded was used primarily for the purchase of a perpetual license of the ProPHLEX code (75K) and for a single trip to SACLANTCEN to collaborate with researchers on site currently using the code. An additional trip to the Acoustical Society meeting in December was a venue for participants in the upcoming SAX04 experiments and research to plan on the upcoming collaborative project.

KEYWORDS: Acoustic Scattering, Underwater Acoustics, Sediment Acoustics

APPLIED MATHEMATICS

NPS MINE AND UNDERSEA WARFARE PROGRAM

C. Scandrett, Professor

Department of Mathematics

Sponsors: Program Executive Office, Mine and Undersea Warfare

OBJECTIVE: Oversee the work done by the Mine Warfare Chair, and assist where necessary in the performance of his/her duties. The general requirements of the Mine Warfare Chair include: 1) facilitating student visits to mine warfare commands and research activities; 2) planning and executing mine warfare workshops and symposia; 3) serving as curator of the Menneken Lecture Series on Mine Warfare, and 4) being the liaison between the PEO, NPS, and Navy Labs.

SUMMARY: Some of the accomplishments that occurred this past year include:

1. Set up of the Undersea Warfare Research Center with 20 NPS faculty
2. Hosted the 5th International Symposium on Technology and the Mine Problem, held at NPS in April. Three hundred scientists, engineers, military and civilian deminers, and program sponsors from the international communities in Europe and the Pacific and from the US Army, US Marine Corps, and US Navy met in Monterey to share recent results and advances in the technologies that support future countermeasures systems development
3. Hosted a conference entitled "The enemy is still below: the global diffusion of submarines and related technology," sponsored by Lawrence Livermore National Labs in May.
4. Initiated a program through ONR's National Naval Responsibility Program (NNRP) that brings Navy Lab civilians to NPS for a one-year masters program. Two students are currently on-board from CSS and NUWC.
5. Managed to get NPS as the spring site for the NDIA conference for 2003.

PUBLICATION:

Proceedings of the Fifth International Symposium have been produced, and will be distributed in 2003.

PRESENTATIONS:

Several Presentations were made to Fleet Admirals including RADM Ellison, RADM Slaught, RADM Sullivan (N77 – sponsor of the UW curriculum), and many others.

KEYWORDS: Mines, Mining, Undersea Warfare

**DEPARTMENT OF
APPLIED MATHEMATICS**

**2002
Faculty Publications
and Presentations**

PUBLICATIONS

Beaver, P. and Canright, D., "The Quasimonotonicity of Linear Differential Systems-The Complex Spectrum," *Applicable Analysis*, 80:127-131, 2002.

Borges, C.F. and Pastva, T.A., "Total Least Squares Fitting of Bezier and B-Spline Curves to Ordered Data," *Computer Aided Geometric Design*, Vol. 19, No. 4, pp. 275-289, 2002.

Canright, D. and Huber, M., "A Boundary-layer Model of Thermocapillary Flow in a Cold Corner," *Physics of Fluids*, 14(9):3272-3279, 2002.

Canright, D. and Huber, M., "Thermocapillary Feedback Near a Cold Wall: A Boundary-layer Model, 55th Annual Meeting of the Division of Fluid Dynamics of the American Physical Society, Dallas, TX, 24-26 November 2002," *Bulletin of the American Physical Society*, 47(10):197, 2002.

Fahroo, F. and Ross, I.M., "Direct Trajectory Optimization by a Chebyshev Pseudo-spectral Method," *Journal of Guidance, Control and Dynamics*, Vol. 25, No. 1, pp. 160-166, 2002.

Gragg, W.B., "Convergence of the Unitary QR Algorithm with a Unimodular Wilkinson Shift," *Mathematics of Computation*, Vol. 72, No. 241, 2003, 25 June 2002, (published electronically).

Kang, W. and Yeh, H.-H., "Coordinated Attitude Control of Multi-Satellite Systems," *International Journal of Robust and Nonlinear Control*, Vol. 12, pp. 185-205, 2002.

Neta, B., Reich, S. and Victory, H.D., "Galerkin Spectral Synthesis Methods for Diffusion Equations with General Boundary Conditions," *Annals of Nuclear Energy*, Vol. 29, pp. 913-927, 2002.

Owen, G., "The Condorcet Jury Theorem," *Supplement III, Encyclopædia of Mathematics*, Kluwer Academic Publishers, 109-110, 2002.

Owen, G., "The Condorcet Paradox," *Supplement III, Encyclopædia of Mathematics*, Kluwer Academic Publishers, 110, 2002.

Owen, G., "Game Theory," *Academic Press Encyclopædia of Physical Sciences, VI*, 389-396 (revision of 1987 article), 2002.

Scandrett, C., "Scattering and Active Acoustic Control from a Submerged Spherical Shell," *Journal of the Acoustical Society of America*, 111(2), 893-907, 2002.

Wang, T.-L. and Gragg, W.B., "Convergence of the Shifted QR Algorithm for Unitary Hessenberg Matrices," *Mathematics of Computation*, Vol. 71, No. 240, pp. 1473-1496, 2002.

CONFERENCE PAPERS

Givoli, D. and Neta, B., "High-Order Non-Reflecting Boundary Conditions for Dispersive Wave Problems," *Proceeding of the International Conference on Computational and Mathematical Methods in Science and Engineering*, Alicante, Spain, 20-25 September 2002.

Kang, W. and Sparks, A., "Coordinated Attitude and Formation Control of Multi-satellite Systems," *Proceedings of the AIAA Guidance, Navigation and Control Conference*, Monterey, CA, August 2002.

Kang, W., Xi, N., Zhao, Y., Tan, J. and Wang, Y., "Formation Control of Multiple Autonomous Vehicles: Theory and Experimentation," *Proceedings of the IFAC World Congress*, Barcelona, Spain, July 2002.

Kang, W. and Xiao, M., "Controllable or Uncontrollable? - A Bifurcation Point of View," *Proceedings of the IEEE Conference on Decision and Control*, Las Vegas, NV, December 2002.

Ross, I.M. and Fahroo, F., "A Direct Method for Solving Nonsmooth Optimal Control Problems," *Proceedings of the 2002 IFAC World Conference*, Barcelona, Spain, July 2002.

Ross, I.M. and Fahroo, F., "A Perspective on Methods for Trajectory Optimization," *Proceedings of the AIAA/AAS Astrodynamics Conference*, Monterey, CA, 5-8 August 2002.

Ross, I.M. and Fahroo, F., "Pseudo-spectral Methods for Optimal Motion Planning of Differentially Flat Systems," *Proceedings of the 41st Conference on Decision and Control*, Las Vegas, NV, December 2002.

Ross, I.M., King, J.T. and Fahroo, F., "Designing Optimal Spacecraft Formations," *Proceedings of the AIAA/AAS Astrodynamics Conference*, Monterey, CA, 5-8 August 2002.

Ross, I.M. Rea, J. and Fahroo, F., "Exploiting Higher-order Derivatives in Computational Optimal Control," *Proceedings of the 2002 IEEE Mediterranean Conference*, Lisbon, Portugal, July 2002.

Strizzi, J., Ross, I.M. and Fahroo, F., "Towards Real-time Computation of Optimal Controls for Nonlinear Systems," *Proceedings of the AIAA Guidance, Navigation and Control Conference*, Monterey, CA, 5-8 August 2002.

van Joolen, V., Neta, B. and Givoli, D., "High-Order Non-Reflecting Boundary Conditions for Dispersive Wave Problems in Stratified Media," *Proceedings of 2003 Coastal Engineering*, Cadiz, Spain, 23-26 June 2003, accepted for publication.

Yan, H., Fahroo, F. and Ross, I.M., "Real-time Computation of Neighboring Optimal Guidance," *Proceedings of the AIAA Guidance, Navigation and Control Conference*, Monterey, CA, 5-8 August 2002.

PRESENTATIONS

Canright, D. and Huber, M., "Boundary-layer Model for Thermocapillary Feedback Near a Cold Wall," SIAM 50th Anniversary and 2002 Annual Meeting, Philadelphia, PA, 8-12 July 2002.

Canright, D. and Huber, M., "Thermocapillary Feedback Near a Cold Wall: A Boundary-layer Model," 55th Annual Meeting of the Division of Fluid Dynamics of the American Physical Society, Dallas, TX, 24-26 November 2002.

Couch, M.A., Wood, E.R. and Canright, D., "Incorporating Unsteady Aerodynamics into Nonlinear Rotor Dynamics Simulations," 43rd AIAA/ASME/ASCE/AHS Structures, Structural Dynamics and Materials Conference, Denver, CO, 22-25 April 2002.

Rasmussen, C., "A Program for Education in Certification and Accreditation," WISE 3/WECS 5, Monterey, CA, 26-28 June 2003.

BOOK

Alfriend, K.T., Neta, B., Luu, K. and Walker, C.A.H., "Spaceflight Mechanics 2002," *Advances in the Astronautical Sciences*, Vol. 112, Univelt, Inc.: San Diego, 2002, (2-volume book).

Gambarelli, G. and Owen, G., "Power in Political and Business Structures," *Power and Fairness*, Jahrbuch für neue politische Ökonomie, Mohr Siebeck, Tübingen, pp. 57-68, M.J. Holler, H. Kliemt, D. Schmidtchen and M.E. Streit (Eds.), 2002.

TECHNICAL REPORT

Givoli, D. and Neta, B., "High-Order Higdon Non-Reflecting Boundary Conditions for the Shallow Water Equations," Naval Postgraduate School Technical Report, NPS-MA-02-001, 2002.

**DEPARTMENT OF
MECHANICAL ENGINEERING**

**TERRY R. MCNELLEY
CHAIR**

MECHANICAL ENGINEERING

OVERVIEW:

The mission of the Department of Mechanical Engineering is to increase the combat effectiveness of U.S. and Allied armed forces and to enhance the security of the United States through advanced education that focuses on the ability to identify, formulate and solve technical and engineering problems in areas related to mechanical engineering and that spans issues of research, design, development, procurement, operation, maintenance and disposal of components and systems for Naval platforms.

RESEARCH MISSION:

The research mission of the Department of Mechanical Engineering is to increase the combat effectiveness of U.S. and Allied armed forces and to enhance the security of the United States through research in areas related to mechanical engineering and that spans the field from basic phenomena to engineering design, development, operation, maintenance and disposal of components and systems for Naval platforms.

CURRICULA SERVED:

The Mechanical Engineering Department serves the Naval and Mechanical Engineering Curriculum (570) and the Mechanical and Reactors Engineering Curriculum (571). Both curricula are in support of Navy needs for individuals having advanced technical education in mechanical engineering and related fields. The 570 Curriculum provides the educational component for the Engineering Duty Officer program and the research program in the Department is designed to support the requirement for Officers having the ability to identify, formulate and solve technical and engineering problems in areas related to mechanical engineering.

DEGREES GRANTED:

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

RESEARCH THRUSTS:

There are five different disciplines of research thrusts such as Fluid Dynamics, Heat Transfer and Turbomachinery; Dynamics Systems, Controls and Robotics; Solid Mechanics, Vibrations, and Shock; Materials Science and Engineering; Total Ship Systems Engineering

FACULTY EXPERTISE:

- Fluid Dynamics, Heat Transfer and Turbomachinery:
Distinguished Professor Turgut Sarpkaya, Professor Matthew Kelleher, Associate Professor Knox Millsaps, Jr., Associate Professor Ashok Gopinath
- Dynamics Systems, Controls and Robotics:
Professor Anthony Healey, Professor Morris Driels, Associate Professor Fotis Papoulias
- Solid Mechanics, Vibration, and Shock:
Professor Young Shin, Professor Young Kwon, Associate Professor Joshua Gordis
- Materials Science and Engineering:
Professor Terry McNelley, Professor Alan Fox, Associate Professor Indranath Dutta
- Total Ship Systems Engineering:
Professor Charles Calvano

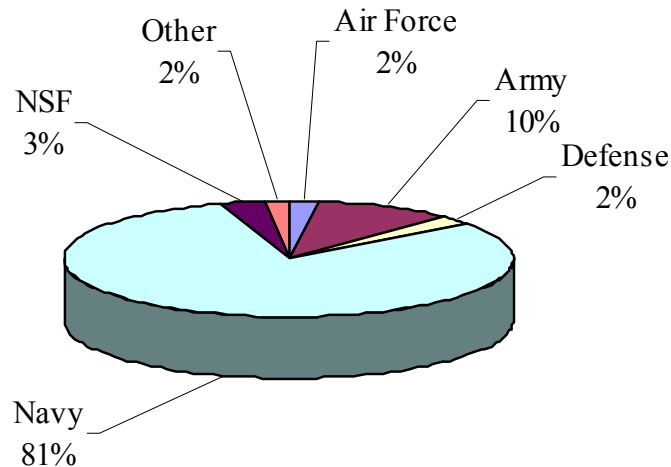
MECHANICAL ENGINEERING

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.

SPONSORED RESEARCH PROGRAMS (Research and Academic)-FY2002:

The Naval Postgraduate School's sponsored program exceeded \$61 million in FY2002. Sponsored programs include both research and educational activities funded from an external source. A profile of the sponsored program for the Department of Mechanical Engineering is provided below.



Size of Program: \$1,815K

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MECHANICAL ENGINEERING

TOTAL SHIP SYSTEMS ENGINEERING (TSSE) IN SUPPORT OF NAVSEA CONTRACT DESIGN

Charles N. Calvano, Professor
Fotis A. Papoulias, Associate Professor
Department of Mechanical Engineering
Robert C. Harney, Senior Lecturer
Department of Systems Engineering
Sponsor: Naval Sea Systems Command

OBJECTIVE: This program is intended to support the ongoing Total Ship Systems Engineering program, which, in turn, works with and supports NAVSEA and NAVSEA activities in the performance of ship concept design studies and in the evaluation of ship designs. In addition to the general areas of effort described in the associated Memorandum of Agreement, the 2002 effort will include examination of the potential role and utility of a Joint Command and Control Ship, such as that currently being considered by the JCC(X) program office. TSSE and other campus design projects which TSSE supports will include examination of the capabilities and potential contributions of the JCC(X) to the expeditionary warfare cross discipline problem. Work done as part of this program will support student design education and be used to ensure classroom material continues to be relevant to ongoing Navy ship-related technology developments.

PUBLICATION:

Calvano, C.N. and Philip, J., "Systems Engineering in an Age of Complexity," *Systems Engineering, the Journal of the International Council on Systems Engineering*, (accepted).

KEYWORDS: Systems Engineering, Ship Design, Design Evaluation, Effectiveness Assessment

THE ACQUIRE MODEL AND ITS APPLICATION TO THE MOUT ENVIRONMENT

Morris Driels, Professor
Department of Mechanical Engineering
Sponsors: U.S. Army TRADOC Analysis Command – Monterey

OBJECTIVE: Review Army target acquisition methodologies applying to MOUT.

SUMMARY: This project focused on the applicability of the U.S. Army's standard target acquisition model Acquire to a MOUT environment. A literature review revealed that it could be used with some minor modifications, and limiting constraints.

THESIS DIRECTED:

Neal, D., "Target Acquisition Model for Military Operations in Urban Terrain," Master's Thesis, Naval Postgraduate School, March 2002.

KEYWORDS: Target Acquisition, MOUT, Combat Modeling

JMEM AIR TO SURFACE TASKS 3,8,16

Morris Driels, Professor
Department of Mechanical Engineering
Sponsor: Joint Coordinating Group

OBJECTIVE: To improve delivery accuracy methodology and to develop a real time DA capability.

SUMMARY: This continuing task completed a major milestone in 2002 by delivering the prototype Joint Delivery Accuracy Program (JDAP) to the sponsors. This product will now be integrated by the contractor into JAWS version 2.3 due for release in July 2003.

KEYWORDS: Bombing Accuracy, Weaponering

DEVELOPMENT OF SMART MICROELECTRONIC SOLDER JOINTS FOR MICROELECTRONIC PACKAGING

I. Dutta, Associate Professor
Department of Mechanical Engineering
Sponsor: U.S. Army Research Office

OBJECTIVE: To develop smart, adaptive solder joints for high-end microprocessor packaging applications in advanced military and commercial sectors.

SUMMARY: Flip Chip solder joints in electronic packaging applications are subjected to extreme thermo-mechanical conditions during many high-end defense and commercial applications. During cycling, the microstructure coarsens, plastic strains localize, and the solder joint eventually fails by low-cycle fatigue induced by permanent creep deformation. The purpose of this project is to develop a new generation of smart solders, which take advantage of the shape-memory effect of reinforcements to internally actuate themselves to reduce internal strain concentrations and thereby enhance joint and package life.

PRESENTATION:

Dutta, I., Majumdar, B.S., Choi, S. and Wright, W., "A Strategy for Producing Adaptive Lead-Free Solder Joints Via Shape-Memory Alloy Reinforcement of Solder Alloys," 132nd TMS Annual Meeting, 3-6 March 2003, (invited).

KEYWORDS: Electronic Packaging, Solder, Thermal Cycling, Deformation

INTERFACIAL SLIDING IN MULTI-COMPONENT SYSTEMS

I. Dutta, Associate Professor
Department of Mechanical Engineering
Sponsor: National Science Foundation

OBJECTIVE: To investigate the mechanisms of creep at interfaces of dissimilar materials.

SUMMARY: The goal of this project is to develop a phenomenological understanding of the mechanisms operative during sliding of interfaces at high temperatures. A combination of experimental and analytical means are being utilized to investigate the kinetics of interfacial sliding and its effect on thin film systems.

PUBLICATIONS:

Peterson, K.A., Dutta, I. and Chen, M.W., "Diffusionally Accommodated Interfacial Sliding in Metal-Silicon Systems," *Acta Mater.*, December 2002, (in press).

Peterson, K.A., Dutta, I. and Chen, M.W., "Measurement of Creep Kinetics at Al-Si Interfaces," *Scripta Mater.*, 47, p. 649, 2002.

Peterson, K.A., Dutta, I. and Chen, M.W., "Processing and Characterization of Diffusion Bonded Aluminum-Silicon Interfaces," *Journal of Mater. Proc. Tech.*, November 2002, (in press).

Peterson, K.A., Dutta, I. and Park, C., "Interfacial Creep in Multi-Component Material Systems," *Journal of Metals, Minerals and Materials Soc. (JOM)*, 55, No. 1, pp. 37-43, 2003.

Park, C. and Dutta, I., "An Environmentally Protected Hot-Stage Atomic Force Microscope for Studying Deformation in Microelectronic Device Structures," *Rev. Sci. Instrum.*, (in review).

MECHANICAL ENGINEERING

CONFERENCE PAPERS:

Dutta, I., Peterson, K. and Chen, M.W., "Plasticity and Interfacial Sliding in Cu Thin Film:Si Substrate Systems During Thermal Cycling," *Plasticity, Damage and Fracture at Macro, Micro and Nano Scales, Proceedings of the Ninth International Symposium on Plasticity*, NEAT Press, pp. 117-119, A.S. Khan and O. Lopez-Pamies (Eds.), 2002.

Peterson, K.A., Park, C. and Dutta, I., "Interfacial Sliding in Back-End Interconnect Structures in Microelectronic Devices," *Silicon Materials - Processing, Characterization and Reliability, Proceedings of the MRS Symposium, MRS*, Vol. 716, p. 483, J. Veteran, D.L. O' Meara, V. Misra and P. Ho (Eds.), 2002.

PRESENTATION:

Dutta, I., Peterson, K.A. and Chen, M.W., "Interfacial Sliding in Multi-Component Materials Systems and Its Mechanism," *Modeling the Performance of Engineering Structural Materials III*, TMS, pp. 253-267, T.S. Srivastan, D.R. Leseur and E.M. Taleff (Eds.), 2002, (invited).

THESES DIRECTED:

Peterson, K., "Interfacial Creep in Multi-Material Systems," Doctor of Philosophy Dissertation, Naval Postgraduate School, September 2002.

Thornell, M., "A Methodology for Studying Interfacial Creep at Thin Film/Silicon Interfaces," Master's Thesis, Naval Postgraduate School, December 2002.

KEYWORDS: Composite, Multi-layers, Thin Films, Creep, Interfacial Sliding

THERMO-MECHANICAL BEHAVIOR OF SOLDER JOINTS FOR ELECTRONIC PACKAGING

I. Dutta, Associate Professor

Department of Mechanical Engineering

Sponsors: National Science Foundation, Semiconductor Research Corporation and INTEL Corporation

OBJECTIVE: To obtain a mechanistic understanding of the relationship between microstructural coarsening and applied constraints during thermo-mechanical cycling of solder joints.

SUMMARY: Flip Chip and Ball Grid Array solder joints in electronic packaging applications are subjected to large imposed strains and temperature variations during service conditions. During cycling, the microstructure coarsens, plastic strains localize, and the solder joint eventually fails by low-cycle fatigue induced by permanent creep deformation. The purpose of this project is to understand the dependence of microstructural coarsening on the plastic strain state in a solder joint during thermo-mechanical cycling.

PUBLICATIONS:

Dutta, I., "A Constitutive Model for Creep of Lead-Free Solders Undergoing In-situ Microstructural Coarsening: A First Report," *Journal of Electronic Mater.*, 32, October 2002, (to appear April 2003).

Dutta, I., Gopinath, A. and Marshall, C., "Underfill Constraint Effects During Thermo-Mechanical Cycling of Flip Chip Solder Joints," *Journal of Electronic Mater.*, 31, p. 253, 2002.

MECHANICAL ENGINEERING

CONFERENCE PAPERS:

Dunne, J.E., Smith, V.E., Gopinath, A. and Dutta, I., "Modeling the Effects of Cycling of a Localized Heat Source on the Durability of a FCOC with Defects," *Proceedings of the 52nd Electron. Comp. Tech. Conference (ECTC-IEEE)*, p. 622, 2002.

Dutta, I., Park, C., and Choi, S., "Creep and Microstructural Coarsening in Lead-Free Microelectronic Solder Joints" *Proceedings of the InterPACK 2003*, International Electronic Packaging Technology Conference, Maui, HI, July 2003.

PRESENTATION:

Dutta, I., Choi, S. and Anastasio, N., "Microstructural Coarsening and Creep Response of Microelectronic Solder Joints," Symposium on Lead Bearing and Lead-Free Solders, 2002 TMS Fall Meeting, Columbus, OH, 6-10 October 2002, (invited).

THESES DIRECTED:

Anastasio, N., "Development of an Impression Creep Apparatus for Testing Lead-free Microelectronic Solder Joints," Master's Thesis, Naval Postgraduate School, June 2002.

KEYWORDS: Electronic Packaging, Solder, Thermal Cycling, Deformation

EVALUATION OF COOLING TECHNOLOGIES FOR MAGNETORESTRICTIVE ACTUATORS

Ashok Gopinath, Associate Professor
Department of Mechanical Engineering

Sponsor: Naval Surface Warfare Center, Carderock Division

OBJECTIVE: To evaluate available cooling technologies that would work within the design constraints of magnetostrictive actuators and maintain operating temperatures below a safe threshold.

SUMMARY: This project was a short-term piece of work for NSWC. The goal of the project was to investigate and recommend possible cooling technologies that would maintain the temperature of magnetostrictive actuators under safe operating limits. After exploring various options, and keeping the design constraints in mind, it was recommended that for baseline use simple low maintenance off the shelf heat exchanger components with no moving parts be used for robust and reliable performance of the actuator in the harsh environments envisioned. It was found that the basic cooling needs could be met with an extended surface natural convection cooling design such as a press fitted pin fin assembly. The working constraints were that the ambient temperature could be as high as 35 C while the actuator temperature was not to exceed 95 C, and that the final package was to fit within a cylindrical package of dimensions no more than one foot in length and diameter. Sample baseline calculations were provided for a typical case of an assembly of 35 circular/annular aluminum fins that could provide a heat transfer rate of as much as 650 W. In addition, active cooling enhancement strategies were recommended through the use of vortex tubes that work off standard high pressure air lines to provide a jet/stream/curtain of cold air. It was suggested that strategically located vortex tubes could be used to provide an empirically calibrated blast(s) of cold air on the actuator along the length of its travel to maintain its temperature within safe operating limits.

TECHNICAL REPORT:

Gopinath, A., "Evaluation of Cooling Technologies for Magnetostrictive Actuators," Naval Postgraduate School Technical Report.

KEYWORDS: Magnetostrictive Actuator, Natural Convection, Fin Assembly, Vortex Tubes

MECHANICAL ENGINEERING

MODELING OF HEAT TRANSFER IN A ROCKET ENGINE COMBUSTION CHAMBER

Ashok Gopinath, Associate Professor
Department of Mechanical Engineering
Sponsor: Air Force Research Laboratory

OBJECTIVE: To model the large radiative energy transfer rates in Micro-TPV devices and to carry out a design study of the parameters that influence its performance.

SUMMARY: A numerical study was conducted to predict the combined convective and radiative heat transfer rates on the walls of a small aspect ratio cylinder representative of the scaled model of a rocket engine combustion chamber. A high-temperature, high-pressure environment was simulated in the cylinder, with gas velocities at low subsonic levels typical of the conditions leading to the entrance of the nozzle section of a rocket engine. The composition of the gases in the cylinder was determined from the TEP program for the burning of rocket fuel at typical values of the O/F ratio. The thrust of the study was to determine the radiative contribution to the heat transfer rate from the hot participating chamber gases to the cooler wall so as to provide data that can be used to improve the prediction capabilities of currently used computer codes such as PERCORP that treat the radiation in an *ad hoc* manner. The results from the numerical model will be corroborated with data obtained by the ongoing experimental effort by the PI. The calculations were carried out using the commercial CFD package CFDACE, and were first benchmarked against known results in the literature for the simpler case of gray chamber walls and a gray participating medium. The non-gray computations were subsequently carried out using gas absorption coefficient values obtained from the exponential wide band model with the help of the fire-modeling program, RADCAL. The effect of different chamber wall temperatures and gas compositions was examined. The main findings of the study are that the radiative contributions at the high gas temperatures being considered are comparable to the convective values, and strongly spectral in nature. Furthermore, this radiative contribution reaches a maximum at a unique optimal optical thickness of the gas that lies within the extremes of the optically thin and thick limiting cases.

THESIS DIRECTED:

Savur, M.K., "A Numerical Study of Combined Convective and Radiative Heat Transfer in a Rocket Engine Combustion Chamber," Master's Thesis, Naval Postgraduate School, December 2002.

KEYWORDS: Missile, Propulsion, Signature, Infrared, IR, Soot

THERMOPHOTOVOLTAIC (TPV) POWER CONVERSION

Ashok Gopinath, Associate Professor
Department of Mechanical Engineering
Sponsor: Un-sponsored

OBJECTIVE: To model the large radiative energy transfer rates in Micro-TPV devices and to carry out a design study of the parameters that influence its performance.

SUMMARY: TPV technology is of great interest to Naval Reactors as a potential solution for direct energy conversion for submarine propulsion in the future. The device works by transfer of thermal energy by radiation from a high temperature emitter to a semiconductor collector placed in close proximity in which it is converted to electrical energy. When the gap between emitter and collector in a TPV device is of the order of the wavelength of radiation, the now so-called Micro-TPV device can yield very large power densities. In this project a Micro-TPV device based on an InGaAs collector was modeled to determine the radiative transfer rates from emitter to collector, as well as the resulting electrical power density and efficiency. Different emitter materials and temperatures, various collector band gap levels, and a range of (micron and sub-micron) level spacings between emitter and collector surfaces were considered. The results have been presented in numerical and graphical form for a wide ranging parameter space and could help the device designer in making an optimal choice of operating conditions. In particular, it was found that among the metals, tungsten and rhenium are superior emitter materials, although silicon carbide can

exceed their performance for gap spacing levels limited by current technology. However if advances in spacing control technology make smaller (sub-micron) gaps feasible, rhenium emitter devices could provide a significant increase in power density (10–100 W/cm²), with efficiencies as high as 20 %. In CY-2003 an experimental phase of the project under the sponsorship of Naval Reactors will commence to demonstrate suitable techniques for back-end cooling of high power density MTPV devices.

CONFERENCE PAPER:

Bierley, J.M. and Gopinath, A., "A Parametric Design Study of InGaAs MTPV Cells Coupled to Various Emitters at Near and Far Spacings," *Fifth International Conference on Thermophotovoltaic Generation of Electricity*, Rome, Italy, 15-19 September 2002.

THESIS DIRECTED:

Bierley, J.M., "A Parametric Design Study of InGaAs MTPV Cells Coupled to Various Emitters at Near and Far Spacings," Master's Thesis, Naval Postgraduate School, March 2002.

KEYWORDS: Thermophotovoltaic, TPV, Micro-TPV, Emitter, Collector, Receiver, Radiation, Quantum Efficiency, Fill Factor, Dark Current, Power Density

TURBINE CONVECTIVE COOLING CONCEPTS EVALUATION

**Ashok Gopinath, Associate Professor
Department of Mechanical Engineering**

Sponsors: Naval Air Systems Command, Naval Air Warfare Center and Defense Advanced Research Projects Agency

OBJECTIVE: To provide support and validatory analyses of ongoing work in a new MEMs-based micro-heat exchanger turbine cooling concept.

SUMMARY: This project is a continuation from FY-2001. The primary thrust of the project was to develop a multi-physics computational analysis of the proposed heat exchanger design. The micro-heat exchanger is based on the concept of the use of pin fins in the narrow gap of a shroud enclosed turbine blade to obtain a large volumetric density of heat transfer area. A finite element numerical analysis based on the package ANSYS has been initiated to predict the flow and heat transfer characteristics of such a micro pin fin heat exchanger. In such a short pin fin enclosed array configuration, both the pins and the end wall make substantial contributions to the heat transfer, which need to be identified. For the small pin fin size relative to the blade radius of curvature, a planar model was assumed and a fully three dimensional numerical analysis was carried out of a staggered array configuration. Various streamwise and spanwise pin fin spacings were used to determine both row-averaged and array-averaged heat transfer coefficients for the heat exchanger. A range of flow Reynolds numbers was covered and different turbulence models were evaluated and the results corroborated with available experimental data in the literature. The heat transfer performance was compared with overall pressure drop characteristics to predict an optimal configuration. An experimental phase of the project was also commenced and will continue into FY-2003.

CONFERENCE PAPERS:

Hamilton, L.J., Adametz, D.S., Lind, E.K. and Gopinath, A., "Numerical Analysis of the Performance of a Staggered Cross-Pin Array Heat Exchanger," *8th AIAA/ASME Joint Thermophysics and Heat Transfer Conference*, St. Louis, MO, 24-26 June 2002.

Hamilton, L.J. and Gopinath, A., "Numerical Analysis of the Performance of a Staggered Cross-Pin Array Heat Exchanger," *Turbine Engine Technology Symposium*, Dayton, OH, 9-12 September 2002.

THESIS DIRECTED:

Lind, E.K., "Analysis of Turbulence Models in a Cross Flow Pin Fin Micro-Heat Exchanger," Master's Thesis, Naval Postgraduate School, June 2002.

KEYWORDS: Pin-Fin Array, Compact Heat Exchanger, Micro Heat Exchanger, Turbine Blade Cooling

EVALUATION OF VENDOR-PROPOSED CONCEPTS FOR MOTION COMPENSATION FOR ROLL-ON/ROLL-OFF STERN RAMPS

J. H. Gordis, Associate Professor

Fotis A. Papoulias, Associate Professor

Department of Mechanical Engineering

Sponsor: Naval Surface Warfare Center, Carderock Division

OBJECTIVE: The current stern ramp designs on many Navy ships (Cape T, Cape H, LMSR, etc.) used in roll-on roll-off operations has been determined to be structurally inadequate in sea state 3 and above. This phase of this continuing project involved the technical evaluation of two concepts for motion compensation systems to be placed between the foot of the ramp and the RRDF (barge) on which the ramp rests. The two concepts were proposed to NSWC/Carderock by two independent vendors, and NPS (Gordis/Papoulias) were funded by NSWC/Carderock to critically evaluate these concepts for effectiveness in reducing ramp stresses.

SUMMARY: A mathematical model describing the fundamental physics of a ship/ramp/barge system, including the motion compensators as proposed by the vendors, was developed. The model properly accounts for hydrodynamic proximity effects and structural coupling between the bodies. Preliminary parametric studies, utilizing a standard second order model for the frequency response properties of the connecting body, of the response amplitude operator of the ramp motion were performed for varying wave directions and isolator stiffness and damping. These were utilized for random wave analysis in standard fully developed seas. These models were used to generate wave motion inputs to large finite element models of the ramps and motion compensators, and ramp stress was calculated. The results indicated neither of the vendor-proposed motion compensation systems would be effective in reducing ramp stress, and in fact, under certain circumstances, would increase ramp stress.

NSWC/Carderock did NOT fund these two vendor concepts based on this work, which showed the ineffectiveness of the concepts. This resulted in significant savings of funds for the Navy.

TECHNICAL REPORTS:

Gordis, J.H., Papoulias, F.A. and Haigh, J.J., "Motion Compensator Analysis Executive Summary," Naval Postgraduate School Technical Report, March 2002.

Haigh, J.J. and Gordis, J.H., "Motion Compensator Analysis," Naval Postgraduate School Technical Report, March 2002.

THESIS DIRECTED:

Haigh, J.J., "Computational Dynamics and Stress Analysis of Full-Scale Model Roll-On, Roll-Off (Roro) Stern Ramp with Wave Motion Compensation," Master's Thesis, Naval Postgraduate School, June 2002.

KEYWORDS: Frequency Response, Seakeeping, RORO Operations, Vibration Isolation

MECHANICAL ENGINEERING

CENTER FOR AUTONOMOUS UNDERWATER VEHICLE RESEARCH DURIP PROJECT

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Department of Mechanical Engineering
Douglas Horner, Research Associate
Donald Brutzman, Associate Professor
Department of Information Sciences
Sponsor: Office of Naval Research

LONG TERM GOAL: The goals are to develop Command and Control strategies for multi vehicle mine hunting systems using small autonomous underwater vehicles in very shallow water (VSW) environments. To this end, this project purchases a second vehicle for the NPS Center for Research. This is a Defense University Research Instrumentation Program (DURIP) project funded in FY 2002.

OBJECTIVE: Command and Control with multiple vehicles in very shallow water requires vehicle to vehicle communication. The objectives of this work are to develop strategies for multi-vehicle command and control for heterogeneous systems. This will be done by demonstrations of vehicle communication and mission re-configuration underwater. To this end, acoustic control of vehicles is a first step, leading to vehicle - vehicle communication and control underwater. Acoustic control is a requirement since radio control is not efficient unless vehicles are on the surface.

SUMMARY: The approach - and the purpose of the approved funding was to purchase a *REMUS* vehicle in the Center for AUV Research to explore coordinated control between the existing *ARIES* vehicle (see www.cs.nps.navy.mil/research/auv/auvframes.html) and the *REMUS*. Unfortunately, it will be a future activity to install an acoustic modem on *REMUS* although experiments are underway with acoustic modem control of *ARIES*. Experiments will be performed both in simulation and by validation in water.

At this point, a *REMUS* vehicle has been purchased by NPS. The delivery is expected April 2003. This vehicle will be used to 1) Map Monterey Bay bottom conditions in the shallow water areas. 2) It will be used to support the upcoming AOSN II experiment in Monterey Bay Summer 2003 with oceanographic measurements, and, 3) We will study the possibilities to reconfigure the *REMUS* vehicle to carry a modem package. To date the purchase order has been placed for the full amount of funding available.

CENTER FOR AUTONOMOUS UNDERWATER VEHICLE RESEARCH

A.J. Healey, Professor
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Douglas Horner, Research Associate
Department of Information Sciences
Sponsor: Naval Postgraduate School

OBJECTIVE: This year, a horizontal model of the *REMUS* AUV has been developed and a simple avoidance behavior is studied for horizontal plane maneuvering. The approach used is based on computer simulation using MATLAB and motion visualization in the NPS AUV Workbench. The NPS AUV Workbench is Java and XML based simulation software which includes sliding control vehicular motion and the OA algorithm described above. It permits easy generation of mission scenarios with flexible placement of mine and obstacles to validate, verify, and improve navigation algorithms.

SUMMARY: A Sliding Mode steering controller has been developed for *REMUS* based on a hydrodynamic model taken from the literature and modified based on experimental data gathered during Navy exercises. A track following guidance algorithm used by the vehicle has been implemented in the simulations and additive steering commands based on a weighted sum of range and bearing estimates to targets in the field has been studied for its effectiveness as a collision avoidance controller. The results have shown consistence avoidance with a controlled return to the track path even for multiple and complex obstacles. The overall goal of the program is a multi-step approach which includes going from simulated obstacle avoidance to incorporation of OA algorithms into the *ARIES* and *REMUS* vehicles. The first step of providing the OA simulation has been completed.

CONFERENCE PAPER:

Fodrea, L.T. and Healey, A.J., "Obstacle Avoidance Control for the *REMUS* Autonomous Underwater Vehicle," *IFAC Workshop on Guidance and Control of Unmanned Underwater Vehicles*, Newport, UK, April 2003, (invited).

THESES DIRECTED:

Fodrea, L., "Obstacle Avoidance Control for the *REMUS* Autonomous Underwater Vehicle," Master's Thesis, Naval Postgraduate School, December 2002.

Keller, J., "Tracking Control of Autonomous Underwater Vehicles," Master's Thesis, Naval Postgraduate School, September 2002.

TACTICAL DECISION AIDS USING MODELING AND SIMULATION

A.J. Healey, Professor

Department of Mechanical Engineering

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Modeling, Virtual Environments and Simulation Institute

Donald Brutzman, Associate Professor

Department of Information Sciences

Sponsor: Office of Naval Research

OBJECTIVE: The current mine warfare common operational picture used by the U.S. Navy for mine countermeasures is MEDAL (Mine warfare Environmental Decision Aids Library). MEDAL is a component of the GCCS-M global command and control system used by the Navy. It is used to evaluate asset positions, minelike contacts, snippet images of contacts, snippet images of mines, and bathymetry maps. Other data such as classification of bottom type may be displayed if available. Current MEDAL capabilities are limited for importing and displaying the AUV collected data. The NPS objectives include gathering, converting, archiving, and translating AUV data into the MEDAL format. The goal is to improve understanding of the overall mine warfare situational picture through the collection and display of AUV data into fleet Command and Control systems. This includes the timeliness of data gathering including the post processing of sonar and video images for import into MEDAL. Long term goals are to develop a standard XML tagset for storage, retrieval and transformation of data from AUV missions and to integrate 3D visualization of data to enhance decision making, particularly in regard to deciding whether a contact is in fact a mine.

SUMMARY: One issue in this project is how to deal with data from unclassified assets that are in development from university institutions, translate into the form used by MEDAL, and import the results into the classified Navy systems used in the fleet. To this end we have defined an Automated Data Server system (ADS) that is linked through a local area network (LAN) to a stand alone MEDAL system. The MEDAL system runs on a TAC4 or better HP workstation. At the present time, it only runs on the HP systems with the 10.20 OS and the GCCS-M operating system. The ADS has been refined and is now interactive through screen entry from an operator. Future versions will be automated without operator intervention so that the software could run inside the control system of the AUVs. The ADS allows the operator to view data through a VRML 3D viewer in which models of vehicles and contacts can be seen thereby extending MEDAL into 3-D views.

The ADS has been developed and demonstrated during the Kernal Blitz 01, the AUVFEST 01, and the FBE-J exercises. While the *REMUS* / SAHRV vehicle was used mostly during FBE-J, the system gathered data from the Bluefin BPAUV vehicle. In particular we gathered environmental data and illustrated how to display the bathymetry, temperature, and sound speed and optical backscattering maps into MEDAL.

KEYWORDS: Tactical Decision Aid, MEDAL

MECHANICAL ENGINEERING

DEVELOPMENT OF INTERACTIVE FINITE ELEMENT METHOD ON THE WORLD WIDE WEB

Young W. Kwon, Professor
Department of Mechanical Engineering
Sponsor: Chief of Naval Education and Training

OBJECTIVE: This was to develop a finite element method course on the world wide web for distributed learning classes.

SUMMARY: The finite element method course offered at NPS (ME-4613) was developed on the world wide web for DL students. The web tools called Blackboard was used to developed the course. The course materials contained concepts of the finite element technique and its application to various mathematical problems in mechanical engineering disciplines including boundary value problems, initial value problems, and eigenvalue problems.

KEYWORDS: Finite Element Method, DL Program

EFFECTS OF MICRO-STRUCTURAL VARIATION ON LOCAL DAMAGE INITIATION AND GROWTH OF SPECIMEN

Young W. Kwon, Professor
Department of Mechanical Engineering
Sponsor: Air Force Research Laboratory

OBJECTIVE: This was a continuing research project from past several years during which a numerical modeling and simulation technique, called a multi-level (micro-macro) technique, had been developed and evaluated against experimental results. This year's effort was to study the effect of micro-structural variation on local damage initiation and growth.

SUMMARY: This project discussed the effects of non-uniform, random particle distribution on damage initiation and growth, leading to short cracks and breakage of particle reinforced composite specimens. A multi-scale technique was employed to model and simulate damage. Damage was described at the constituent material level (i.e. micro-level) and the results were compared qualitatively and quantitatively with experimental observation. Both results agreed well. Non-uniform, random particle distribution yielded sporadic crack initiation and growth within a uniform tensile specimen. No local crack propagated beyond a certain size. Breakage of the specimens was not caused by the continuous growth of a single critical crack. Instead, coalescence of neighboring sporadic short cracks resulted in breakage of the specimens. Computer simulation indicated that random particle distribution affected the strength of the composite significantly, but as expected, not its effective stiffness. However, if there was a pre-existing crack in the specimen before loading, the effect of the random particle distribution on the initial crack and the strength of the composite was almost negligible.

PUBLICATIONS:

Kwon, Y.W. and Liu, C.T., "Microstructural Effects on Damage Behavior in Particle Reinforced Composites," *Polymers and Polymer Composites*, (accepted).

Kwon, Y.W. and Roach, K., "Unit-Cell Model of 2/2-Twill Woven Fabric Composites for Multi-Scale Analysis," *Computer Modeling in Engineering and Sciences*, (accepted).

CONFERENCE PAPERS:

Kwon, Y.W. and Liu, C.T., "Study of Interaction Between Non-uniform Particle Distribution and the Crack Initiation and Growth Under Tensile Loading," *International Conference on Computational Engineering and Sciences*, Reno, NV, August 2002.

MECHANICAL ENGINEERING

Kwon, Y.W. and Liu, C.T., "Study of Microstructural Effects in Particulate Composites," *Recent Advances in Solids and Structures-2002, IMECE 2002*, New Orleans, LA, 2002.

KEYWORDS: Composite Materials, Particle Reinforcement, Solid Rocket Propellant, Damage and Crack, Modeling and Simulation, Initial Crack Size, Micro-structure

MODELING IN NANO-MECHANICS

Young W. Kwon, Professor
Department of Mechanical Engineering
Sponsor: Unfunded

OBJECTIVE: Molecular dynamics simulation technique was developed for static problems and coupled with the finite element method.

SUMMARY: A computational technique was developed to model and simulate molecular or atomic behavior of materials under static loads. Interatomic potential was used to maintain equilibrium among molecules or atoms under loads and constraints. In addition, a smeared continuum model was derived to represent a very large number of molecules or atoms collectively based on energy equivalency. The finite element method was applied to the smeared continuum model. Then, the molecular or atomic model was coupled with the finite element analysis model so that more flexible loads and constraints could be applied to the molecular or atomic model. In addition, such a coupling would be useful for transition from nanoscale to continuum scale. Some example problems were presented to illustrate the developed techniques. An example included a multi-scale technique for woven fabric composites made of carbon nanotubes. The effective stiffnesses at different stages of the nano-composites were computed.

PUBLICATIONS:

Kwon, Y.W., "Computational Nanomechanics," (submitted).

Kwon, Y.W. and Jung, S.H., "Atomic Model and Coupling with Continuum Model for Static Equilibrium Problems," (submitted).

CONFERENCE PAPERS:

Kwon, Y.W. and Jung, S.H., "Atomistic Model for Static Equilibrium Problems," *Proceedings of the Sixth International Conference on Computational Structures Technology*, CST02/paper No. 2, 1-12, Prague, Czech Republic, September 2002.

Kwon, Y.W. and Jung, S.H., "Computational Nanomechanics," *Recent Advances in Solids and Structures - 2002, IMECE 2002*, New Orleans, LA, 2002.

KEYWORDS: Nanomechanics, Molecular Dynamics, Continuum Mechanics

SHIP DAMPING STUDIES FOR ENERGY DISSIPATION IN SHIP SYSTEM

Young W. Kwon, Professor
Department of Mechanical Engineering
Sponsor: Naval Surface Warfare Center

OBJECTIVE: This study was to understand energy dissipation in a ship system and to learn how to model and simulate it.

SUMMARY: The purpose of this research was to study the effects that welding has on damping. Measurements and comparisons of the damping ratios of two welded stiffened plates, two flat plates and one machined stiffened plate were undertaken. The frequency response and natural frequencies of five

steel structures are determined experimentally. A finite element model was created for three of the structures to determine the natural frequencies and associated mode shapes. The damping ratios were then determined using the half-power point method. The results showed that at frequencies less than 500 Hz, welding tended to cause the damping ratio to increase. The experimental and numerical results showed that the mode shapes that experienced the highest degree of stress at a weld were associated with the natural frequencies with the highest damping ratio.

PUBLICATION:

Carey, A.E., "Experimental Studies of Welding Effects on Damping for UnderSea Warfare Application," *MSME*, September 2002.

KEYWORDS: Damping, Ship Structures, Welding

THE MECHANICAL AND MICROSTRUCTURAL CHARACTERIZATION OF COMMERCIAL AA5083 MATERIALS

Terry R. McNelley, Professor
Department of Mechanical Engineering
Sponsor: University of Texas-Austin

OBJECTIVE: The objective of this program is to determine the mechanisms of elevated temperature deformation and the conditions for transition from grain boundary sliding to solute-drag controlled dislocation creep. Also, the mechanisms associated with cavitation failure during superplastic deformation will be clarified.

SUMMARY: Superplastic forming of aluminum alloys has become an established technology for aerospace systems and is being used increasingly in transportation and other applications. The commercial alloy AA5083 is an aluminum-base material having Mg and Mn as the main alloying additions, and it provides a combination of superplastic forming characteristics, corrosion resistance, weldability, and post-forming mechanical properties that make it suitable for a wide range of aerospace, marine and automotive applications. There are two particular difficulties: (1) empirically developed methods for production of fine-grained AA5083 sheet material result in high cost, and (2) available sheet materials exhibit widely different ductility values at elevated temperature even when their grain sizes 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:

Kulas, M.A., Krajewski, P.E., McNelley, T.R. and Taleff, E.M., "Deformation and Failure Mechanisms in Commercial AA5083 Materials," *Hot Deformation of Aluminum Alloys III*, TMS: Warrendale, PA, Z. Jin, et al. (Eds.).

McNelley, T.R., Swisher, D.L. and Pérez-Prado, M.T., "Deformation Bands and the Formation of Grain BoundARIES in a Superplastic Aluminum Alloy," *Metallurgical and Materials Transactions A*, Vol. 33A, pp. 279-90, 2002.

Peréz-Prado, M.T., González-Doncel, G., Ruano, O.A. and McNelley, T.R., "Texture Analysis and the Transition from Slip to Grain Boundary Sliding in a Discontinuously Recrystallized Superplastic Aluminum Alloy," *Acta Materialia*, Vol. 49, pp. 2259-68, 2002.

PRESENTATION:

McNelley, T.R., Maestas, T.A., Kulas, M.A. and Taleff, E.M., "Investigation of the Deformation and Failure Mechanisms in AA5083 Materials," Symposium on Superplasticity and Superplastic Forming, ASMI Fall Meeting, Columbus, OH, 9 October 2002, (invited).

THESIS DIRECTED:

Maestas, A., "Study of Processing and Microstructure of a Superplastic 5083 Aluminum Alloy," Master's Thesis, Naval Postgraduate School, March 2002.

KEYWORDS: Aluminum, Superplasticity, Recrystallization, Grain BoundARIES, Thermomechanical Processing

MICROSTRUCTURE EVOLUTION AND CONTROL DURING FRICTION STIR PROCESSING (FSP) OF CAST NAVAL BRONZE MATERIALS

Terry R. McNelley, Professor
Department of Mechanical Engineering
Sponsor: Defense Advanced Research Projects Agency

OBJECTIVE: The objective of this program is to determine the effect of friction stir processing (FSP) on the microstructure and properties of a cast nickel-aluminum bronze (NAB) material utilizing various micro-analytical methods as well as conventional mechanical testing. Of particular concern is to determine the mechanism of microstructure refinement during FSP as well as the influence of processing parameters.

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. In many NAB applications it would be desirable to have alternative methods available to selective 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.

CONFERENCE PAPER:

Oh-ishi, K., Cuevas, A.M., Swisher, D.L. and McNelley, T.R., "The Influence of Friction Stir Processing on Microstructure and Properties of a Cast Nickel Aluminum Bronze Material," *Proceedings of THERMEC2003, International Conference on Thermomechanical Processing of Metals and Alloys*, Trans Tech: Zurich, T. Chandra, et al. (Eds.).

PRESENTATION:

Oh-ishi, K., Cuevas, A.M., Park, C. and McNelley, T.R., "Microstructure Evolution During FSP of an As-cast NAB Material," Workshop on Friction Stir Welding and Processing, Rockwell Scientific Corporation, Thousand Oaks, CA, December 2002.

THESIS DIRECTED:

Cuevas, A.M., "Microstructure Characterization of Friction Stir Processed Nickel-Aluminum Bronze Through Orientation Imaging Microscopy," Master's Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: Nickel Aluminum Bronze, Friction Stir Processing, Castings, Propellers, Stir Zone, Thermomechanically Affected Zone, Shear Deformation

ULTRA-FINE AND NANO-GRAIN MICROSTRUCTURES BY SEVERE PLASTIC DEFORMATION

Terry R. McNelley, Professor
Department of Mechanical Engineering
Sponsor: Unfunded

OBJECTIVE: The goal of this program is to determine mechanisms by which ultra-fine grain structures form in severely deformed materials, such as those processed by equi-channel angular (ECA) pressing

SUMMARY: Ultra-fine grain sizes in the sub-micrometer or even nanometer range can be achieved in metallic materials by imposing extremely large plastic strains during deformation processing. Such grain refinement will result in drastic improvements in strength/toughness combinations for structural applications, as well as in improved ductility during elevated temperature forming. Methods such as ECA pressing are required in order to impart 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:

McNelley, T.R., Swisher, D.L., Horita, Z. and Langdon, T.G., "Influence of Processing Route on Microstructure and Grain Boundary Development During Equal-Channel Angular Pressing of Pure Aluminum," *Ultra-Fine Grained Materials II*, pp. 15-24, TMS: Warrendale, PA, Y.T. Zhu, et al. (Eds.).

Terhune, S.D., Swisher, D.L., Oh-ishi, K., Horita, Z., Langdon, T.G. and McNelley, T.R., "An Investigation of Microstructure and Grain-Boundary Evolution During ECA Pressing of Pure Aluminum," *Metallurgical and Materials Transactions A*, Vol. 33A, pp. 2173-84, 2002.

PRESENTATION:

McNelley, T.R., Swisher, D.L., Horita, Z. and Langdon, T.G., "Influence of Processing Route During Equal-Channel Angular Pressing of Pure Aluminum," Second International Symposium on Ultra-Fine Grain Materials: Processing and Structure, TMS Annual Meeting, Seattle, WA, February 2002, (invited).

KEYWORDS: Aluminum, Grain Refinement, Nano-grain Materials, Recrystallization, Grain Boundaries, Materials Processing

MECHANICAL ENGINEERING

LOW OBSERVABLE MULTI-FUNCTION STACK (LMS) EXHAUST ENHANCED MIXING SUPPRESSOR

**Knox T. Millsaps, Associate Professor
Department of Mechanical Engineering**

Sponsor: Naval Surface Weapon Center - Carderock Division

OBJECTIVE: To develop and demonstrate a gas turbine exhaust signature suppression system, which is capable of meeting specified infrared (IR) and radar cross-section (RCS) goals, under specific engine-imposed constraints and overall systems constraints that the system be integrated into a low observable topside.

SUMMARY: This was the final year of a 4-year advanced technology demonstrator (ATD) project to develop a low observable multi-function stack (LMS) as part of the series of ATDs to create integrated topside technology for the next generation of surface combatants. In previous years, the NPS part of this project was to create design concepts and develop supporting analytical codes for the preliminary design of enhanced mixing ejectors, and to test and optimize cold-flow geometry for reducing plume radiation. These designs were next tested at larger scale at a hot-flow facility in Memphis with NPS assistance. Finally, last year the full-scale hardware was tested in an at-sea trial. NPS supplied engineering consulting services as well as integration advice throughout the project and was a member of the integrated product team (IPT).

PUBLICATIONS:

Millsaps, K.T., Imber, R.D. and Ratcliffe, R.J., "Development of the Enhanced Mixing Suppressor for the LMS (U)," *NSWCCD-74-TR-2001/010*, January 2001, (SECRET).

Ratcliffe, R., Imber, R., Bird, W. and Millsaps, K.T., "Final Report for the Low Observable Multi-Function Stack Advanced Technology Demonstrator Program (U)," (SECRET).

Ratcliffe, R., Imber, R., Bird, W. and Millsaps, K.T., "Test Report for LMS at Sea Trials (U)," (SECRET).

CONFERENCE PAPER:

Millsaps, K.T. and Markowicz, J.C., "An Improved Preliminary Design Method for Ejectors," *ASME TURBO EXPO 2003 LAND, SEA and AIR*, GT03-38141, Atlanta, GA, 16-19 June 2003.

PRESENTATION:

Millsaps, K.T. and Markowicz, J.C., "An Improved Preliminary Design Method for Ejectors," *ASME TURBO EXPO 2003 LAND, SEA and AIR*, GT03-38141, Atlanta, GA, 16-19 June 2003.

THESIS DIRECTED:

Gombas, J.D., "Reduction of Marine Gas Turbine Exhaust Infrared Signature," Master's Thesis, Naval Postgraduate School, March 2002.

KEYWORDS: Propulsion, Signature, IR, Gas Turbines, Exhaust, Enhanced Mixing

REVIEW OF ADVANCED TECHNOLOGY GAS TURBINE RESEARCH AND DEVELOPMENT PROGRAMS

**Knox T. Millsaps, Associate Professor
Department of Mechanical Engineering**

Sponsors: Naval Surface Warfare Center, Carderock Division and Naval Systems Engineering Station

OBJECTIVE: To review and evaluate the current research and development program for the advanced technology gas turbine program for the U.S. Navy's surface fleet gas turbine life cycle manager and to make technical recommendations for program improvement and to help create the Technology Roadmap. To support the priority advanced technology programs with technical support.

SUMMARY: The gas turbine technology programs were reviewed and a technology roadmap for future programs was created. Two areas of particular interest were identified that required technical support from the Naval Postgraduate School. Specifically, improved methods for the detection and localization of gas turbine compressor fouling, and analysis of using reheat in marine gas turbine cycles for both propulsion and power production. An analytical model of a gas turbine compressor was created to predict the impact that blade roughness from fouling would have on the mass flow, work coefficient, and efficiency of a three-stage axial compressor as a function of the location of fouling. This model was used to create numerical values of influence coefficients, which relate percentage changes in one parameter to percentage changes in other parameter. This analysis suggested the appropriate parameters that are the most sensitive for predicting the location and severity of compressor fouling. A thermodynamic analysis of re-heat cycles in marine power and propulsion gas turbines was conducted to predict the utility of such re-heat cycles. In particular it was shown that both inter-turbine and intra-turbine reheat offer significant improvements in power density and fuel consumption.

PUBLICATIONS:

Baker, J.D. and Millsaps, K.T., "Using Condition Based Maintenance in Assessing the State of Fouling and Degradation in a Gas Turbine Compressor," *ASNE Fleet Maintenance Conference*, Norfolk, VA, November 2003, (abstract submitted).

Millsaps, K.T. and Baker, J.D., "Analysis of the Sensitivity of Multi-Stage Axial Compressors to Fouling at Various Stages," *IGTI Conference*, May 2004, (abstract submitted July 2003).

Millsaps, K.T. and Rodman, B.E., "Thermodynamic Analysis of Inter-Turbine and Intra-Turbine Reheat Gas Turbines for Marine Propulsion and Ship Service Applications," *Turbine Engine Technology Symposium*, Dayton, OH, 9-12 September 2002.

Millsaps, K.T. and Rodman, B.E., "Thermodynamic Analysis of Inter-Turbine and Intra-Turbine Reheat Gas Turbines for Marine Propulsion and Ship Service Applications," *IGTI Conference*, May 2004, (abstract submitted July 2003).

THESIS DIRECTED:

Baker, J.D., "Analysis of the Sensitivity of Multi-Stage Axial Compressors to Fouling at Various Stages," Master's Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: Propulsion, Gas Turbines, Condition Based Maintenance, CBM, Compressor Fouling, Thermodynamic Analysis, Reheat, Intra-turbine and Inter-turbine Combustion, Augmentors, Inter Turbine Burning

MECHANICAL ENGINEERING

DISTANCE LEARNING SUPPORT FOR TS4001

Fotis A. Papoulias, Associate Professor
Department of Mechanical Engineering
Sponsor: Chief of Naval Education and Training

OBJECTIVE: The goal of this project was to develop resources in support of ship design in the World Wide Web.

SUMMARY: The purpose of this project was to develop a web based class on Ship Design in support of the TSSE program. The outcome of this project was the development of a comprehensive web site on Naval Architecture and Ship Design, with over two thousand files, incorporating text, graphs, support information material, and fully interactive examples. The site is fully integrated into the Blackboard web based delivery system adopted by NPS.

KEYWORDS: Ship Design, Distance Learning

EXTENDED STATE SPACE MODELING OF RRDF

Fotis A. Papoulias, Associate Professor
Department of Mechanical Engineering
Sponsor: Naval Surface Warfare Center, Carderock Division

OBJECTIVE: The goal of this project was to develop a model in order to bridge the gap between existing constant coefficient time domain and more accurate hydrodynamic models.

SUMMARY: A mathematical model describing the fundamental dynamics in the interface problem between a ship, a barge, and a connecting ramp was developed and solved. The hydrodynamics for the ship and the barge were described by a 12-degree of freedom fully coupled model, which was based on potential theory and incorporated proximity effects. Ramp structural dynamics were studied by a finite element model, which was calibrated based on detailed studies of commercially available codes. The models were coupled together through a spring/damper and the solution of the system was obtained in both regular waves and a representative sea state. Parametric studies with regards to different coupling conditions proved that optimization based on either relative motions or ramp maximum stress is possible. Work in this area is continuing.

THESES DIRECTED:

Haigh, J.J., "Computational Dynamics and Stress Analysis of Full Scale Model Roll-on, Roll-off Stern Ramp with Wave Motion Compensation," Master's Thesis, Naval Postgraduate School, June 2002.

Higgins, B., "Motion Analysis of a Trolley Interface for Ship-to-Ship Cargo Transfer," Master's Thesis, Naval Postgraduate School, December 2002.

KEYWORDS: Frequency Response, Seakeeping, RORO Operations, Vibration Isolation

MOTION MINIMIZATION IN HIGH SPEED TOWING OPERATIONS

Fotis A. Papoulias, Associate Professor
Department of Mechanical Engineering
Sponsor: Office of Naval Research

OBJECTIVE: The objective of this project was to support the Office of Naval Research in further development of the novel SLICE hull form with a trailer hull.

SUMMARY: The focus of this project was on a hinge connection between the "tractor" and "trailer" SLICE vessels. This provides a number of technical challenges in high-speed high sea state ocean towing

systems that have not been studied in the past. A model describing the dynamics of the two bodies under tow was developed. A series of runs was conducted in order to gain some insight into the seakeeping behaviors of the two ships. A generic spring/damper connection was assumed to exist at the interface. Current studies aim at more realistic configurations, along with the establishment of a design and analysis procedure in order to quantify the performance degradation in a seaway. A simulation model for low frequency motions was also developed, and a comprehensive stability analysis is underway.

THESES DIRECTED:

Glenn, E., "Close Proximity Vessel Towing in Six Degree of Freedom Motions in Short Crested Seas," Master's Thesis, Naval Postgraduate School, September 2002.

Gokce, M., "Coupled Stability Analysis of Close Proximity Ship Towing," Master's Thesis, Naval Postgraduate School, March 2002.

Korkut, M., "Nonlinear Dynamics of Close Proximity Ship Towing," Master's Thesis, Naval Postgraduate School, December 2002.

Okan, O., "A Design Procedure for Seakeeping Analysis of Close Proximity Ship Towing," Master's Thesis, Naval Postgraduate School, March 2002.

Rodriguez, R., "A Characterization of Sway Forces Induced by Close Proximity Ship Towing," Master's Thesis, Naval Postgraduate School, March 2002.

KEYWORDS: Towing, Seakeeping

ROBUST DISTRIBUTED CONTROL OF SHIPBOARD SYSTEMS

Fotis A. Papoulias, Associate Professor
Department of Mechanical Engineering
Sponsor: Office of Naval Research

OBJECTIVE: The goal of this ongoing project is to analyze the effectiveness of a market based approach to power distribution in warships.

SUMMARY: In an effort to more effectively and efficiently utilize the total installed power shipboard, the U.S. Navy is developing the technologies and systems to implement an Integrated Power System including high-power-density motors, converters, and pods. As such, the future Navy surface combatant offers considerable opportunities for control systems to monitor status, manage information, automate functions, direct reconfiguration, allocate capacity, and augment crew capabilities during both normal and combat scenarios. In cooperation with Biosgroup, the Naval Postgraduate School has provided domain expertise relevant to the development of multiagent systems for distributed control in warships. In this context, NPS has identified a target ship platform, the relevant IPS architecture and component technology, delineated reasonable component operational capabilities, created representative ship fault scenarios including cascading casualty situations, developed dynamic operational scenarios that require power system reconfiguration or reallocation, provided guidance as to the reasonableness of prospective "control" actions, and served as an interface to accommodate the application of such control actions in a reduced-scale Navy test-bed.

KEYWORDS: Distributed Control, Casualty Control

MECHANICAL ENGINEERING

DYNAMICS OF BOW WAVES/SPRAY GENERATION

T. Sarpkaya, Distinguished Professor
Department of Mechanical Engineering
Sponsor: Office of Naval Research

OBJECTIVE: This continuing basic research is an experimental investigation of the formation of bow waves on Destroyers. The objective is to understand enough of the hydrodynamics of the effect of bow shape on the jet separation in order to minimize the spray generation and resistance. In addition, the effect of the contaminants on the decay of turbulence in the wake of the destroyer is studied extensively.

SUMMARY: Measurements of bow waves were made with several high-speed imagers, a pulsating laser, and a Digital Particle Image Velocimeter (DPIV) system and analyzed through the use of appropriate software. The Reynolds number ranged from 2.4×10^4 to 4×10^4 , the Froude number from 15 to 30, and the Weber number from 1,500 to 3,000. The characteristics of the separated sheet have been evaluated for a large number of bow motions and their combinations: heave, pitch and yaw in calm seas. Additional work involves the effect of waves on the heave and pitch of the test models (scale model of an actual destroyer).

PUBLICATION:

Markle, H.B. and Sarpkaya, T., "Bow Waves on a Free-Running, Heaving and/or Pitching Destroyer," *Naval Hydrodynamics*, National Academy of Sciences, Washington, D.C., pp. 1-15, 2002.

CONFERENCE PAPER:

Markle, H.B. and Sarpkaya, T., "Bow Waves on a Free-Running, Heaving and/or Pitching Destroyer," *Proceedings of the 24th Naval Hydrodynamics Symposium*, Fukuoka, Japan, 7-13 July 2002.

THESIS DIRECTED:

Markle, H.B., "An Experimental Investigation of the Bow Wave on *USS COLE* (DDG-67)," Master's Thesis, Naval Postgraduate School, September 2001.

KEYWORDS: Hydrodynamics, Drop Formation, Spray

FLOW-INDUCED VIBRATIONS

T. Sarpkaya, Distinguished Professor
Department of Mechanical Engineering
Sponsor: Office of Naval Research

OBJECTIVE: To compose an inspired review of all that is best in the works of the past century on flow-induced vibrations for the next generation of researchers and engineers. Everything important, from the fundamental phenomena to new directions for research, from theory and numerical simulations to experiments, are to be covered in a seminal journal paper.

SUMMARY: Flow-induced vibrations occur in many engineering situations, such as bridges, stacks, transmission lines, offshore structures, heat exchangers, marine cables, flexible risers in petroleum production, and other hydrodynamic and hydroacoustic applications. During the past century, a great deal of work has been done on flow-induced vibrations and fluidelastic instability. The number of contributions has increased exponentially. Thus, the amount of time required for any one researcher to comprehend the literature and to plow through the empirical morass became an increasingly larger fraction of his research time. Clearly, to move forward and to make contributions that shape the art and science of flow-induced vibrations in the new century, one must know and fully understand the essence of the work done during the past century, i.e., the safeguarding as well as safeguarding hand of the understanding of the existing theoretical, experimental, numerical and empirical evidence must be periodically re-energized and

marshaled for new discoveries and applications. This requires a comprehensive review, at least every 25 years.

CONFERENCE PAPER:

Sarpkaya, T., "A Compendious Review of Vortex Induced Vibrations," *International Union of Theoretical and Applied Mechanics Congress*, Rutgers University, NJ, 2-6 June 2002.

KEYWORDS: VIV, Vortex, Vibration, Flow, Oscillation, Structures

MECHANISM OF SPRAY GENERATION AT THE FREE SURFACE OF LIQUID JETS

T. Sarpkaya, Distinguished Professor
Department of Mechanical Engineering
Sponsor: Office of Naval Research

OBJECTIVE: This continuing basic research is an experimental investigation of the ligament and drop formation at the free surface of liquid wall jets, flowing over smooth and sand-roughened plates towards the understanding of the physics of droplet formation, in general, and of the spray formation on bow-sheets, in particular.

SUMMARY: Measurements were made with several high-speed imagers, a pulsating laser, and a Digital Particle Image Velocimeter (DPIV) system and analyzed through the use of appropriate software. The wall-jet Reynolds number ranged from 2.4×10^4 to 4×10^4 , the Froude number from 15 to 30, and the Weber number from 1,500 to 3,000. The characteristics of the ligament forest and droplets were determined from the digitized images. In addition various surfactants were used to determine the effect of contamination on the integral length scale of turbulence.

PUBLICATIONS:

Markle, H.B. and Sarpkaya, T., "Bow Waves on a Free-Running, Heaving and/or Pitching Destroyer," *Naval Hydrodynamics*, National Academy of Sciences, Washington, D.C., pp. 1-15, 2002.

Sarpkaya, T., "Experiments on the Stability of Sinusoidally Oscillating Flow over a Circular Cylinder," *Journal of Fluid Mechanics*, Vol. 457, pp. 157-180, 2002.

CONFERENCE PAPER:

Markle, H.B. and Sarpkaya, T., "Bow Waves on a Free-Running, Heaving and/or Pitching Destroyer," *Proceedings of the 24th Naval Hydrodynamics Symposium*, Fukuoka, Japan, 7-13 July 2002.

THESIS DIRECTED:

Markle, H.B., "An Experimental Investigation of the Bow Wave on *USS COLE* (DDG-67)," Master's Thesis, Naval Postgraduate School, September 2001.

KEYWORDS: Hydrodynamics, Drop Formation, Spray

MECHANICAL ENGINEERING

MODEL OF DYNAMICS AND DECAY OF WAKE VORTICES IN PARALLEL RUNWAYS

**T. Sarpkaya, Distinguished Professor
Department of Mechanical Engineering**

Sponsor: National Aeronautics and Space Administration - Langley Research Center

OBJECTIVE: The purpose of the investigation was (a) to enhance the new vortex decay model for the prediction of the descent of aircraft trailing vortices subjected to realistic environmental conditions (stratification, turbulence, cross wind, headwind, shear effects, and ground effect), and (b) to apply the model to field data obtained with Lidar in Memphis and Dallas–Fort Worth airports. In addition, to extend the results to parallel runways, wake transport between runways, vortex bouncing and lofting, and other decay phenomena.

SUMMARY: A robust and relatively simple physics-based vortex decay model has been devised. It does not violate any hydrodynamical principles, has only one model constant, uses the turbulence eddy dissipation rate in conjunction with a theoretical model (as verified by experiments and numerical simulations), and it requires no cumbersome algorithms to account for the ground effects. Acquisition of better and more detailed field data (vortex velocities and positions; wind, shear and their gradients; better temperature, humidity, and eddy dissipation profiles), the quantification of the consequences of unstable stratification, and the optimization of the new model parameters constitute the essence of this continuing research of vital international importance. The model has been successfully tested at the Dallas-Fort Worth airport in September 2001. It is now being recast for the prediction of landings on parallel runways

PUBLICATION:

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

OTHER:

The model has now been incorporated into NASA’s AVOSS program for the management of aircraft landings at large airports (JFK, Memphis, DFW, and New Orleans). Sarpkaya is cited as one of the inventors of the model by NASA. In addition, NASA has presented Sarpkaya with the prestigious award of “Turning Goals into Reality” for his exceptional contributions.

KEYWORDS: Trailing Vortices, Aircraft Wakes, Wake Hazard

REVIEW OF HYDRODYNAMIC LOADS ON STRUCTURES

**T. Sarpkaya, Distinguished Professor
Department of Mechanical Engineering
Sponsor: Nuclear Regulatory Commission**

OBJECTIVE: To review the appropriate topical reports and any other relevant data on hydrodynamic loads on structures submerged in the pressure suppression pools of boiling-water nuclear reactors. The ultimate purpose of these reviews and detailed analyses is to provide sound technical advice to NRC on unsteady flow about specific types of strainers and, in particular, on the prevailing Keulegan-Carpenter numbers and acceleration drag loads so that NRC can perform its regulatory duties in the light of the expert opinion and complete its review of the strainers under their consideration.

SUMMARY: A thorough study of about 3,000-page reports and papers led to the conclusion that the determination of the typical values of the Keulegan-Carpenter number, K , and the acceleration drag coefficient, C_m , for the conditions expected following a loss-of-coolant accident (LOCA) and safety/relief valve (SRV) discharge requires the load carrying capacities (LCCs) of the strainers, the positions of the largest stresses on the strainers and/or their attachments; the velocities, accelerations, (their magnitudes and directions) and their distribution throughout the suppression pool during the first few seconds of LOCA and SRV. In summary, the existing analyses and experiments are inadequate for the assessment of the safety of

the strainers in Boiling-Water Nuclear Reactors. Proper analyses and experiments have been performed to provide sound technical guidance to NRC towards the fulfillment of its regulatory duties.

PUBLICATIONS:

Sarpkaya, T., "On the Force Decompositions of Lighthill and Morison," *Journal of Fluids and Structures*, Vol. 15, No. 2, pp. 227-233, February 2001.

Sarpkaya, T., "Revised Final Technical Evaluation Report to NRC," September 2002.

THESIS DIRECTED:

Osgood, D.B., "Flow About Perforated Bodies," Master's Thesis, Naval Postgraduate School, June 2000.

KEYWORDS: Nuclear Reactors, Inertial Force, Perforated Bodies, Unsteady Flow

SHIP DAMPING STUDIES FOR ENERGY DISSIPATION IN SHIP STRUCTURE SYSTEM

Young S. Shin, Professor

Young W. Kwon, Professor

Department of Mechanical Engineering

Sponsor: Naval Surface Warfare Center, Carderock Division

OBJECTIVE: To investigate ship damping mechanisms for energy dissipation in ship structure system

SUMMARY: The following tasks were performed: (1) a state-of-the-art literature survey for ship damping, (2) UNDEX test data analysis for identification of energy dissipation sources, (3) simple laboratory tests and simulations to explain the identified elements, (4) ship damping studies for distribution of energy dissipation and parametric studies using ship shock simulations, and (5) development of implementation strategy in transient ship shock analysis.

PUBLICATIONS:

Shin, Y.S. and Ham, I.B., "Damping Modeling Strategy for Naval Ship Systems-I," Preliminary Report for Review, October 2002.

Shin, Y.S. and Ham, I.B., "Damping Modeling Strategy for Naval Ship System-II," Final Draft Report for Review, December 2002.

THESES DIRECTED:

Cahill, J.J., "Experimental Studies of Noise/Vibration Damping for Undersea Warfare Applications," Master's Thesis, Naval Postgraduate School, June 2002.

Carey, A.E., "Experimental Studies of Welding Effects on Damping for Undersea Warfare Applications," Master's Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: Ship Damping, Energy Dissipation, Underwater Explosion

MECHANICAL ENGINEERING

SHOCK AND VIBRATION ANALYSIS IN SUPPORT OF DDG-81 CLASS SHOCK FOLLOW-ON ACTIONS

Young S. Shin, Professor
Department of Mechanical Engineering
Sponsor: Naval Sea Systems Command

OBJECTIVE: To perform shock and vibration analysis in support of DDG-81 Class shock follow-on actions including DDG-81 Flight IIA ship shock modeling and simulation to predict dynamic responses to underwater explosions. The predicted results will be compared with ship shock trial test data.

SUMMARY: This is a continuation of work sponsored by NAVSEA PMS400D. We have previously conducted 3D Ship Shock Modeling and Simulation for DDG-53 (FLT I) John Paul Jones and proved that we can predict ship shock responses well. This task includes the investigation of the ship shock modeling and simulation for DDG-81 (FLY IIA), Winston Churchill. With the experience and knowledge acquired from DDG-53 work, the surrounding fluid model was significantly improved and the energy dissipation scheme is also improved. The dynamic transient responses of ship system and subsystem structures are computed. The results are to be compared with DDG-81 Ship Shock Trial Data.

CONFERENCE PAPERS:

Shin, Y.S., "Response of Undersea Vehicles to Underwater Explosions," *Proceedings of UDT2002*, Undersea Defense Technology Conference, Cheju, Korea, 8-10 October 2002.

Shin, Y.S., "Ship Shock Modeling and Simulation for Far-Field Underwater Explosion," *Proceedings of the Third International Conference on Engineering Computational Technology*, Prague, Czech Republic, 4-6 September 2002, (to appear in special edition of *Computer and Structures* in Summer 2003).

PRESENTATIONS:

Shin, Y.S., "Overview of Underwater Shock and DDAM," 73rd Shock and Vibration Symposium, 3-hour tutorial, Newport RI, 19-22 November 2002.

Shin, Y.S., "Response of Undersea Vehicles to Underwater Explosions," UDT2002, Undersea Defense Technology Conference, Cheju, Korea, 8-10 October 2002.

Shin, Y.S., "Ship Shock Modeling and Simulation for Far-Field Underwater Explosion," Third International Conference on Engineering Computational Technology, Prague, Czech Republic, 4-6 September 2002.

THESIS DIRECTED:

Hart, D., "DDG-81 Ship Shock Modeling and Simulation: Surrounding Fluid Effects," Master's Thesis, Naval Postgraduate School, March 2002.

KEYWORDS: Underwater Explosion, Ship Shock, DDG-51 Class Ship, Modeling and Simulation

**DEPARTMENT OF
MECHANICAL ENGINEERING**

**2002
Faculty Publications
and Presentations**

JOURNAL ARTICLES

Carey, A.E., "Experimental Studies of Welding Effects on Damping for UnderSea Warfare Application," *MSME*, September 2002.

Dutta, I., Gopinath, A. and Marshall, C., "Underfill Constraint Effects During Thermo-Mechanical Cycling of Flip Chip Solder Joints," *Journal of Electronic Mater.*, 31, p. 253, 2002.

Dutta, I., Peterson, K.A. and Chen, M.W., "Interfacial Sliding in Multi-Component Materials Systems and Its Mechanism," *Modeling the Performance of Engineering Structural Materials III*, TMS, T.S. Srivastan, D.R. Leseur and E.M. Taleff (Eds.), pp. 253-267, 2002.

Kwon, Y.W. and Altekin, A., "Multi-level, Micro-macro Approach for Analysis of Woven Fabric Composites," *Journal of Composite Materials*, Vol. 36, No. 8, pp. 1005-1022, 2002.

Kwon, Y.W., Cooke, R.E. and Park, C., "Representative Unit-Cell Models for Open-Cell Metal Foams With or Without Elastic Fillers," *Materials Science and Engineering A*, 343, pp. 63-70.

Kwon, Y.W. and Lannamann, D.L., "Dynamic Modeling and Simulation of Interfacial Cracks in Sandwich Structures for Damage Detection," *Journal of Sandwich Structures and Materials*, Vol. 4, No. 2, pp. 175-199, April 2002.

Markle, H.B. and Sarpkaya, T., "Bow Waves on a Free-Running, Heaving and/or Pitching Destroyer," *Naval Hydrodynamics*, National Academy of Sciences, Washington, D.C., pp. 1-15, 2002.

McNelly, T.R., Swisher, D.L., Horita, Z. and Langdon, T.G., "Influence of Processing Route on Microstructure and Grain Boundary Development During Equal-Channel Angular Pressing of Pure Aluminum," *Ultra-Fine Grained Materials II*, pp. 15-24, TMS: Warrendale, PA, Y.T. Zhu, et al. (Eds.).

McNelly, T.R., Swisher, D.L. and Pérez-Prado, M.T., "Deformation Bands and the Formation of Grain Boundaries in a Superplastic Aluminum Alloy," *Metallurgical and Materials Transactions A*, Vol. 33A, pp. 279-90, 2002.

Pérez-Prado, M.T., González-Doncel, G., Ruano, O.A. and McNelly, T.R., "Texture Analysis and the Transition from Slip to Grain Boundary Sliding in a Discontinuously Recrystallized Superplastic Aluminum Alloy," *Acta Materialia*, Vol. 49, pp. 2259-68, 2002.

Peterson, K.A., Dutta, I. and Chen, M.W., "Measurement of Creep Kinetics at Al-Si Interfaces," *Scripta Mater.*, 47, p. 649, 2002.

Peterson, K.A., Dutta, I. and Park, C., "Interfacial Creep in Multi-Component Material Systems," *Journal of Metals, Minerals and Materials Soc. (JOM)*, 55, No. 1, pp. 37-43, 2003.

Sarpkaya, T., "Experiments on the Stability of Sinusoidally Oscillating Flow over a Circular Cylinder," *Journal of Fluid Mechanics*, Vol. 457, pp. 157-180, 2002.

Sarpkaya, T., "On the Force Decompositions of Lighthill and Morison," *Journal of Fluids and Structures*, Vol. 15, No. 2, pp. 227-233, February 2001.

Sarpkaya, T., "Review of Inviscid Incompressible Flows," *Journal of the American Institute of Aeronautics and Astronautics (AIAA J)*, Vol. 40, No. 7 (July), pp: 1476-1487.

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

MECHANICAL ENGINEERING

Terhune, S.D., Swisher, D.L., Oh-ishi, K., Horita, Z., Langdon, T.G. and McNelley, T.R., "An Investigation of Microstructure and Grain-Boundary Evolution During ECA Pressing of Pure Aluminum," *Metallurgical and Materials Transactions A*, Vol. 33A, pp. 2173-84, 2002.

CONFERENCE PAPERS

Dunne, J.E., Smith, V.E., Gopinath, A. and Dutta, I., "Modeling the Effects of Cycling of a Localized Heat Source on the Durability of a FCOC with Defects," *Proceedings of the 52nd Electron. Comp. Tech. Conference (ECTC-IEEE)*, p. 622, 2002.

Dutta, I., Park, C. and Choi, S., "Creep and Microstructural Coarsening in Lead-Free Microelectronic Solder Joints" *Proceedings of InterPACK 2003, Intl. Electronic Packaging Technology Conference*, Maui, HI, July 2003.

Dutta, I., Peterson, K. and Chen, M.W., "Plasticity and Interfacial Sliding in Cu Thin Film:Si Substrate Systems During Thermal Cycling," *Plasticity, Damage and Fracture at Macro, Micro and Nano Scales, Proceedings of the Ninth International Symposium on Plasticity*, NEAT Press, A.S. Khan and O. Lopez-Pamies (Eds.), pp. 117-119, 2002.

Kwon, Y.W. and Jung, S.H., "Atomistic Model for Static Equilibrium Problems," *Proceedings of the Sixth International Conference on Computational Structures Technology*, CST02/paper No. 2, 1-12, Prague, Czech Republic, September 2002.

Kwon, Y.W. and Jung, S.H., "Computational Nanomechanics," *Recent Advances in Solids and Structures - 2002, IMECE 2002*, CD-Rom Vol. 3, New Orleans, LA, 2002.

Kwon, Y.W. and Liu, C.T., "Study of Interaction Between Non-uniform Particle Distribution and the Crack Initiation and Growth Under Tensile Loading," *Proceedings of the International Conference on Computational Engineering and Sciences*, Reno, NV, August 2002.

Kwon, Y.W. and Liu, C.T., "Study of Microstructural Effects in Particulate Composites," *Recent Advances in Solids and Structures-2002, IMECE 2002*, CD-Rom Vol. 3, New Orleans, LA, 2002.

Markle, H.B. and Sarpkaya, T., "Bow Waves on a Free-Running, Heaving and/or Pitching Destroyer," *Proceedings of the 24th Naval Hydrodynamics Symposium*, Fukuoka, Japan, 7-13 July 2002.

Peterson, K.A., Park, C. and Dutta, I., "Interfacial Sliding in Back-End Interconnect Structures in Microelectronic Devices," *Silicon Materials - Processing, Characterization and Reliability, Proceedings of the MRS Symposium*, MRS, Vol. 716, p. 483, J. Veteran, D.L. O' Meara, V. Misra and P. Ho (Eds.), 2002.

Shin, Y.S., "Response of Undersea Vehicles to Underwater Explosions," *Proceedings of UDT2002*, Undersea Defense Technology Conference, Cheju, Korea, 8-10 October 2002.

Shin, Y.S., "Ship Shock Modeling and Simulation for Far-Field Underwater Explosion," *Proceedings of the Third International Conference on Engineering Computational Technology*, Prague, Czech Republic, 4-6 September 2002.

PRESENTATIONS

Bierley, J.M. and Gopinath, A., "A Parametric Design Study of InGaAs MTPV Cells Coupled to Various Emitters at Near and Far Spacings," Fifth International Conference on Thermophotovoltaic Generation of Electricity, Rome, Italy, 15-19 September 2002.

Dutta, I., Choi, S. and Anastasio, N., "Microstructural Coarsening and Creep Response of Microelectronic Solder Joints," Symposium on Lead Bearing and Lead-Free Solders, 2002 TMS Fall Meeting, Columbus, OH, 6-10 October 2002.

Fodrea, L.T. and Healey, A.J., "Obstacle Avoidance Control for the REMUS Autonomous Underwater Vehicle," IFAC Workshop on Guidance and Control of Unmanned Underwater Vehicles, Newport, UK, April 2003.

Hamilton, L.J., Adametz, D.S., Lind, E.K. and Gopinath, A., "Numerical Analysis of the Performance of a Staggered Cross-Pin Array Heat Exchanger," 8th AIAA/ASME Joint Thermophysics and Heat Transfer Conference, St. Louis, MO, 24-26 June 2002.

Hamilton, L.J. and Gopinath, A., "Numerical Analysis of the Performance of a Staggered Cross-Pin Array Heat Exchanger," Turbine Engine Technology Symposium, Dayton, OH, 9-12 September 2002.

Kwon, Y.W. and Jung, S., "Atomistic Model for Static Equilibrium Problems," Sixth International Conference on Computational Structures Technology, Prague, Czech Republic, September 2002.

Kwon, Y.W. and Jung, S., "Computational Nanomechanics," 2002 ASME International Mechanical Engineering Congress and Exposition, New Orleans, LA, 2002.

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Kwon, Y.W. and Liu, C.T., "Study of Microstructural Effects in Particulate Composites," 2002 ASME International Mechanical Engineering Congress and Exposition, New Orleans, LA, 2002.

McNelley, T.R., Maestas, T.A., Kulas, M.A. and Taleff, E.M., "Investigation of the Deformation and Failure Mechanisms in AA5083 Materials," Symposium on Superplasticity and Superplastic Forming, ASMI Fall Meeting, Columbus, OH, 9 October 2002.

McNelley, T.R., Swisher, D.L., Horita, Z. and Langdon, T.G., "Influence of Processing Route During Equal-Channel Angular Pressing of Pure Aluminum," Second International Symposium on Ultra-Fine Grain Materials: Processing and Structure, TMS Annual Meeting, Seattle, WA, February 2002.

Millsaps, K.T., "Congressional Decision Processes for Funding of Defense Science and Technology Programs," ASME Board on Government Affairs, Washington D.C., 12 September 2002.

Millsaps, K.T., "Overview of Presidents Budget Request for DDR&E Programs for FY2003," Research and Development Conference, Washington D.C., 4-5 March 2002.

Millsaps, K.T. and Rodman, B.E., "Thermodynamic Analysis of Inter-Turbine and Intra-Turbine Reheat Gas Turbines for Marine Propulsion and Ship Service Applications," Turbine Engine Technology Symposium, Dayton, OH, 9-12 September 2002.

Oh-ishi, K., Cuevas, A.M., Park, C. and McNelley, T.R., "Microstructure Evolution During FSP of an As-cast NAB Material," Workshop on Friction Stir Welding and Processing, Rockwell Scientific Corporation, Thousand Oaks, CA, December 2002.

Sarpkaya, T., "A Compendious Review of Vortex Induced Vibrations," International Union of Theoretical and Applied Mechanics Congress, Rutgers University, NJ, 2-6 June 2002.

Sarpkaya, T. and Markle, H.B., "Quantification of the Bow Waves and Spray Sheets," Pasadena, CA, April 2002 and University of California-San Diego, CA, September 2002.

Shin, Y.S., "Overview of Underwater Shock and DDAM," 73rd Shock and Vibration Symposium, 3-hour tutorial, Newport RI, 19-22 November 2002.

MECHANICAL ENGINEERING

Shin, Y.S., "Response of Undersea Vehicles to Underwater Explosions," UDT2002, Undersea Defense Technology Conference, Cheju, Korea, 8-10 October 2002.

Shin, Y.S., "Ship Shock Modeling and Simulation for Far-Field Underwater Explosion," Third International Conference on Engineering Computational Technology, Prague, Czech Republic, 4-6 September 2002.

TECHNICAL REPORTS

Gopinath, A., "Evaluation of Cooling Technologies for Magnetostrictive Actuators," Technical Report.

Gordis, J.H., Papoulias, F.A. and Haigh, J.J., "Motion Compensator Analysis Executive Summary," Technical Report, March 2002.

Haigh, J.J. and Gordis, J.H., "Motion Compensator Analysis," Technical Report, March 2002.

Millsaps, K.T., Imber, R.D. and Ratcliffe, R.J., "Development of the Enhanced Mixing Suppressor for the LMS (U)," NSWCCD-74-TR-2001/010, January 2001, (SECRET).

Ratcliffe, R., Imber, R., Bird, W. and Millsaps, K.T., "Final Report for the Low Observable Multi-Function Stack Advanced Technology Demonstrator Program (U)," (SECRET).

Ratcliffe, R., Imber, R., Bird, W. and Millsaps, K.T., "Test Report for LMS at Sea Trials (U)," (SECRET).

Sarpkaya, T., "Revised Final Technical Evaluation Report to NRC," September 2002.

Shin, Y.S. and Ham, I.B., "Damping Modeling Strategy for Naval Ship Systems-I," Preliminary Report for Review, October 2002.

Shin, Y.S. and Ham, I.B., "Damping Modeling Strategy for Naval Ship System-II," Final Draft Report for Review, December 2002.

CONTRIBUTION TO BOOKS

"Recent Advances in Solids and Structures-2002, ASME PVP," *2002 ASME International Mechanical Engineering Congress and Exposition*, ASME, New York: New York, Y.W. Kwon and H.H. Chung (Eds.).

**DEPARTMENT OF
METEOROLOGY**

**CARLYLE WASH
CHAIR**

METEOROLOGY

OVERVIEW:

The Department of Meteorology provides graduate-level instruction in the science of meteorology and its application in support of military operations. To maintain expertise and provide support to student theses, the faculty performs research in the Navy-relevant areas of synoptic and dynamic meteorology, remote sensing, numerical modeling, tropical meteorology, boundary layer meteorology, and environmental effects.

Over 40 years ago, 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

METEOROLOGY

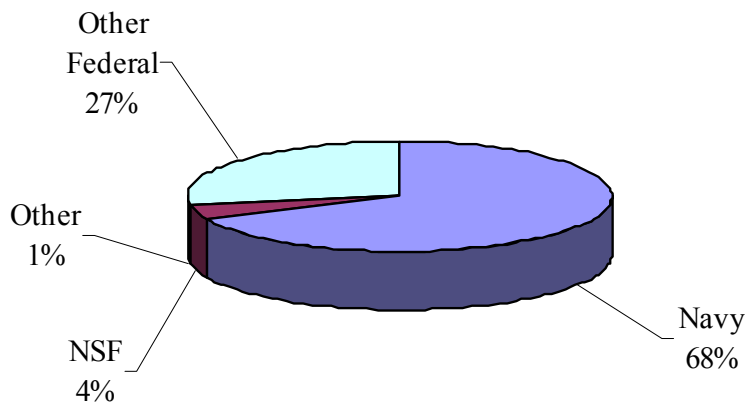
- Tropical Cyclone Motion:
Distinguished Professor Russell Elsberry, Research Assistant Professor Kevin Cheung, Research Associate Professor Patrick Harr
- Boundary Layer Meteorology:
Professor Kenneth Davidson, Associate Professor Qing Wang
- Climate Dynamics:
Professor Chih-Pei Chang, Professor Roger Williams, Research Associate Hway-Jen Chen, Senior Lecturer Tom Murphee
- Atmospheric Factors in EM/EO Propagation:
Professor Kenneth Davidson, Research Associate Professor Peter Guest, Research Associate Paul Fredrickson
- Polar Meteorology:
Research Associate Professor Peter Guest

RESEARCH FACILITIES:

- **IDEA Laboratory:** The Interactive Digital Environmental Analysis (IDEA) laboratory has Silicon Graphics workstations specifically designed and funded for instruction. The lab computers are used to analyze and display real-time satellite data and numerical model output.
- **Tactical Laboratory:** The Tactical Lab operates an SMQ-11 DMSP satellite receiver that collects and processes classified environmental data and runs military tactical decision aids used to support operations.
- **Synoptic Analysis and Forecasting Laboratory:** The Synoptic Analysis and Forecasting Lab uses a suite of computers and advanced display devices to provide local and global real-time meteorological data and numerical products for instruction and research in operational weather forecasting.
- **Atmospheric Boundary Layer Measurements Laboratory:** The Measurements Lab provides information from a special near-coastal observation site at Fort Ord in support of instruction and research in boundary layer and coastal meteorology. Present instrumentation includes two radar wind profilers, an automatic surface weather station, and rawinsonde systems.

SPONSORED RESEARCH PROGRAMS (Research and Academic)-FY2002:

The Naval Postgraduate School's sponsored program exceeded \$61 million in FY2002. Sponsored programs included both research and educational activities funded from an external source. A profile of the sponsored program for the Department of Meteorology is provided below:



Size of Program: \$2,668K

METEOROLOGY

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METEOROLOGY

DYNAMICS OF NORTHWEST PACIFIC TROPICAL DISTURBANCES AND MONSOON

Chih-Pei Chang, Professor
Roger Terry Williams, Professor
Department of Meteorology
Sponsor: National Science Foundation

OBJECTIVE: To study the interactions between Asia/Australian monsoon and tropical disturbances, particularly the dynamics of the formation and intensification of tropical disturbances in the monsoon confluence region in the Northwest Pacific.

SUMMARY: In this year a study was carried out of the formation of concentric vorticity structure in typhoons. The observational evidence was Typhoon Lekima During 25-26 September 2001, when it moved northwestward near the southern tip of Taiwan. At 0900 local time 25 September, the typhoon possesses a small and strong central core vortex (of 10^{-3} s^{-1} to 10^{-2} s^{-1} vorticity field) with a huge area of convection southwest of the vortex. Subsequent revolution as indicated by radar reflectivity suggests that the huge area of convection stretched and wrapped around the central vortex to form a concentric eyewall structure in less than 10 hours. In this work a nondivergent barotropic model was used to test a hypothesis that the formation of the concentric eyewall in Typhoon Lekima may be in part due to the vorticity advective dynamics. In this hypothesis it is postulated that the concentric eyewall is a result of the shearing out of the huge area of convection into a band surrounding the central vortex. The hypothesis was tested by considering the interaction between a small and strong inner vortex (the tropical cyclone core) and a larger and weaker outer vortex (the vorticity induced by the moist convection outside the central vortex of a tropical cyclone). The formation of the concentric eyewall is studied in terms of the separation distance, the vorticity strength ratio, and the radius size ratio of the two vortices. In general, the formation of the concentric vorticity structure requires a very strong core vortex (at least 4 times stronger than the neighboring vorticity), a larger area of the weaker vorticity field (2 times larger in size), and a separation distance of 2 to 3 times of the inner vortex radius. The evolution in Typhoon Lekima appeared to meet these conditions. The negative vorticity anomaly between the two vortices serves as a “shield” to impose a barrier to the inward mixing the outer vorticity field. If the separation distance is too close, the resultant evolution most likely leads to either a merger or a tripole vortex formation. The central core vortex has to be strong to maintain itself against any deformation field from the environment due to the outer vortex. In addition, the stronger vortex induces a differential rotation across the weaker vortex to strain out the latter into a vorticity band surrounding the former. The change of sign of vorticity gradient across the band satisfies the Rayleigh necessary condition for instability. However, the band is stabilized by the Fjortoft sufficient condition for stability because the strong inner vortex can cause the wind at the inner edge to be stronger than the outer edge, allowing the vorticity band and therefore the concentric structure to be sustained.

PUBLICATIONS:

Chang, C.-P. and Li, T., “Tropical Tropospheric Biennial Oscillation and ENSO,” Selected Papers, 4th Conference on East Asia and Western Pacific Meteorology and Climate, *World Scientific Series on Meteorology of East Asia*, Vol. 1, 159-171, 2002.

Chang, C.-P., Liu, C.H. and Kuo, H.C., “Typhoon Vamei: An Equatorial Tropical Cyclone Formation,” *Geophysical Research Letters*, 30, 2002, (in press).

KEYWORDS: West Pacific, Typhoons, Tropical Meteorology, Tropical Cyclones

METEOROLOGY

FORECAST OF CLOUD PROBABILITY IN SOUTHEAST ASIA

**Chih-Pei Chang, Professor
Department of Meteorology**

**Sponsor: Naval Sea System Command in Collaboration with Ministry of Defense,
Republic of Singapore**

OBJECTIVE: The objective is to analyze historical GMS satellite blackbody temperature data, airport surface station cloud data, and gridded NWP analyzed wind data to derive empirical forecast tools for the probability of cloud cover in the vicinity of Singapore.

SUMMARY: Five forecast tools were planned. The two climatology tools are the diurnal cycle and the persistence climatology. The GMS blackbody temperature data was used to produce the distribution of diurnal cycles at 25 km resolution over the Southeast Asia in different months. This tool is useful over locations of large diurnal amplitude during un-disturbed conditions. Airport META reports at five locations around Singapore were used to develop the climatology and persistence climatology models for cloud cover at different levels. The other three tools are of the synoptic type and are applicable for northern winter when the large-scale influence to the cloud development is significant. The three synoptic tools are based on low level NWP wind analysis from NCEP and NOGAPS. The first is a synoptic model with low-level wind changes being the predictor. Work has been completed for several airports. The second is a synoptic model in which the relative position of two low centers, one in the South China Sea and the other in southern Bay of Bengal, are the predictors. The third model uses cold surge as the predictor.

PUBLICATIONS:

Statistical and synoptic model reports to Ministry of Defense, Republic of Singapore.

KEYWORDS: Cloud Probability, Tropical Meteorology, Monsoon, Southeast Asia, China Seas

MONSOON DISTURBANCES OVER THE CHINA SEAS

**Chih-Pei Chang, Professor
Department of Meteorology
Sponsor: Office of Naval Research**

OBJECTIVE: The objectives are: (1) to study the structure and the dynamic and thermodynamic properties of the disturbances in the vicinity of the Southeast and East Asian monsoon region that stretches from Indian Ocean to the tropical western Pacific, including the South China Sea and Yellow Sea, which are of particular interest to naval operations; and (2) to study the ability and sensitivity of Navy operational numerical models in analyzing and predicting these disturbances.

SUMMARY: In this year the analysis of Typhoon Vamei was completed, which formed near Singapore on 0600 UTC 27 December 2001. Due to the diminishing Coriolis effect, the belt 300 km either side of the equator has been considered by sailors to be free from tropical storms. This is because tropical cyclones have rarely been observed to form equatorward of 5° latitude, where the diminishing Coriolis effect prevents effective generation of relative vorticity by horizontal convergence. Typhoon Vamei was the first recorded tropical cyclone formation within 1.5 degrees of the equator. With its radius of convective cloud area of near 200 km, the storm circulation was on both sides of the equator. Naval ships reported maximum sustained surface wind of 39 m s⁻¹ and gust wind of up to 54 m s⁻¹, which caused damages to the carrier USS Carl Vinson and an accompanying ship. This was the first-ever recorded tropical cyclone formation at such equatorial latitude. In this work the low-level wind fields were analyzed to determine the roles played by monsoonal cold surges, pre-existing disturbances, and upper level divergence in the formation of Vamei. It was found that the development was the result of two interacting systems, a weak Borneo vortex that drifted into the southern tip of the South China Sea and remained there for four days, and a strong and persistent cold surge that created the large background cyclonic vorticity at the equator. Based on the statistics of the behavior of both systems, the probability of a similar equatorial development was estimated to be once every 100-400 years.

PUBLICATIONS:

Chang, C.-P., Liu, C.H. and Kuo, H.C., "Typhoon Vamei: An Equatorial Tropical Cyclone Formation," *Geophysical Research Letters*, 30, 2002, (in press).

Chen, J.M., Chang, C.-P. and Li, T., "Annual Cycle of the South China Sea Surface Temperature in the NCEP/NCAR Reanalysis," *Journal of Meteorological Society of Japan*, 2002, (under revision).

KEYWORDS: Numerical Weather Prediction, Tropical Meteorology, Monsoon, China Seas

MONSOON-ENSO INTERACTIONS

Chih-Pei Chang, Professor

Department of Meteorology

Sponsor: National Oceanic and Atmospheric Administration

OBJECTIVE: To study the structure of the interannual variations of the Asian-Australian monsoon and its relationship with El Nino – Southern Oscillations (ENSO).

SUMMARY: In this year a conceptual coupled atmosphere-ocean model was used to understand the origin of the Indian Ocean Dipole Mode (IODM). In the model various positive and negative air-sea feedback processes were involved. Among them were the cloud-radiation-SST feedback, the evaporation-SST-wind feedback, the thermocline-SST feedback, and the monsoon-SST feedback. Numerical results indicate that air-sea interactions in the tropical Indian Ocean support a natural damped mode, which is different from the self-sustained ENSO mode in the tropical Pacific. The difference arises from the distinctive characteristics of the basic state of the coupled system in the tropical Indian and Pacific Oceans. By use of observational analyses and physical reasoning, the authors identified four fundamental differences between air-sea interactions in the two oceans. The first difference is represented by the strong contrast of the cloud-SST phase relationship between the warm pool and cool tongue. The second difference arises from the reversal of the basic-state zonal wind and east-west tilting of the ocean thermocline, which leads to distinctive effects of ocean waves on the SST. The third difference lies in the existence of the Asian monsoon and its negative feedback on the IODM. The fourth difference is that the southeast Indian Ocean is a region where there exists a positive atmosphere-ocean thermodynamic feedback.

The phase-locking of the IODM can be, to a large extent, explained by the seasonal dependence of the aforementioned thermodynamic air-sea feedback. In addition, anomalous Indian monsoon also plays a role. Although the El Nino exerts the strongest forcing toward the end of a year, its impact on the anomalous monsoon heating peaks in northern summer. Thus the anomalous monsoon may exert the greatest impact on the IODM toward the end of boreal summer.

In the presence of realistic ENSO forcing, the model was capable of simulating most of IODM events during the last 50 years that were associated with ENSO, indicating that ENSO is one of major forcings that trigger the IODM events. The failure of simulation of the IODM events in 1961 and 1994 suggests that other types of climate forcing may also play a role. The authors' observational analyses revealed that the 1994 event resulted from anomalous heating over Indochina/South China Sea in boreal summer, whereas the 1961 event might be traced back to the preceding winter when there was anomalous heating over the maritime.

PUBLICATIONS:

Chang, C.-P. and Li, T., "Tropical Tropospheric Biennial Oscillation and ENSO," Selected Papers, 4th Conference on East Asia and Western Pacific Meteorology and Climate, *World Scientific Series on Meteorology of East Asia*, Vol. 1, 159-171, 2002.

Chen, J.M., Chang, C.-P. and Li, T., "Annual Cycle of the South China Sea Surface Temperature in the NCEP/NCAR Reanalysis," *Journal of Meteorological Society of Japan*, 2002, (under revision).

METEOROLOGY

Li, T., Wang, B., Chang, C.-P. and Zhang, Y., "A Theory for the Indian Ocean Dipole Mode," *Journal of Atmospheric Science*, 2002, (submitted).

PRESENTATIONS:

Chang, C.-P., Wang, Z., Ju, J. and Li, T., "Interactions of Maritime Continent Winter Monsoon, ENSO and Indian Ocean Winds," Workshop on the Monitoring and Prediction of ENSO Event and Sea Temperature Structure of the Warm Pool in the Western Pacific Ocean, Macao, February 2002, (invited).

Chang, C.-P., Wang, Z., Ju, J. and Li, T., "Maritime Continent Winter Monsoon Rainfall and ENSO, CAS/TWAS/WMO," Second International Symposium on Physico-Mathematical Problems Related to Climate Modeling and Prediction, Shanghai, September 2002, (invited).

KEYWORDS: Monsoon, El Nino, ENSO, Climate Variations, Tropical Meteorology

AN INTEGRATED MODEL FOR ASSESSMENT OF RF/IR DETECTABILITY FOR FORCE PROTECTION

K. L. Davidson, Professor
Paul A. Frederickson, Research Associate
Department of Meteorology
Sponsor: Space and Naval Warfare Command

OBJECTIVE: Expediently apply, modify and improve existing atmospheric models for linkage to propagation assessment tools (TDAs) for maximizing their benefit to warfighters for radar and IR detection prediction, sensor configuration optimization, tactical decision-making and for Force Defense.

SUMMARY: Documented performance of NPS evaporation duct model within AREPS with respect to refractive effects in region immediately above the surface for cases from RED'01 and SCI'01 data, Mabey (2002). Collaborated with NPS-SSC with insertion of NPS evaporation duct model into AREPS Version 3.0 Beta. With SSC/DREV/TNO, performed an evaluation of the NPS gradient and turbulence model with respect to near-surface optical turbulence/refraction TDA candidate model (IRBLEM) based on direct profile and turbulence information from joint METOC-propagation collection in RED. Established and documented METOC model adaptability and common components across TDA's by evaluating evaporation duct model with both SMOOS(R)-type data and with COAMPS data for detection of low cross section surface targets. Designed the adaptability of tested detectability models with TDA's for emerging requirements, e.g. Force defense. The models/measurements are being applied in tests of NSW combatant boats by NSWC-CD and in ChemBio dispersion tests by collaborating NPS groups for HLS programs. Evaluated system error associated with neglecting non-neutral evaporation duct profile shapes, Eckardt (2002). Examined additional application of through-the-sensor with thesis research on TEP's application as a weather radar, Robinson (2003). Application of the METOC model and model uses are being examined in theses by Kuehn (2003), and Newton (2003). The operational propagation model factor in results is being examined by Moys (2003).

PUBLICATION:

Frederickson, P.A. and Davidson, K.L., "An Operational Bulk Evaporation Duct Model," *Journal of Applied Meteorology*, 2003, (submitted).

Tsintikidis, D., Doss-Hammel, S.M., Frederickson, P.A. and Davidson, K.L., "Infrared Propagation in the Marine Atmospheric Surface Layer: Extinction and Refraction," *Preprints, 12th Conference on Interactions of the Sea and Atmosphere, American Meteorological Society*, Long Beach, CA, 9-13 February 2003, [83rd AMS Annual Meeting, Combined Preprints CD-ROM].

METEOROLOGY

PRESENTATIONS:

Davidson, K.L. and Frederickson, P.A., "Near-Surface Meteorology Descriptions and Radar Propagation," South Dakota School of Mines and Technology, 31 January 2002.

Davidson, K.L., Frederickson, P.A. and Anderson, K.D., "Evaluation of COAMPS Microwave Propagation Predictions for the RED Experiment," Fourth RED Working Group Meeting, University of California, Irvine, CA, 14 February 2003.

Frederickson, P.A., Davidson, K.L., Stapleton, J., Shanklin, D., Wiss, R., Nguyen, T., et al., "Evaluation of Evaporation Duct Model Performance Using AREPS," National Radio Science Meeting (URSI), Boulder, CO, 9-12 January 2002.

THESES DIRECTED:

Eckardt, M.C., "Assessing the Effects of Model Error on Radar Inferred Evaporative Ducts," Master's Thesis, Naval Postgraduate School, March 2002.

Robinson, S., "Utility of Tactical Environmental Processor (TEP) as a Doppler at-Sea Weather Radar," Master's Thesis, Naval Postgraduate School, June 2002.

KEYWORDS: Meteorological Measurement, Marine Atmosphere Boundary Layer

ATMOSPHERIC CORRECTIONS FOR GEODETIC QUALITY RADIO RANGING USING REAL DATA

K. L. Davidson, Professor
Department of Meteorology
James R. Clynch, Research Professor
Department of Oceanography
Sponsor: National Reconnaissance Office

OBJECTIVE: Assess the role of atmospheric conditions, application of models and measurement capabilities in estimating tropospheric factors in global reconnaissance system performances.

SUMMARY: The primary goal was to establish limits on the noise (uncertainty) in radio frequency measurements that transit the atmosphere under the influence of temporal and spatial variations of the neutral atmosphere in space and time. The limitations at very low elevation angles for high altitude and space observation platforms were evaluated and quantified. Only the troposphere was considered, not the ionosphere. The results are applicable from about 500 MHz to 100 GHz. Atmospheric profile data from 6 world-wide locations were obtained in the form of balloon data. Two weeks of data were examined from Oakland, Vandenberg, San Diego, Sweden, Singapore and the Persian Gulf. Spatial variations were studied using the US west coast sites. Ray tracing was used to examine the total delay and the bending for radio signals.

The primary quantity studied was the variation at each site. The natural variability will limit the utility of any model not driven with near real time data. At elevations below 2 degrees the effect were found to be significant. The variations were found up to 6 m in delay and 4 milliradians in bending below 0.6 deg. At 2 degrees the variations were 1.2 m and 0.8 mrad. Using data up to 600 km away (within the same air mass) reduced the variations above 1 degree by about 90 percent.

PRESENTATION:

Clynch, J. and Davidson, K.L., "Limits on Tropospheric Corrections from Natural Variations," ION GPS-02, Portland, OR, 25-27 September 2002.

KEYWORDS: Propagation, Refraction

METEOROLOGY

BUOY POWER GENERATION: ONR SMALL BUSINESS INNOVATION RESEARCH PROGRAM

K. L. Davidson, Professor
Department of Meteorology
Jeffrey D. Paduan, Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: Monitor Performance and Progress, of Performing Company in Phase II of SBIR Project on Power Generation from Buoy as the Government Technical Monitor. The performing company is Venture Scientific International LLC.

SUMMARY: The topic of the SBIR effort is on-board electrical power for Navy meteorological/ research buoys that operate along the ocean coastlines. Monitored was the progress of laboratory bench-scale, integrated power system (fuel cell) and a prototype system that will ultimately produce at least 35 watts over a period of 6 months without maintenance or refueling. The VSI SeaWater Activated Power System (SWAPS, trademark applied) was engineered to avoid any interference with buoy measurements (e.g., water surface temperature) or any environmental contamination. The base metal for hydrogen production from seawater will remain magnesium, the third most prevalent marine mineral (half of all worldwide magnesium is extracted from the sea). Provided oversight on the VSI SWAPS team proposal to continue the work with PEM fuel cells and their manufacturers, since these have by far the best combination of maturity, reliability, low-cost, and efficiency. Remaining engineering design and fabrication needs are mainly to limit bio-fouling in the hydrogen reactor, dehumidify the hydrogen entering the fuel cell, and assure flow of clean air to the fuel cell.

KEYWORDS: Meteorological Measurement, Marine Atmosphere Boundary Layer

DEMONSTRATION OF LINKED UAV OBSERVATIONS AND ATMOSPHERIC MODEL PREDICTIONS IN CHEM/BIO ATTACK RESPONSE

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Department of Meteorology
Isaac I. Kaminer, Associate Professor
Richard M. Howard, Associate Professor
Department of Aeronautics and Astronautics
Douglas Miller, Research Assistant Professor
Department of Meteorology
Sponsor: Naval Postgraduate School

OBJECTIVE: Perform field demonstration of linked UAV sampling and atmosphere modeling to response to ChemBio attack. Goal Tactical Decision Aids (TDA) would provide source and future location of ChemBio agent.

SUMMARY: This was a development/demonstration/evaluation of integration of technology that will enable operational units to have a near-real time decision aid to respond to a ChemBio attack. Proposed atmospheric model formulation, UAV configuration/instrumentation and field measurement effort were accomplished. The demonstration was conducted at McMillan Field, Camp Roberts, CA in October 2002. Model results showed promise in capturing the diurnal evolution of near surface temperatures that drive the local circulations in the warm season and the feasibility of linking a coarse grid mesoscale model to a fine scale diagnostic wind model for producing fine resolution forward and backward trajectories. In the demonstration, the UAV Frog made meteorological observations that directly impact the atmospheric modeling effort. These were wind speed, direction, temperature, location (altitude, pressure, and latitude/longitude), and time (UTC). The UAV performed in a highly efficient manner with regard to collecting meteorological as well as navigation information. The developed and demonstrated UAV real-time software has showed its compatibility with real-time processing requirements, adequate accuracy and robustness.

METEOROLOGY

TECHNICAL REPORT:

Davidson, K.L., Kaminer, I., Miller, D. and Dobrokhodov, V., "Demonstration of Linked UAV Observations and Atmospheric Model Predictions in Chem/Bio Attack Response," Naval Postgraduate School Technical Report, NPS-MR-03-001, 2003.

THESES DIRECTED:

Sir, C., "Demonstration of Model Prediction and UAV Sampling for Dispersion Response," Master's Thesis, Naval Postgraduate School, June 2003.

Tan, M., "Precision Air Data Support for Chem/Bio Attack Response," Master's Thesis, Naval Postgraduate School, March 2003.

KEYWORDS: Meteorological Measurement, Mesoscale Model, UAVs, Unmanned Aerial Vehicles

EVALUATION OF MBL PROFILE ESTIMATIONS (TDROP AND BULK METHODS)

K. L. Davidson, Professor

Department of Meteorology

Sponsor: Space and Naval Warfare Command

OBJECTIVE: Validate and verify the Tactical Drop-sondes (TDrop) and bulk methods to meet requirements for accurate and tactically significant measurements of temperature, moisture, and pressure within the lower overland and marine atmosphere.

SUMMARY: Field data based evaluations were conducted relative to requirements/ performance of various in situ measurement methods for estimating refractivity profiles. Analyses were performed on TDrop deployments over land, near Fort Huachuca, AZ and on kite-borne radiosonde used in the overwater near-surface layer. The TDrops appeared to provide significantly more accurate and more sensitive temperature and humidity (relative and vapor pressure) measurements than the versions that were used during the Monterey Bay experiment in the year 2000. The temperature probe response suggested problems caused by the "thermal inertial" of the casing have been greatly reduced. Analyses were conducted of application of near-surface refractivity model for inclusion within any in situ operational measurement system, i.e. SMOOS(R). It was found that for times when the water was warmer than the air, the near-surface refractivity model was as accurate at profiles measured directly with the kite borne radiosonde.

CONFERENCE PAPER:

Davidson, K.L., Guest, P.S., Mabey, D.L., Frederickson, P.A. and Anderson, K.D., "The Use of Kite Observations to Study Air-sea Interaction Controlled Atmospheric Surface Layer Profiles During the RED Experiment," *Preprints, 12th Conference on Interactions of the Sea and Atmosphere, American Meteorological Society*, Long Beach, CA, 9-13 February 2003, [83rd AMS Annual Meeting, Combined Preprints CD-ROM].

PRESENTATIONS:

Guest, P.S., Davidson, K.L., Frederickson, P.A. and Mabey, D.L., "Using Instrumented Kites to Quantify Atmospheric Conditions During the RED Experiment," National Radio Science Meeting (URSI), Boulder, CO, 7-10 January 2002.

TECHNICAL REPORT:

Guest, P.S. and Davidson, K.L., "TDrop Evaluation-Arizona Test," Naval Postgraduate School Technical Report, NPS-MR-02-001, 21 March 2002.

METEOROLOGY

THESIS DIRECTED:

Mabey, D., "Variability of Refractivity in the Surface Layer RED Buoy/Kite Profiles," Master's Thesis, Naval Postgraduate School, June 2002.

KEYWORDS: Meteorological Measurement, Marine Atmosphere Boundary Layer

LONG-TERM FLUX-BUOY MEASUREMENTS AT WALLOPS ISLAND: MEAN METOC, TURBULENCE, NEAR-SURFACE SCALAR PROFILES, AND SURFACE WAVES

**K. L. Davidson, Professor
Department of Meteorology**

Sponsor: Naval Surface Warfare Center, Dahlgren Division

OBJECTIVE: Obtain near-surface atmospheric and surface data that will enable gradients of the radar/radio wave refractivity and wave conditions to be estimated for interpretation of near-horizon EM propagation

SUMMARY: Equipment was prepared and performance characteristics evaluated for environmental measurements from an instrumented buoy in support of the long-term Wallops'03-04' propagation experiment. During 2002, sensors and components were selected and evaluated for both mean and turbulent measurements from the buoy. The sensors describe near-surface refractivity profiles that are being analyzed for near-surface atmosphere effects on detection of targets. The NPS 'Flux' buoy will be deployed off Wallops Island, VA, for a period of approximately 8 months, from about August 2003 through March 2004. Power generation and mass memory storage estimates were determined and possible reductions were examined because to scheduled duration. Mass memory requirements seem to set the recovery times. Real time transfer of fast sampled data is being examined.

PRESENTATION:

Frederickson, P.A., Davidson, K.L., Stapleton, J., Shanklin, D., Wiss, R., Nguyen, T., et al., "Evaluation of Evaporation Duct Model Performance Using AREPS," National Radio Science Meeting (URSI), Boulder, CO, 9-12 January 2002.

THESES DIRECTED:

Eckardt, M.C., "Assessing the Effects of Model Error on Radar Inferred Evaporative Ducts," Master's Thesis, Naval Postgraduate School, March 2002.

KEYWORDS: Meteorological Measurement, Propagation Loss, Evaporation Duct

METOC DATA ACQUISITION (MORIAH/SMOOS(R))

**K. L. Davidson, Professor
Department of Meteorology**

Sponsor: Space and Naval Warfare Command

OBJECTIVE: Support acquisition strategy of a shipboard Meteorology and Oceanography parameter sensor system, SMOOS(R), by carrying out validation, verification and integration procedures. Evaluate planned software evaporation duct calculation. Compare alternative methods for estimating EM/EO conditions, i.e., RFC.

SUMMARY: NPS evaluated and documented performance characteristics of MORIAH hardware and Software for use in the complex METOC and electronic environment of a Navy warship. These were also done for MORIAH like systems mounted on buoys deployed in coastal regimes in support of propagation tests. System performance evaluation was of characteristics of both the MORIAH hardware and acquisition

METEOROLOGY

and calculation/editing software. The algorithm for evaporation duct refractivity profiles using SMOOS(R)-type data was evaluated with buoy-based data collected in collection associated with the NSWC-DD directed *Ship-Based Defense Demonstration, IAFCE Task – MPME (Wallops1998& 2000) and the Roughness and Evaporation Duct experiment of August-September 2001*, Frederickson et al 2001 and Mabey 2002. Further, the SMOOS(R) acceptable errors for all airflow and surface properties were used in an evaluation of the impact of the neutral profile assumptions within the Refractivity from Clutter (“RFC”) procedure, Eckardt 2002.

PRESENTATION:

Frederickson, P.A., Davidson, K.L., Stapleton, J., Shanklin, D., Wiss, R., Nguyen, T., et al., “Evaluation of Evaporation Duct Model Performance Using AREPS,” National Radio Science Meeting (URSI), Boulder, CO, 9-12 January 2002.

THESIS DIRECTED:

Eckardt, M.C., “Assessing the Effects of Model Error on Radar Inferred Evaporative Ducts,” Master’s Thesis, Naval Postgraduate School, March 2002.

KEYWORDS: Meteorological Measurement, Marine Atmosphere Boundary Layer

REFRACTIVITY PROFILE COLLECTION DURING VESSEL SIGNATURE TESTS: DAM NECK, VA, AND SAN CLEMENTE ISLAND, CA

K. L. Davidson, Professor

Department of Meteorology

Sponsor: Naval Surface Warfare Center, Carderock Division

OBJECTIVE: Perform METOC data collection to estimate vertical profiles of temperature, humidity along radar paths during vessel signature tests. Relate METOC influences on S- and X-band radar detection of combatant boats.

SUMMARY: Boat-based measurements were made in tests to determine the atmosphere and ocean surface effects on combatant boat signatures. The measurements supported vessel signature tests conducted by the Naval Surface Weapons Center, Carderock Division (NSWC-CD). 2002 tests were at Dam Neck, VA (July-August 2002) and 2003 tests will occur at San Clemente Island, CA (May-June 003). Since radar propagation was a factor in system performance, near-surface refractivity profiles were obtained from measured pressure, air temperature and humidity, sea surface temperature and wind speeds. Balloon-launched and kit-borne rawinsonde data characterized the refractivity conditions through the entire marine boundary layer, particularly the height and strength of possible surface based ducts that affect Rf propagation. Continuous METOC measurements were made by a boat-mounted system for evaporation duct strengths estimates. Estimation of the atmospheric influence was based on AREPS using the collected atmosphere and ocean surface data. The radar and target parameters were determined by test design criteria.

CONFERENCE PAPER:

Davidson, K.L., Guest, P.S., Mabey, D.L., Frederickson, P.A. and Anderson, K.D., “The Use of Kite Observations to Study Air-sea Interaction Controlled Atmospheric Surface Layer Profiles During the RED Experiment,” *Preprints, 12th Conference on Interactions of the Sea and Atmosphere, American Meteorological Society*, Long Beach, CA, 9-13 February 2003, [83rd AMS Annual Meeting, Combined Preprints CD-ROM].

METEOROLOGY

PRESENTATION:

Davidson, K.L., "METOC Descriptions and Radar/IR Detectability Assessment," Naval Surface Weapons Center, Carderock Division, West Bethesda, MD, 16 July 2002.

KEYWORDS: Meteorological Measurement, Radar Detectability, Combatant Boats

REFRACTIVITY PROFILE COLLECTION: RED AND SCI'01

K. L. Davidson, Professor
Department of Meteorology
Sponsor: Naval Research Laboratory

OBJECTIVE: Characterize the low altitude refractivity conditions (particularly the evaporation duct and height and strength of possible surface based ducts) that affected RF propagation along the Rf and EO propagation paths during the Roughness and Evaporation Duct (RED) experiment conducted off Oahu, HI in August-September 2001, and the Radar System Performance tests (SCI'01) conducted off San Clemente Island, CA, in November-December 2001.

SUMMARY: Performed analyses of refractivity profiles on the basis of launched rawinsondes and kite-borne sonde profiles from small boats during RED and SCI'01. In RED, the profiles were obtained to provide information for interpreting radio frequency (RF) propagation measurements along a 26 km path between the R/V FLIP, moored 10 km off the north shore of Oahu, and a shore receiver station on Mokapu Peninsula and optical propagation measurements obtained along a 10 km path between FLIP and the north shore of Oahu. In SCI'01 the profiles were obtained near SCI in the region of test priority. The NPS measurement platforms were small vessels in both cases. Continuous METOC data were collected to estimate the evaporation duct profile with bulk methods. In RED NPS obtained 190 individual near-surface (up to ~100 meters) kite-borne sonde profiles and 20 upper-air balloon-sonde profiles on eight different days during the experiment. In SCI'01, 11 captured-kite profile sets and 4 up-down rawinsonde profiles were obtained over 4 days.

PUBLICATION:

Frederickson, P.A., Davidson, K.L., Jones, F.K. and Mabey, D.L., "SCI 2001 Sensor Technology Test, Preliminary METOC Data Atlas," 82 pp.

PRESENTATION:

Guest, P.S., Davidson, K.L., Frederickson, P.A. and Mabey, D.L., "Using Instrumented Kites to Quantify Atmospheric Conditions During the RED Experiment," National Radio Science Meeting (URSI), Boulder, CO, 7-10 January 2002.

THESIS DIRECTED:

Mabey, D., "Variability of Refractivity in the Surface Layer Over the Sea," Master's Thesis, Naval Postgraduate School, March 2002.

KEYWORDS: Meteorological Measurement, Marine Atmosphere Boundary Layer, Optical Transmission, Rf Transmission

METEOROLOGY

SCALING NEAR-SURFACE ATMOSPHERIC AND SURFACE WAVE INFLUENCES ON RADAR PROPAGATION OVER THE SEA (RED)

K. L. Davidson, Professor

Paul A. Frederickson, Research Associate

Department of Meteorology

Sponsor: Office of Naval Research

OBJECTIVE: Improve models for describing near-horizon Rf/EO propagation over the ocean through evaluation of the Monin-Obukhov surface-layer scaling for near surface turbulence and refractivity gradients over ocean waves and surface roughness parameterizations.

SUMMARY: Analyses and interpretations were performed on measurements of near-surface refractive gradients, turbulent intensity, and surface wave data obtained during NPS flux buoy deployments from coordinated propagation experiments. These data were from combined collections of buoy data and EM and EO propagation data obtained during the RED experiment conducted in the late summer of 2001. Collaborative analyses/interpretations in 2002, following the field experiment, emphasized both mean and turbulent airflow properties. With respect to turbulence, interpretations addressed the use of current bulk methods for estimating optical turbulence (C_n^2) and the profile scaling parameters (T^* , q^* , and u^*). Wave influences have been addressed to qualitatively identify their effects on scalar profiles. Existing results were derived from inertial dissipation and direct covariance measurements of turbulent fluxes, merged with buoy profile data to examine flux-profile scaling. The results demonstrate that current models for describing near surface turbulence and refractivity profiles performed well in the unstable conditions that occurred during RED.

PUBLICATIONS:

Anderson, K., Frederickson, P. and Terrill, E., "Air-Sea Interaction Effects on Microwave Propagation Over the Sea During the Rough Evaporation Duct (RED) Experiment," *Preprints, 12th Conference on Interactions of the Sea and Atmosphere*, American Meteorological Society, Long Beach, CA, 9-13 February 2003, [83rd AMS Annual Meeting, Combined Preprints CD-ROM].

Doss-Hammel, S.M., Tsintikidis, D., Frederickson, P.A. and Davidson, K.L., "Near-Surface Scintillation in the Marine Atmospheric Layer During the RED Field Campaign," *Preprints, 12th Conference on Interactions of the Sea and Atmosphere*, American Meteorological Society, Long Beach, CA, 9-13 February 2003, [83rd AMS Annual Meeting, Combined Preprints CD-ROM].

Doss-Hammel, S.M., Zeisse, C.R., Barrios, A.E., de Leeuw, G., Moerman, M., de Jong, A.N., et al., "Low Altitude Infrared Propagation Over the Ocean," *Applied Optics*, 41, 3706-3724, 2002.

Frederickson, P.A. and Davidson, K.L., "Observational Buoy Studies of Coastal Air-Sea Fluxes," *Journal of Climate*, 14, 593-599, 2003.

Frederickson, P.A., Davidson, K.L., Anderson, K.D., Doss-Hammel, S.M. and Tsintikidis, D., "Air-Sea Interaction Processes Observed from Buoy and Propagation Measurements During the RED Experiment," *Preprints, 12th Conference on Interactions of the Sea and Atmosphere*, American Meteorological Society, Long Beach, CA, 9-13 February 2003, [83rd AMS Annual Meeting, Combined Preprints CD-ROM].

Tsintikidis, D., Doss-Hammel, S.M., Frederickson, P.A. and Davidson, K.L., "Infrared Propagation in the Marine Atmospheric Surface Layer: Extinction and Refraction," *Preprints, 12th Conference on Interactions of the Sea and Atmosphere*, American Meteorological Society, Long Beach, CA, 9-13 February 2003, [83rd AMS Annual Meeting, Combined Preprints CD-ROM].

PRESENTATIONS:

Davidson, K.L. and Frederickson, P.A., "Mid-Path Near-Surface Atmospheric Properties in the Roughness and Evaporation Duct (RED) Experiment," National Radio Science Meeting (URSI), Boulder, CO, 7-10 January 2002.

Davidson, K.L., Frederickson, P.A. and Mabey, D.L., "Mid-Path Near-Surface Atmospheric Properties in the Roughness and Evaporation Duct (RED) Experiment," RED Experiment Data Workshop, San Diego, CA, 5-6 February 2002.

KEYWORDS: Meteorological Measurement, Marine Atmosphere Boundary Layer, Optical Transmission, Rf Transmission, EM/EO Propagation

THE APPLICATION OF REGIONAL AEROSOL PROPERTIES TO AVHRR AEROSOL RETRIEVAL ALGORITHMS

**Philip A. Durkee, Professor
Department of Meteorology**

Sponsors: National Oceanic and Atmospheric Administration, Pacific Marine Environmental Laboratory

OBJECTIVE: The object of this project is to analyze, compare and integrate shipboard measured aerosol optical with AVHRR (Advanced Very High-Resolution Radiometer) satellite retrievals of aerosol properties. NOAA PMEL has conducted several cruises in the Pacific, Atlantic and Indian Oceans over the past 10 years. NPS has cooperated with PMEL to collect AVHRR data coincident with these cruises. The data sets will provide the basis for regional improvements to satellite retrievals of aerosol properties under GACP.

SUMMARY: This year's efforts ended the three-year funding of this project as part of GACP. NPS has retrieved AOD for all available midday AVHRR collected during the RITS-II cruise in the fall of 1993. In addition, these data have been binned onto a 0.1-deg x 0.1-deg grid for compositing and statistical analysis. Attention has been focused on the midday AVHRR due to the reduced error associated with maximum daylight. In the case of RITS-II data, the very clean conditions observed during the cruise resulted in AOD values of zero being retrieved in many places. These are regions near the minimum sensitivity of the AVHRR optical sensor, and this suggests a careful interpretation of the retrievals before performing the final composite. NPS has also produced a composite analysis for the RITS cruise (spring 1993) dataset and the CSP cruise (spring 1996) dataset. Results from the binned and composited datasets from INDOEX (both 1-km LAC and 4-km GAC datasets) were presented at the AGU meeting in December of 1999.

PUBLICATIONS:

Durkee, P.A., Nielsen, K.E., Smith, P.J., Russell, P.B., Schmid, B., Livingston, J.M., et al., "Regional Aerosol Optical Depth Characteristics from Satellite Observations: ACE-1, TARFOX and ACE-2 Results," *Tellus*, 52B, 484-497, 2002.

Gassò, S., Hegg, D.A., Covert, D.S., Collins, D., Noone, K.J., Öström, E., et al., "Influence of Humidity on the Aerosol Scattering Coefficient and its Effect on the Upwelling Radiance During ACE2," *Tellus*, 52B, 546-567, 2002.

Johnson, D.W., Osborne, S., Wood, R., Suhre, K., Johnson, R., Businger, S., et al., "An Overview of the Lagrangian Experiments Undertaken During the North Atlantic Regional Aerosol Characterization Experiment (ACE-2)," *Tellus*, 52B, 290-320, 2002.

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Livingston, J.M., Kapustin, V.N., Schmid, B., Russell, P.B., Quinn, P.K., Bates, T.S., et al., "Shipboard Sunphotometer Measurements of Aerosol Optical Depth Spectra and Columnar Water Vapor During ACE-2 and Comparison with Selected Land, Ship, Aircraft, and Satellite Measurements," *Tellus*, 52B, 594-619, 2000.

Schmid, B., Livingston, J.M., Russell, P.B., Durkee, P.A., Jonsson, H.H., Collins, D.R., et al., "Clear-sky Closure Studies of Lower Tropospheric Aerosol and Water Vapor During ACE-2 Using Airborne Sunphotometer, Airborne in-situ, Space-borne and Ground Based Measurements," *Tellus*, 52B, 568-593, 2000.

Welton, E.J., Voss, K.J., Gordon, H.R., Maring, H., Smirnov, A., Holben, B., et al., "Ground-Based Lidar Measurements of Aerosols During ACE-2: Instrument Description, Results, and Comparisons with Other Ground-Based and Airborne Measurements," *Tellus*, 52B, 636-651, 2000.

KEYWORDS: Satellite Remote Sensing, Aerosol, Climatology

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 Command

OBJECTIVE: Develop an automated computer method to estimate the location and strength of elevated ducts in coastal and open ocean regions using satellite imagery received on U.S. Navy ships and regional METOC centers. This project supports development of boundary layer analysis techniques using satellite radiances. The output from this method will be input for radar propagation assessment programs to improve Force Protection and Naval Fires/Strike objectives.

SUMMARY: This project is a satellite remote sensing tool to estimate the height of the marine boundary layer and elevated duct strength and depth in coastal and open-ocean regions. It will be an input to radar propagation assessment tools, or other tactical aids. The project will provide computer software to run on the standard shipboard/regional center METOC satellite receiver/processing computer. Marine stratus clouds will be identified in NOAA polar orbiter (AVHRR) imagery and the cloud-top height will be estimated. The existence of an elevated duct, and information about the duct strength and depth, will be estimated from the satellite imagery and, possibly, external information. The duct information will be provided in output forms suitable for radar propagation assessment programs and/or other tactical aids. It may be possible to modify the technique to work with geostationary satellite imagery.

FY02 work began in April 2002 and a preliminary version of an automated process to automate the boundary layer estimations from satellite radiances and estimate cloud-top height for marine stratocumulus clouds was developed by the end of the fiscal year. In FY03, the physical assumptions of the technique will be explored, refined, and error estimates will be made based on case studies. An elevated duct strength estimation algorithm will be developed and added to the automation process.

KEYWORDS: Satellite, Remote Sensing, Clouds, Marine Atmospheric Boundary Layer, Elevated Duct

TARGET AREA METOC MERIT SUPPORT

Philip A. Durkee, Professor

Department of Meteorology

Sponsor: National Reconnaissance Office

OBJECTIVE: This project supports preparation of algorithms for the Target Area Meteorology/Oceanography (TAM) MERIT project. TAM is also known under Navy TENCAP as Radiant Sleet. Two

METEOROLOGY

primary algorithms will be developed, tested, and validated: (1) atmospheric visibility and (2) near surface air temperature.

SUMMARY: Deliverables from this project consist of completing three algorithms: 1) Visibility Index - Land (VisI-L); 2) Visibility Index – Marine (VisI-M) for water regions; and 3) Near Surface Temperature Analysis (NSTA). These algorithms will be integrated into the Multi-Spectral Testbed (MSTB) developed under the MERIT program by Ball Aerospace and Technology Corp. The ultimate deliverable from VisI-L and VisI-M is an assessment of visual range as would be observed by a trained meteorological observer located within the image scene and along a specified path at various wavelengths important for laser propagation. NSTA is expected to provide an assessment of air temperatures near the surface over an image scene.

During the first year of funding, prototypes of all three algorithms were developed. Surrogate data sets have been developed to begin testing the assumptions and procedures within the prototype algorithms.

KEYWORDS: Satellite, Remote Sensing, Aerosol Processes, Atmospheric Radiation

STRUCTURE CHANGES OF TROPICAL CYCLONES

Russell L. Elsberry, Professor

Department of Meteorology

Sponsor: National Aeronautics and Space Administration

OBJECTIVE: This research project in cooperation with Professor Elizabeth Ritchie of the University of New Mexico is a combined observational and modeling study of the effects of vertical wind shear on the core structure and intensity of a tropical cyclone. A specific objective is to define the role of environmental vertical wind shear in developing asymmetries in the core structure and how the intensity then increases or decreases.

SUMMARY: The observational phase is based on the Convection and Moisture Experiment (CAMEX-4) field program. An analysis is in progress of tropical storm Chantal during a period in which the environmental vertical wind shear was evidently hindering its further intensification to a hurricane. Extensive dropwindsonde data from NASA and NOAA aircraft are being used in the analysis. A progress report (Ritchie and Elsberry 2002c) was presented at the CAMEX-4 Workshop.

Ritchie and Elsberry (2001a) have simulated the effects of three vertical wind shear profiles observed during the extratropical transition on a tropical cyclone. The development of convective asymmetries as increasing vertical wind shear is imposed appears to be simulated well by the model.

Ritchie and Elsberry (2002a, b) have constructed simulations that isolate the role of the midlatitude trough strength during the re-intensification stage of extratropical transition. The strength of the trough is varied from weak through strong while maintaining the initial position of the tropical cyclone 15° lat. to the south and 25° long. to the east. The control simulations are the development of the midlatitude troughs without the tropical cyclone being present. Upper-level divergence is considerably enhanced in the development region by the outflow from the tropical cyclone. A substantial increase in the areal extent and strength of the development potential is attributed to the enhanced jet stream dynamics as the tropical cyclone outflow interacts with the upper-level trough.

PUBLICATION:

Ritchie, E.A. and Elsberry, R.L., “Simulations of the Extratropical Transition of Tropical Cyclones: Contributions by Midlatitude, Upper-Level Trough,” *Monthly Weather Review*, 2002, (in press).

PRESENTATIONS:

Ritchie, E.A. and Elsberry, R.L., “Simulations of the Extratropical Transition of Tropical Cyclones: Contributions by the Midlatitude, Upper-Level Trough,” *Preprints, 25th Conference on Hurricanes and Tropical Meteorology, San Diego, CA*, American Meteorological Society, Boston, MA, 493-494, 2002.

METEOROLOGY

Ritchie, E.A. and Elsberry, R.L., "The Structural Changes of Tropical Cyclones Upon Interaction with Vertical Wind Shear," *CAMEX-4 Workshop*, New Orleans, LA, 13-15 March 2002.

KEYWORDS: Tropical Cyclone Structure, Tropical Cyclone Intensity, Vertical Wind Shear Effects

SUPPORT OF U.S. WEATHER RESEARCH PROJECT HURRICANE LANDFALL SCIENCE COORDINATOR

**Russell L. Elsberry, Professor
Department of Meteorology
Sponsor: Office of Naval Research**

OBJECTIVE: This project is for Professor Elsberry to serve as the Science Coordinator for the Hurricane Landfall program of the U. S. Weather Research Program, for which the Office of Naval Research is one of the sponsors.

SUMMARY: The first task was to facilitate the analysis of the Hurricane Landfall (HL 2001) field experiment data set. A talk (Marks and Elsberry 2002) was presented at the CAMEX-4 Workshop that highlighted the data set and encouraged participation by the tropical cyclone community in the analysis.

The second task continued involvement in the organization of the Joint Hurricane Testbed (JHT) as a USWRP project. The JHT evolved from the Hurricane Operational Transition (HOT) center proposed in the Hurricane Landfall Implementation Plan. A talk (Elsberry 2002b) was presented at the Interdepartmental Hurricane Conference describing the first-year proposals and how they map into the USWRP Hurricane Landfall research goals. I serve as the USWRP representative on the JHT Steering Committee and have been instrumental in formulating the Terms of Reference for the JHT. The second major effort was the review of the nine second-year proposals for JHT. The results of this review were again put on the Tropical Storms bulletin board to achieve wide distribution and encourage future participation.

Another major task was organizing the USWRP workshop on Numerical Modeling for Tropical Cyclone Intensity and Precipitation in San Diego during May 2002. The Workshop report (Elsberry 2002c) will be available soon. I also participated in the USWRP Workshop on Hurricane Weather and Research Forecast (HWRF) Model Development.

A meeting summary (Elsberry 2002a) describing the tropical cyclone-related precipitation session at the *AMS Symposium of Precipitation Extremes* was published in the *Bulletin of the American Meteorological Society*.

Finally, I participated in various USWRP discussions. I serve on the Science Steering Committee and participated in their meeting and the subsequent Executive Program Committee meeting during April. I also participated in the USWRP Warm-season Precipitation Workshop during April, and contributed to the final report.

PUBLICATIONS:

Elsberry, R.L., "Predicting Hurricane Landfall Precipitation: Optimistic and Pessimistic Views from the Symposium on Precipitation Extremes," *Bulletin of the American Meteorological Society*, 83, 1233-1239, 2002.

Marks, F.D. and Elsberry, R.L., "USWRP HL 2001 Breakout Session Summary," *Proceedings of the 56th Interdepartmental Hurricane Conference*, New Orleans, LA, 11-15 March 2002.

PRESENTATIONS:

Elsberry, R.L. and Rappaport, E.N., "2002b: Joint Hurricane Testbed—A Hurricane Research to Operations Program," 56th Interdepartmental Hurricane Conference, New Orleans, LA, 11-15 March 2002.

Elsberry, R.L., "2002d: Numerical Modeling for Tropical Cyclone Intensity and Precipitation," two presentations at Central Weather Bureau, Taiwan, and National Taiwan University, 18-19 June 2002.

METEOROLOGY

Elsberry, R.L., "2002e: Summary of the USWSRP Hurricane Landfall Workshop," Hurricane Weather Research Forecast (HWRF) Workshop, 29 May 2002.

Elsberry, R.L., "2002f: USWRP Hurricane Landfall Program Review," Hurricane Weather Research Forecast (HWRF) Workshop, 30 May 2002.

OTHER:

Elsberry, R.L., "2002c: Numerical Modeling for Tropical Cyclone Intensity and Precipitation—A Workshop Report," in circulation for review prior to posting on website.

KEYWORDS: Tropical Cyclones, Joint Hurricane Testbed, U.S. Weather Research Program Hurricane Landfall

SYSTEMATIC APPROACH TO TROPICAL CYCLONE FORECASTING

Russell L. Elsberry, Professor

Mark A. Boothe, Meteorologist

Department of Meteorology

Sponsor: Space and Naval Warfare Command

OBJECTIVE: This project is to extend the concept and principles of the Systematic Approach to Tropical Cyclone Track Forecasts to the North Indian Ocean. This Systematic Approach was first developed for the western North Pacific, eastern and central North Pacific, Atlantic, and Southern Hemisphere tropical cyclone basins. With the completion of this project, the Systematic Approach will have been applied to all tropical cyclone basins.

SUMMARY: The first step was to develop a Meteorological Knowledge Base for the North Indian Ocean. Synoptic patterns and regions were assigned for 64 storms during 1991-2001 using the Navy Operational Global Atmospheric Prediction System analyses each 12 hours that a tropical cyclone existed. All of the 656 cases could be classified in three common synoptic patterns that have been found to apply in all of the tropical cyclone basins mentioned above. No synoptic patterns were found to be unique to the North Indian Ocean. About 75% of the cases are in the Standard synoptic pattern.

A preliminary Numerical Model Traits Knowledge Base was developed that included only eight tropical cyclones during 2000-2001. The model track forecast errors are relatively small as only 33%, 62%, and 70% of the Navy global, Navy regional, and United Kingdom Meteorological Office models, respectively, exceed 150 n mi at 72 h. Only 12 cases of large (> 225 n mi at 72 h) track forecast errors occurred in the two-year period. Half of these large-error cases are associated with erroneous model predictions in the midlatitudes. Another one third of the large errors originate from improper model treatments of the tropical circulations. The remaining two cases originate from erroneous initial cyclone positions. Since these are the same error sources as in other basins, the Systematic Approach has global application.

THESIS DIRECTED:

Spollen, R.A., "Meteorological and Model Traits Knowledge Bases for North Indian Ocean Tropical Cyclone Track Forecasting," Master's Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: Tropical Cyclones, North Indian Ocean, Systematic Approach to Track Forecasting

METEOROLOGY

TRANSITION OF DYNAMICAL MODEL TRACK PREDICTION EVALUATION SYSTEM

Russell L. Elsberry, Professor
Mark A. Boothe, Meteorologist
Department of Meteorology

Sponsor: National Oceanic and Atmospheric Administration

OBJECTIVE: This research project is to transition to the Tropical Prediction Center/National Hurricane Center (TPC/NHC) a Dynamical Model Evaluation expert System (DYMES). The primary effort during the first year was to convert the code and conduct a preliminary near-real time test of the system. The objective during this second year was to produce a version suitable for a pre-operational implementation test.

SUMMARY: The U. S. Weather Research Program Hurricane Landfall has sponsored the Joint Hurricane Testbed program to facilitate a transition of research toward operations at the TPC/NHC. This project has adapted for use in the Atlantic a similar expert system for the western North Pacific (Boothe et al. 2002a). During the second year, the code has been adapted to use model fields via the TPC/NHC communication lines, and modifications have been made based on the experience during the first year.

A pre-operational implementation test was conducted during the 2002 hurricane season in the Atlantic and eastern North Pacific. After a training period, personnel at TPC/NHC and M. Boothe at NPS conducted a two-week trial of the DYMES during August 2002. The application of DYMES was then continued for the remainder of the hurricane season by LCDR Laura Salvador (Navy Liaison at TPC/NHC) and M. Boothe at NPS on a quasi-operational basis. Analysis of the results is in progress.

PUBLICATION:

Boothe, M.A., Elsberry, R.L. and Salvador, L., "2002a: Beta Test and Development of a Prototype Dynamical Model Track Prediction Evaluation System for the Atlantic," *Preprints of the 25th Conference on Hurricanes and Tropical Meteorology, San Diego, CA*, American Meteorological Society, Boston, MA, 331-332, 2002.

PRESENTATION:

Boothe, M.A., Elsberry, R.L. and Salvador, L., "2002b: Beta Test and Development of a Prototype Dynamical Model Track Prediction Evaluation System for the Atlantic," 56th Interdepartmental Hurricane Conference, New Orleans, LA, 11-15 March.

KEYWORDS: Tropical Cyclones, Joint Hurricane Testbed, Dynamic Model Evaluation System

TROPICAL CYCLONE MOTION AND STRUCTURE STUDIES

Russell L. Elsberry, Professor
Patrick A. Harr, Research Associate Professor
Kevin Cheung, Research Assistant Professor
Department of Meteorology

Sponsor: Office of Naval Research

OBJECTIVE: This basic research project seeks to understand the physical processes leading to changes in tropical cyclone motion and structure. This report will cover only the activities of the senior PI as separate reports have been prepared for those segments led by P. Harr and by K. Cheung.

SUMMARY: The major activity during 2002 has been leadership of the fifth International Workshop on Tropical Cyclones (IWTC-V). An overview of tropical cyclone research and forecasting was obtained via editing of about 500 pages of workshop materials. As Topic 1 Chair on Tropical Cyclone Structure and Structure Change, an overview of six subtopic reports was prepared (Elsberry 2002a). After the topic presentations, plenary discussion, and working group discussions, a Chapter report was prepared. In

METEOROLOGY

addition to editing the final report to the World Meteorological Organization, the Preface, Introduction (Elsberry 2000d) and a chapter on the forecaster survey (Elsberry and Velden 2002) was prepared.

A chapter was published based on earlier work on the Systematic Approach to Tropical Cyclone track forecasting. Elsberry and Carr (2002) summarized the Systematic Approach application of the dynamical model selective consensus. Another book chapter (Elsberry 2002b) summarized the advances in tropical cyclone track forecasting during the period of the International Decade for Natural Disaster Reduction.

The possible application of the Systematic Approach to tropical cyclone forecasting for the prediction of storm surge, waves, and ocean circulation on forecasting was presented at a World Meteorological Organization workshop co-sponsored by the Office of Naval Research International Field Office (Elsberry 2002c).

PUBLICATIONS:

Elsberry, R.L., "2002a: Tropical Cyclone Structure and Structure Change: Topic 1 Chair Report," *Fifth International Workshop on Tropical Cyclones*, World Meteorological Organization, WMO/TD No. 1136.

Elsberry, R.L., "2002b: Track Forecast Guidance Improvements for Early Warnings of Tropical Cyclones," *Early Warning Systems for Natural Disaster Reduction, Chapter 4.3*, Springer (Berlin), J. Zschau and A. N. Küppers (Eds.), 167-184.

Elsberry, R.L., "2002c: Introduction, Chap. 1," *Final Report of Fifth International Workshop on Tropical Cyclones*, World Meteorological Organization, Geneva, Switzerland, (in press).

Elsberry, R.L. and Carr, L.E., III, "2002: Systematic Approach for Tropical Cyclone Track Forecasting with Dynamical Model Selective Consensus," *East Asia and Western Pacific Meteorology and Climate, World Scientific Series on Meteorology of East Asia*, Vol. 1, Imperial College Press, London (UK), C.-P. Chang, G. Wu, B. Jou and C. Y. Lam (Eds.), 228-236.

Elsberry, R.L. and Velden, C., "2002: Forecaster Survey of Uses of Satellite Observations. Appendix B," *Final Report of the Fifth International Workshop on Tropical Cyclones*, World Meteorological Organization, Geneva, Switzerland, (in press).

PRESENTATION:

Elsberry, R.L., "2000d: Tropical Cyclone Forecasting with the Systematic Approach for the Western North Pacific," JCOMM/TPC Workshop on South China Sea Storm Surge, Waves, and Ocean Circulation Forecasting, Hanoi, Vietnam, 21-24 January 2002.

KEYWORDS: Tropical Cyclones, International Workshop on Tropical Cyclones, Systematic Approach to Tropical Cyclone Forecasting

USING THE SHEBA FLUX DATA TO IMPROVE REGIONAL AND GLOBAL CLIMATE MODELS

**Peter Guest, Research Associate Professor
Department of Meteorology
Sponsor: National Science Foundation**

OBJECTIVE: This is a collaborative effort to use the atmospheric surface layer data collected during the Surface Heat Budget of the Arctic field program to develop ice-atmosphere exchange algorithms for local, regional and global model ice-atmosphere model of the Arctic.

SUMMARY: This continues an analysis of data collected during a field program that was performed from September 1997 to September 1998. The data set obtained represents the most comprehensive information on surface-layer properties ever obtained in the central Arctic. The project involves analysis of factors affecting the surface heat and momentum fluxes, including snow drifting, melting of the ice surface,

radiation and cloud effects and the effects of nearby leads. These results are being incorporated into various models that simulate Arctic air-ice-sea interactions and their effects on regional and global climate.

PUBLICATIONS:

Andreas, E.L., Fairall, C.W., Persson, P.O.G. and Guest, P.S., "2002: Probability Distributions for the Inner Scale and the Refractive Index Structure Parameter and Their Implications for Flux Averaging," *Journal of Applied Meteorology*, (in press).

Andreas, E.L., Guest, P.S., Persson, P.O.G., Fairall, C.W., Horst, T.W., Moritz, R.E., et al., "2002: Near-Surface Water Vapor Over Polar Sea Ice is Always Near Saturation," *Journal of Geophysical Research-Oceans*, 107, C10, SHE 8.

Curry, J.A., Schramm, J.L., Alam, A., Reeder, R., Arbetter, T.E. and Guest, P.S., "2002: Evaluation of Data Sets Used to Force Sea Ice Models in the Arctic Ocean," *Journal of Geophysical Research-Oceans*, 107, C10, SHE 2.

Grachev, A.A., Fairall, C.W., Persson, P.O.G., Andreas, E.L. and Guest, P.S., "2003: Stable Boundary-Layer Scaling: The SHEBA Data," *Boundary-Layer Meteorol.*, (submitted).

Intrieri, J.M., Fairall, C.W., Shupe, M.D., Persson, P.O.G., Andreas, E.L., Guest, P.S. and Moritz, R.E., "2002: An Annual Cycle of Arctic Surface Cloud Forcing at SHEBA," *Journal of Geophysical Research-Oceans*, 107, C10, SHE 13.

Persson, P.O.G., Fairall, C.W., Andreas, E.L. and Guest, P.S., "2002: Measurements Near the Atmospheric Surface Flux Group Tower at SHEBA: Near-Surface Conditions and Surface Energy Budget," *Journal of Geophysical Research-Oceans*, 107, C10, SHE 13.

Uttal, T., Curry, J.A., McPhee, M.G., Perovich, D.K., Moritz, R.E., Maslanik, J.A., et al., "2002: The Surface Heat Budget of the Arctic," *Bulletin of the American Meteorological Society*, 83, 255-276.

PRESENTATIONS:

Andreas, E.L., Claffey, K.J., Fairall, C.W., Guest, P.S., Jordan, R.E. and Persson, P.O.G., "2002: Evidence from the Atmospheric Surface Layer That the von Kármán Constant Isn't," 15th Symposium of Boundary Layers and Turbulence, Wageningen, The Netherlands, American Meteorological Association, 15-19 July.

Andreas, E.L., Fairall, C.W., Grachev, A.A., Guest, P.S., Horst, T.W., Jordan, R.E., et al., "2003: Turbulent Transfer Coefficients and Roughness Lengths Over Sea Ice: The SHEBA Results," Seventh Conference on Polar Meteorology and Oceanography and Joint Symposium on High-Latitude Climate Variations, American Meteorological Society, Hyannis, MA, 12-16 May.

Grachev, A.A., Fairall, C.W., Persson, P.O.G., Andreas, E.L. and Guest, P.S., "2002: Stable Boundary-Layer Regimes Observed During the SHEBA Experiment," 15th Symposium of Boundary Layers and Turbulence, Wageningen, The Netherlands, American Meteorological Association, 15-19 July.

Grachev, A.A., Fairall, C.W., Persson, P.O.G., Andreas, E.L. and Guest, P.S., "2003: Turbulence Decay in the Stable Arctic Boundary Layer," Seventh Conference on Polar Meteorology and Oceanography and Joint Symposium on High-Latitude Climate Variations, American Meteorological Society, Hyannis, MA, 12-16 May.

Guest, P.S., Andreas, E.L., Fairall, C.W., Grachev, A.A., Jordan, R.E. and Persson, P.O.G., "2003: Modeling Surface Interactions in the Arctic Ocean: Accuracy vs. Computational Cost," Seventh Conference on Polar Meteorology and Oceanography and Joint Symposium on High-Latitude Climate Variations, American Meteorological Society, Hyannis, MA, 12-16 May.

METEOROLOGY

Jordan, R.E., Andreas, E.L., Fairall, C.W., Grachev, A.A., Guest, P.S. and Persson, P.O.G., "2003: Modeling Surface Exchange and Heat Transfer for the Shallow Snow Cover at SHEBA," Seventh Conference on Polar Meteorology and Oceanography and Joint Symposium on High-Latitude Climate Variation, American Meteorological Society, Hyannis, MA, 12-16 May.

Persson, P.O.G., Andreas, E.L., Fairall, C.W., Grachev, A.A., Guest, P.S. and Perovich, D.K., "2003: Pack Ice Surface Energy Changes at SHEBA Initiated by Late Summer Synoptic Forcing," Seventh Conference on Polar Meteorology and Oceanography and Joint Symposium on High-Latitude Climate Variations, American Meteorological Society, Hyannis, MA, 12-16 May.

KEYWORDS: Polar Meteorology, Air-sea-ice Interactions, Surface Fluxes

NUMERICAL STUDIES OF THE PHYSICAL OCEANOGRAPHY OF THE MEDITERRANEAN SEA

**Robert L. Haney, Professor
Department of Meteorology
Sponsor: Unfunded**

OBJECTIVE: The broad objective of this research is to improve the understanding of the physical oceanography of the Mediterranean Sea.

SUMMARY: During FY02 a study of SAR imaging was completed of the Alboran Sea (Font et al., 2002), and submitted studies of the interannual variability in the Mediterranean Sea (Fernandez et al., 2003a) and numerical modeling of the Gulf Stream (Dietrich et al., 2003). Work is continuing on studies of modeling the surface buoyancy flux in the Mediterranean Sea (Fernandez et al., 2003b) and the dynamics of an ocean eddy over Palamos Canyon (Pascual et al., 2003).

PUBLICATIONS:

Dietrich, D.E., Haney, R.L., Fernandez, V. and Tintore, J., "2003: Model-Determined Surface Heat and Fresh Water Sources Using a Precise, Non-Damping Approach," (in preparation).

Dietrich, D.E., Haney, R.L. and Mehra, A., "2003: Progress in Modeling the Gulf Stream System," *Geophysical Research Letters*, November 2002, (submitted).

Fernandez, V., Dietrich, D.E., Haney, R.L. and Tintore, J., "2003: Numerical Simulation of the Mediterranean Sea Using DieCAST Ocean Model: Seasonal, Mesoscale and Interannual Variability," *Progress in Oceanography*, June 2002, (submitted).

Font, J., Rousseau, S., Shirasago, B., Garcia-Gorriz, E. and Haney, R.L., "2002: Mesoscale Variability in the Alboran Sea: Synthetic Aperture Radar Imaging of Frontal Eddies," *Journal of Geophysical Research*, 107, p.12-1 to 12-17.

Pascual, A., Gomis, D., Haney, R.L. and Ruiz, S., "2003: A Quasi-Geostrophic Analysis of a Meander in the Palamos Canyon (Northwestern Mediterranean)," (in preparation).

EVOLUTION OF TROPICAL CYCLONE CHARACTERISTICS

Patrick A. Harr, Research Associate Professor

Russell L. Elsberry, Professor

Department of Meteorology

Sponsor: Office of Naval Research

OBJECTIVE: Recent research has concentrated on two primary objectives. Extended periods of increased and reduced tropical cyclone activity occur several times during a typical tropical cyclone season. An objective of this project is to identify the physical mechanisms in the large-scale circulation that act to initiate, maintain, and decay periods of enhanced or reduced tropical cyclone activity. If reliable forecasts of extended periods of increased or reduced tropical cyclone activity could be made, maritime operations could be coordinated appropriately.

Because decaying tropical cyclones often transition to fast-moving and rapidly-developing extratropical cyclones that may contain gale-, storm-, or hurricane-force winds (Jones et al., 2002, Harr 2002b), an objective of this project is to improve understanding and prediction of the extratropical transition (ET) phase of a decaying tropical cyclone.

SUMMARY: A Singular Value Decomposition (SVD) analysis has been applied to 850 hPa wind anomalies and OLR anomalies for the period 1979-1998. The SVD modes were used to define spatial and temporal characteristics of the western North Pacific large-scale circulation over intraseasonal (global in space and 30-60 days in time), monsoon trough (regional in space and 10-25 days in time), and synoptic scales. The results of the SVD analysis have been used to identify the contribution of each mode to total large-scale circulation variability, which was then related to tropical cyclone activity or inactivity (Harr and Elsberry 2002). The stability of the circulation modes was established by comparing Empirical Orthogonal Function (EOF) modes based only on wind anomalies for the period 1958-1998. Comparison between the wind-EOF modes and modes defined by coupling wind and OLR anomalies indicates that the 10-25 day variability is best defined during periods of enhanced intraseasonal variability. Experiments with a basic Canonical Correlation Analysis scheme (Harr 2002a) have been conducted to investigate the potential of 15-30 day predictions of tropical cyclone activity based on the circulation modes. While the variability in tropical cyclone activity that is related to the 30-60 day modes is statistically significant, the relationship does not provide adequate predictive skill. However, the skill associated with 15-30 day statistical predictions is increased when the 30-60 day and 10-25 day modes are combined.

The sensitivity of the re-intensification of a decaying tropical cyclone as an extratropical cyclone during the ET process was investigated through numerical simulation (Klein et al. 2002a,b). The sensitivity was examined by modifying the initial conditions of several simulations using the Coupled Ocean Atmosphere Mesoscale Prediction System (COAMPS) such that movement of the tropical cyclone into the midlatitudes was either delayed or accelerated and thus altered the phasing with the midlatitude circulation.

PUBLICATIONS:

Jones, S.C., Harr, P.A., Abraham, J., Bosart, L.F., Bowyer, P.J., Evans, J.L., et al., "2001: The Extratropical Transition of Tropical Cyclones: Forecast Challenges, Current Understanding and Future Directions," *Weather and Forecasting*, (accepted).

Klein, P.M., Harr, P.A. and Elsberry, R.L., "2002a: Extratropical Transition of Western North Pacific Tropical Cyclones: Midlatitude and Tropical Cyclone Contributions to Re-Intensification," *Monthly Weather Review*, 130, 2240-2259.

CONFERENCE PAPERS:

Harr, P.A., "2002a: Intraseasonal Variability and Prediction of Tropical Cyclone Activity Over the Western North Pacific," *Workshop on Weather Extremes and Atmospheric Oscillations, Risk Prediction Initiative*, Hamilton, Bermuda, 51-57, [available at <http://www.bbsr.edu/climate/Wgactivities>.].

Harr, P.A., "2002b: Tropical Cyclone Formation and Extratropical Transition," *Fifth International Workshop on Tropical Cyclones*, World Meteorological Organization, WMO/TD No. 1136.

Harr, P.A. and Elsberry, R.L., "2002: Prediction of Intraseasonal Variability in Tropical Cyclone Activity Over the Western North Pacific Ocean," *Preprints, 25th Conference on Hurricanes and Tropical Meteorology*, American Meteorological Society, 654-655, Boston, MA.

Klein, P.M., Harr, P.A. and Elsberry, R.L., "2002b: Extratropical Transition of Western North Pacific Tropical Cyclones: Midlatitude and Tropical Cyclone Contributions to Re-Intensification," *Preprints, 25th Conference on Hurricanes and Tropical Meteorology*, American Meteorological Society, 541-542, Boston, MA.

KEYWORDS: Tropical Cyclones, Midlatitude Cyclones, Numerical Weather Prediction, Extratropical Transition

PREDICTING TROPICAL CYCLONE FORMATION AND STRUCTURE CHANGE

Patrick A. Harr, Research Associate Professor

Russell L. Elsberry, Professor

Kevin Cheung, Research Assistant Professor

Department of Meteorology

Sponsors: Office of Naval Research and Space and Naval Warfare Systems Center

OBJECTIVE: This Rapid Transition Project co-sponsored by ONR and SPAWAR has an objective to move to operations promising research studies. Our research group has studies various aspects of tropical cyclone formation, which need to be understood due to the Navy requirement for five-day track forecasts. A tropical cyclone may form and reach typhoon intensity in under five days (Harr 2002), which may pose a threat to exercises and ship operations. Because dynamical model tropical cyclone structure and track guidance tends to be less accurate during the early stages of the tropical cyclone life cycle, the prime objective during this past year has been to identify the capability of numerical models to forecast tropical cyclone formation.

SUMMARY: An automated and objective algorithm for detecting and tracking low-level circulations in numerical model analysis and forecast fields (Dorics 2002) has been applied to the June-October 2001 period over the North Atlantic and western North Pacific Ocean basins for the Navy Operational Global Atmospheric Prediction System (NOGAPS). To identify the circulation and its associated physical characteristics, a bivariate normal probability distribution is used to fit an ellipse to the 850 hPa vorticity field. In addition to the basic characteristics of the circulation, a set of environmental parameters has been defined relative to the 95% probability ellipse of the bivariate normal distribution fit to the vorticity field. Therefore, the potential for tropical cyclone formation can be assessed relative to the various environmental factors defined for developing and non-developing circulations.

The data base of analyzed and forecast circulation centers that existed for at least two days has been examined to determine the ability of NOGAPS to accurately predict the timing of the first appearance of the analyzed circulation center. A forecast is considered early (late) if the first forecast of the circulation verifies before (after) the first analysis time. In the case of early forecasts, error statistics cannot be computed because the circulation has not yet appeared in the analysis. On-time forecasts occur when the first forecast of a circulation verifies at the first analysis time. Approximately 40% of the forecasts of circulations contained in NOGAPS sequences that were initialized prior to the appearance of the analyzed circulation verified at the correct time (Dorics et al. 2002). If the definition of on-time is relaxed to span the 12 h prior to and after the first analysis time, then 70% of the forecasts verified on time. The data base will form the basis of an expert-system module that will assist operational forecasters in evaluating circulations as to their potential for developing into a tropical cyclone by placing the current forecast scenarios in the context of historical model traits.

METEOROLOGY

CONFERENCE PAPERS:

Dorics, T., Harr, P.A. and Elsberry, R.L., "2002: Assessment of the Potential for Prediction of Tropical Cyclone Formation in the Navy Global Model," *Preprints, 25th Conference on Hurricanes and Tropical Meteorology*, American Meteorological Society, Boston, MA, 222-223.

Harr, P.A., "2002b: Tropical Cyclone Formation and Extratropical Transition," *Fifth International Workshop on Tropical Cyclones*, World Meteorological Organization, WMO/TD No. 1136.

THESIS DIRECTED:

Dorics, T., "An Assessment of NOGAPS Performance in the Prediction of Tropical Atlantic Circulation Formation," Master's Thesis, Naval Postgraduate School, June 2002.

KEYWORDS: Tropical Cyclones, Midlatitude Cyclones, Numerical Weather Prediction, Extratropical Transition

NOWCAST FOR THE NEXT GENERATION NAVY

John McCarthy, Research Professor

Department of Meteorology

Sponsor: Naval Research Laboratory - Monterey

OBJECTIVE: The board objective of this research is to continue guidance and advocacy for the NOWCAST program, provide senior leadership for Naval Research Laboratory-Monterey technology efforts and foster more collaboration between Naval Research Laboratory-Monterey and Naval Postgraduate School Department of Meteorology.

THESES DIRECTED:

Eckardt, M., "Assessing the Effect of Model Error on Radar Inferred Evaporative Ducts," Master's Thesis, Naval Postgraduate School, March 2002.

Robinson, S., "Utility of Tactical Environmental Processor (TEP) as a Doppler at-Sea Weather Radar," Master's Thesis, Naval Postgraduate School, March 2002.

KEYWORDS: Mesoscale Forecasting, COAMPS, NOWCAST, TAMS-RT

GLOBEC – NORTHEAST PACIFIC CLIMATE CHANGE MECHANISMS

Tom Murphree, Senior Lecturer

Department of Meteorology

Sponsor: National Oceanic and Atmospheric Administration

OBJECTIVE: This project is designed to analyze long term weather and climate variations in the North Pacific – North American atmosphere and ocean, and the mechanisms that produce these variations. This work supports the development of medium and long-range weather and climate forecasts.

SUMMARY: This project is part of the U.S. GLOBEC research program, funded by the National Science Foundation and the National Oceanic and Atmospheric Administration (NOAA). These projects are being conducted in collaboration with researchers in the Department of Oceanography at the Naval Postgraduate School (NPS) and at the Pacific Fisheries Environmental Laboratory (PFEL) of NOAA in Pacific Grove, CA. The goal is to develop a better understanding of the intraseasonal to decadal variations of the atmosphere and ocean in the North Pacific – North American (NPNA) region. Work emphasizes the identification and description of the mechanisms that govern these variations (e.g., teleconnections from remote regions and their impacts on surface wind stress and moisture transports). This research involves dynamical analyses of

observed, analyzed, and modeled atmospheric and oceanic fields. During 2002, focus was on: (1) dynamical analyses of the seasonal cycle, and intraseasonal to decadal variations, of the atmosphere and upper ocean; (2) analyses of the simulation of these variations by a global ocean general circulation model; (3) identification of dynamic similarities in climate change processes operating on intraseasonal, interannual, and decadal scales; and (4) identification of the atmospheric and oceanic teleconnection mechanisms that link the NPNA region to southern and eastern Asia and the tropical Pacific. Some specific aspects of this work are described below.

It is hypothesized that the seasonal evolution of ocean conditions, and the atmospheric factors that force them, may be analogous to the development of intraseasonal, interannual, and decadal climate anomalies. To test this hypothesis, the seasonal co-evolution of observed wind stress curl and upper ocean temperature in the northeast Pacific (NEP) has been analyzed, and the dynamical processes that link these two key fields in atmosphere-ocean interactions. This work is presented in Murphree et al. (2003a) paper. We have used the results of these studies to identify the mechanisms for intraseasonal to decadal climate anomalies. One aspect of this work is presented in Murphree et al. (2003b) paper.

It is also hypothesized that weather and climate vents operating at intraseasonal to decadal scales are, in terms of their major mechanisms, dynamically similar. This hypothesis was tested using observational data for several specific events and for composites of related events (e.g., composites of La Nina events). The results have led us to identify two major characteristic relationships between atmospheric and oceanic anomalies that occur in most major intraseasonal, interannual, and decadal climate events. These relationships extend from 200 hPa in the upper troposphere to 2°0 m deep in the upper ocean, and from east Asia and the tropical Pacific to the North Atlantic. Some of the results of this work were presented in the Schwing et al. (2002a,b) and Murphree et al. (2003a,b) papers, and in several talks. Additional aspects of this research are also the subjects of two papers in preparation that will be submitted in 2003.

PUBLICATIONS:

Murphree, T., Green-Jessen, P.M., Schwing, F. and Bograd, S., “2002a. The Seasonal Cycle of Wind Stress Curl and Its Relationship to Subsurface Ocean Temperature in the Northeast Pacific,” *Geophysical Research Letters*, (in press).

Murphree, T., Bograd, S., Schwing, F. and Ford, B., “2002b. Large Scale Atmosphere-Ocean Anomalies in the Northeast Pacific During 2002 and Their Impacts on the California Current System,” *Geophysical Research Letters*, (submitted).

Murphree, T., Ford, B., Schwing, F. and Bograd, S., “2002c. Dynamic Similarity in North Pacific – North American Climate Variations. Part 1: Characteristic Relationships and Mechanisms,” (in preparation).

Schwing, F.B., Murphree, T. and Green, P.M., “2002a. The Northern Oscillation Index (NOI): A New Climate Index for the Northeast Pacific,” *Progress in Oceanography*, Vol. 53, pp. 115-139.

Schwing, F.B., Murphree, T., deWitt, L. and Green, P.M., “2002b. The Evolution of Oceanic and Atmospheric Anomalies in the Northeast Pacific During the El Niño and La Niña Events of 1995-2001,” *Progress in Oceanography*, Vol. 54, pp. 459-491.

Schwing, F., Murphree, T., Bograd, S. and Ford, B., “2002c. Dynamic Similarity in North Pacific – North American Climate Variations. Part 2: Case Studies,” (in preparation).

Tokmakian, R., “Monitoring North Pacific Heat Content Variability: An Indicator of Fish Quantity?” *Earth Interactions*, (submitted).

PRESENTATIONS:

Green-Jessen, P., Schwing, F.B., Bograd, S.J. and Murphree, T., “The Seasonal Cycle of Upper Ocean Temperatures of the West Coast: Local Atmospheric Forcing and Rossby Wave Propagation,” Ocean Sciences Meeting, Honolulu, HI, February 2002.

METEOROLOGY

Murphree T., Schwing, F., Ford, B. and Hildebrand, P., "Climate Variations in the Northeast Pacific: Dynamic Similarities and Links to the Northwest Atlantic," Ocean Sciences Meeting, Honolulu, HI, February 2002.

Murphree T., Schwing, F., Ford, B. and Hildebrand, P., "Dynamic Similarities in North Pacific-North American Climate Variations," 19th Annual PACLIM Workshop, Pacific Grove, CA, March 2002.

Murphree T., Schwing, F. and Ford, B., "Northeast Pacific Climate Variations: Characteristic Atmosphere-Ocean Relationships and Mechanisms," Northeast Pacific Scientific Investigators Meeting, Corvallis, OR, November 2002.

Schwing, F., Murphree, T., Bograd, S.J. and Green-Jessen, P., "Decadal Regime Shifts: Physical Mechanisms and Ecosystem Consequences," 19th Annual PACLIM Workshop, Pacific Grove, CA, March 2002.

Tokmakian, R., "From WOCE to CLIVAR - Monitoring the Variability of the Mid-Latitude North Pacific Ocean," Northeast Pacific Scientific Investigators Meeting, Corvallis, OR, November 2002.

Tokmakian, R., "From WOCE to CLIVAR - Monitoring the Variability of the Mid-Latitude North Pacific Ocean," WOCE and Beyond Conference, San Antonio, TX, November 2002.

Tokmakian, R., "Monitoring the Variability of the Subtropical Gyres," TOPEX/JASON SWT, Biarritz, France, June 2002.

KEYWORDS: Atmospheric and Oceanic Variations, California Current System, El Niño, GLOBEC, La Niña, Long Term Weather, North Pacific, Ocean Modeling, Medium and Long-range Forecasting, Teleconnections, Weather and Climate System

METEOROLOGY, OCEANOGRAPHY, AND MILITARY OPERATIONS

Tom Murphree, Senior Lecturer

Department of Meteorology

Sponsor: Chief, Naval Education and Training

OBJECTIVE: The objective of this project is to develop an online course that will enable military personnel who take the course to more effectively use meteorological and oceanographic information to improve the planning, conduct, and assessment of military operations.

SUMMARY: The course being developed in this project is: *Meteorology, Oceanography, and Military Operations*. The course has two major learning outcomes: (1) Students will develop a conceptual understanding of the major principles of meteorology and oceanography and their application to the wide range of environments in which the military operates; and (2) Students will develop the ability to use the major principles to make basic analyses and predictions of atmospheric and oceanic variations that are relevant to military operations. Meteorological and oceanographic topics are examined in contexts that are relevant to the students (e.g., atmospheric and oceanic effects on navigation, aviation, weapons operation, safety; environmental forecasting and operations planning; etc.). Military case studies are extensively used. Applications of the basic topics to regions of operational concern (e.g., southwestern Asia, eastern Mediterranean, South China Sea) are emphasized. Course development started in summer 2002 and is currently in progress. Part of the development was conducted as part of LCDR Brett Martin's thesis research (*METOC and Naval Afloat Operations: Risk Management, Safety, and Readiness*, Masters of Science Thesis, Naval Postgraduate School, December 2002; Advisor: Murphree, T., Co-Advisor: C. Wash). The publicly accessible pages for this course are available at: http://online.nps.navy.mil/MROC2000_Me/.

METEOROLOGY

PUBLICATION:

Martin, B. and Murphree, T., "Assessing and Managing METOC Risks in RHIB Operations," training module prepared for Department Head Program of Surface Warfare Officers School, and for development of NPS online course, Meteorology, Oceanography, and Military Operations.

KEYWORDS: Distributed Learning, Education, Online Education, Training, Meteorology, Oceanography, Military Operations

DEVELOPMENT OF MARINE FORECASTER TRAINING MATERIALS

Wendell A. Nuss, Associate Professor

Department of Meteorology

Sponsor: National Weather Service, National Oceanic and Atmospheric Agency

OBJECTIVE: The objective of this project is to develop materials to aid in the training of weather service forecasters in marine meteorology.

SUMMARY: This effort is to develop materials on marine forecasting for web-based training of NWS forecasters. The marine forecaster module from COMET, sessions from previous training workshops held at NPS, and other materials have been reviewed and serve as a basis for these modules. The modules will be produced by COMET. An annual workshop at NPS for NWS marine forecasters was held again and is planned as an ongoing collaboration between the Navy and NWS.

KEYWORDS: Training, Marine Meteorology, Regional Forecasting

DEVELOPMENT OF MESOSCALE TRAINING MATERIALS

Wendell A. Nuss, Associate Professor

Department of Meteorology

Sponsor: Commander, Naval Oceanographic Command

OBJECTIVE: The objective of this project is to develop materials to aid in the training of enlisted forecasters in mesoscale meteorology.

SUMMARY: This effort is conducted jointly with the Cooperative Operational Meteorology Education and Training (COMET) program at the University Corporation for Atmospheric Research (UCAR). NPS leads the effort to develop scientific content for use in web-based training modules being put together at COMET. During the past year modules on sea breezes, coastally-trapped disturbances, gap winds, principles of convection, and mountain-valley circulations were completed. Content for dust forecasting and coastal jets was also passed on to COMET for initial development.

KEYWORDS: Training, Mesoscale Meteorology, Regional Forecasting

HIGH RESOLUTION FIRE WEATHER MODELING

Wendell A. Nuss, Associate Professor

Douglas Miller, Research Assistant Professor

Department of Meteorology

Sponsor: U.S. Dept. of Agriculture, Forest Service

OBJECTIVE: The objective of this research is to develop high resolution model forecasts to support fire and smoke modeling. Local observational data will be assimilated into the numerical model and test will be done to improve the accuracy of the forecasts.

METEOROLOGY

SUMMARY: High resolution fire weather information for the Pacific Southwest region is needed to forecast fire danger, fire behavior, and fire impacts on air quality. The MM5 modeling effort at the Naval Postgraduate School presently runs quasi-operationally for domains that cover the state of California at a resolution of 12km. This forecast is run twice daily, initialized using a data assimilation that blends available observations with an available model first guess that can be the MM5 model itself or some other operational model. We are developing and testing methods to produce high resolution fire weather analyzes and forecasts. RAWS data have been assessed and incorporated into analyzes, and are being evaluated to integrate into fire management products. Several meetings between NPS and fire weather/management personnel have determined the types of products of interest for development.

KEYWORDS: Data Assimilation, Predictability, Regional Forecasting

PRACTICAL LIMITS TO ATMOSPHERIC MESOSCALE PREDICTABILITY

Wendell A. Nuss, Associate Professor
Douglas Miller, Research Assistant Professor
Department of Meteorology
Sponsor: Office of Naval Research

OBJECTIVE: The objective of this research is to determine the ability to numerically predict mesoscale coastal structures in a variety of synoptic scale situations and demonstrate for given small scale structures the time ranges under which they might be considered predictable. The answer is probably dependent on the data assimilation system and one objective is to determine this sensitivity.

SUMMARY: During the past year, a case of explosive cyclogenesis that occurred off the coast of California was used to examine the impact of data assimilation technique on the evolution of the synoptic and mesoscale structures. The case occurred on Feb. 12-13, 2001 during the Pacific Landfalling Jets Experiment (PACJET) and had dropsonde and aircraft observations available in addition to the routine observations. Model simulations have been run for this case using both the MVOI and MQ where observations have been included and excluded (first guess only). These model simulations have been compared to determine the evolution differences and their dynamic causes. The two data assimilation approaches differ in both the mathematical technique to define the structure but also the MQ approach undergoes a divergence removal step prior to insertion into the model. The results were presented at the Mountain Meteorology conference in June 2002.

In addition to the study of data assimilation impacts, a study was begun to examine the growth of mesoscale error in real-time forecasts using the MM5 model run at NPS. The study is not yet complete but model forecasts made routinely twice a day at NPS have been collected between April and September 2002 and reformatted in order to calculate the spread in lagged forecasts. While not ideal to determine mesoscale error, this study does allow the determination of mesoscale error growth due to synoptic scale differences. The data has been processed and a student is relating these error statistics to the synoptic-scale pattern and other factors.

PRESENTATIONS:

Nuss, W.A. and Miller, D.K., "2002: Landfalling Cyclone Forecast Sensitivity to Varying Data Assimilation Methods in a Mesoscale Model," 10th Conference on Mountain Meteorology, Park City, UT, 17-21 June 2002.

Nuss, W.A. and Miller, D.K., "2002: Mesoscale Predictability Studies," Office of Naval Research Workshop for the Predictability Departmental Research Initiative, Boulder, CO, 6-7 May 2002.

Nuss, W.A. and Miller, D.K., "2002: Mesoscale Predictability Studies," Office of Naval Research 6.2-6.4 Science Review Meeting, Monterey, CA, 12-15 February 2002.

KEYWORDS: Data Assimilation, Predictability, Regional Forecasting

METEOROLOGY

ANALYSES OF AIRCRAFT MEASUREMENTS OF BOUNDARY LAYERS AND STRATUS CLOUDS IN THE ARCTIC

**Qing Wang, Associate Professor
Department of Meteorology**

Sponsor: National Aeronautics and Space Administration-Langley

OBJECTIVE: The objective of this project is to understand the inhomogeneity in the Arctic boundary layer as a result of low-level clouds and the ice surface features such as leads. The goal is to understand the magnitude and variation of surface turbulent fluxes in the total energy budget of the Arctic climate system. The study is part of the effort of FIRE-III/SHEBA.

SUMMARY: Aircraft measurements on boundary layer turbulence structure were made by the NCAR C-130 during the Beaufort Arctic Storms Experiment (BASE) in 1994 and during the Surface Heat Budget of the Arctic (SHEBA) experiment in 1998. Data from one flight during the BASE experiment have been analyzed to study the boundary layer inhomogeneity introduced by the presence of low-level clouds and the fractional cloud cover. It was found that the boundary layer thermodynamics were largely determined by the cloud-top height, since the presence of cloud generally resulted in one or two mixed layers below the cloud top. The two-mixed layer structure in some of the soundings is the result of multiple cloud layers, which is different from the decoupled boundary layers in the subtropical marine boundary layers. In addition, the presence of low-level cloud significantly increased the intensity of boundary layer turbulence. However, we did not observe significant increase in the magnitude of surface flux in cloudy region compared to the clear region. Further study indicated that the small flux is caused by the small temperature or moisture perturbation. The turbulence spectra in the clear and cloudy regions indicated that the cloud layer alters the turbulence spectra significantly. In 2002, efforts have been made to incorporate these results into a paper submitted to *Boundary Layer Meteorology*. The funding for this support ended in March of 2002.

PUBLICATION:

Wang, Q. and Wang, S., "2002: Turbulence and Thermodynamic Structure of the Autumnal Arctic Boundary Layer Due to Embedded Clouds," *Boundary Layer Meteorology*, (submitted).

KEYWORDS: Boundary Layer Meteorology, Turbulence Structure, Arctic Research

EVALUATIONS OF SURFACE FLUX AND BOUNDARY PARAMATERIZATIONS IN COAMPS USING AIRCRAFT MEASUREMENTS

**Qing Wang, Associate Professor
Department of Meteorology
Sponsor: Office of Naval Research**

OBJECTIVE: The objective of this project is to evaluate the surface flux and boundary layer parameterizations currently used in COAMPS using measurements from Japan/East Sea Experiment (JES).

SUMMARY: It is generally understood that boundary layer parameterization and surface flux parameterization interact nonlinearly in a mesoscale model. The atmospheric forcing to the ocean is thus affected by the boundary layer parameterizations even with perfect formulation of the drag and exchange coefficients. However, such effect has not been quantified. This project intends to evaluate the behavior of the model predicted boundary layer and surface flux in order to improve the model representation of the lower atmosphere, particularly the surface fluxes. Simulations have been setup using COAMPS for the Japan/East Sea region at NPS for the month of Feb. 2000 during which period observations by the CIRPAS Twin Otter were available. We have processed the measurements from all JES Twin Otter flights and used them to systematically evaluate COAMPS, especially with its near surface mean and turbulence properties. In addition, we attempted to understand the COAMPS/Observations difference through budget analysis of the turbulent kinetic energy.

PUBLICATIONS:

Khelif, D., Friehe, C.A. and Wang, Q., "2002: Wintertime Boundary-Layer Structure and Air-Sea Interaction Over the Japan/East Sea," *Deep Sea Research*, (submitted).

Rados, K., Wang, Q., Kalogiros, J.A., Wang, S., Khelif, D. and Friehe, C., "2002: Evaluation of Marine Boundary Layer Parameterizations in COAMPS Using the JES Experiment Data Set," *15th Symposium on Boundary Layers and Turbulence*, American Meteorological Society, Wageningen, The Netherlands, 632-635, 15-19 July 2002.

KEYWORDS: Surface Flux, Boundary Layer Parameterization, COAMPS, Aircraft Measurement

IMPLEMENTING AND TESTING ENTRAINMENT PARAMETERIZATION FOR STRATOCUMULUS-TOPPED BOUNDARY LAYERS IN COAMPS

Qing Wang, Associate Professor
Department of Meteorology
Sponsor: Office of Naval Research

OBJECTIVE: The objective of this project is to improve the predictions for the stratocumulus-topped boundary layers as well as the cloud-free boundary layers from mesoscale models.

SUMMARY: This project intends to first understand the inversion structure at the top of the stratocumulus-topped boundary layer and the fine-scale entrainment process from *in situ* observations. We will then systematically evaluate the COAMPS performance against the observed data. Within this effort, the feasibility and the successful rate of implementing explicit entrainment parameterization will be assessed and concepts of explicit entrainment parameterization in mesoscale model will be developed and implemented. In 2002, analyzed the inversion structure on top of the marine boundary layer using measurements from the 1987 FIRE Experiment. The intent is to understand the vertical structure of the inversion layer so that they can be properly represented in the low vertical resolution COAMPS model. We also examined the sensitivity of the COAMPS cloud field to entrainment at the cloud top through modification to the minimum mixing length in COAMPS. The result indicates that the implementation of entrainment parameterization may have profound effects on COAMPS in simulating stratocumulus-topped boundary layers.

KEYWORDS: Stratocumulus-topped Boundary Layer, Entrainment, Aircraft Measurements

IMPROVING SURFACE FLUX PARAMETERIZATION IN THE NAVY'S COAMPS

Qing Wang, Associate Professor
Department of Meteorology
Sponsors: Office of Naval Research and Naval Research Laboratory

OBJECTIVE: The objective of this project is to improve surface flux parameterizations, particularly in low-wind conditions.

SUMMARY: The NPS effort on this project focused on several aspects. One is the study on the scale-dependence of surface flux and boundary layer parameterizations in high- resolution mesoscale models, for which we have performed model study with a variety of horizontal resolutions. The study indicated the needed of implementing scale-dependent boundary layer mixing parameterizations in producing the small scale variability anticipated in the high-resolution mesoscale models. As part of the CBLAST-low measurements, Nantucket measurements site include rawinsonde soundings was implemented, sodar measurements, and continuous measurements of mean and turbulent quantities on a 10 m mast. The pilot study was very successful. A good dataset for model evaluation and validation was obtained. A great deal was learned that would benefit out measurements in 2003.

METEOROLOGY

In addition, work was accomplished with other CBLAST dataset in an effort to organize the observations for COAMPS evaluation purposes. In particular, all flights were processed from the 2001 LongEZ measurements and provided this dataset to our collaborator at NRL.

PUBLICATIONS:

Wang, Q. and Eleuterio, D.P., "2001: A Comparison of Bulk Aerodynamic Methods for Calculating Air-Sea Fluxes," *Ninth Conference on Mesoscale Processes*, American Meteorological Society, Fort Lauderdale, FL, 30 July – 2 August 2001.

Wang, Q., Gao, Z. and Wang, S., "2002: Intercomparison of Three Sea Surface Roughness Schemes Using Buoy Data," *15th Symposium on Boundary Layers and Turbulence*, American Meteorological Society, Wageningen, The Netherlands, 551-554, 15-19 July 2002.

Wang S., Wang, Q. and Doyle, J., "2002: Some Improvements to Louis Surface Flux Parameterization," *15th Symposium on Boundary Layers and Turbulence*, American Meteorological Society, Wageningen, The Netherlands, 547-550, 15-19 July 2002.

Whisenant, M.K., Wang, Q., Wang, S. and Doyle, J.D., "2002: Turbulence Parameterizations and Scale Dependence of Turbulence Statistics," *Preprints, 15th Symposium on Boundary Layers and Turbulence*, American Meteorological Society, Wageningen, The Netherlands, 543-546, 15-19 July 2002.

KEYWORDS: Surface Flux Parameterization, Mesoscale Modeling

UNDERSTANDING THE EVOLUTION OF STRATOCUMULUS CLOUDS IN THE COASTAL ZONE

**Qing Wang, Associate Professor
Department of Meteorology
Sponsor: National Science Foundation**

OBJECTIVE: The objective of this project is to examine the physical processes affecting the evolution of coastal stratocumulus clouds.

SUMMARY: During the first year of this project (1999), field measurements of the coastal stratocumulus and the associated boundary layer were made off the coast of Monterey using the CIRPAS Twin Otter research aircraft. In 2001, additional efforts were made in calibrating the wind/turbulence measurements by considering the effects of flow distortion. This effort results in new understanding of aircraft measured turbulence in general. We now have a fully calibrated high-rate turbulence data available to collaborating research groups.

Efforts were made to study the interaction between the evolution of stratocumulus cloud and the coastal flow field. The effects of the coastal jet on the evolution of stratocumulus clouds were studied through analyses on the case observed on July 6. The variation of the cloud layer was analyzed along a vertical crosssection due west from Monterey Bay. We found that the strong low-level coastal jet promoted the cloud decoupling from the surface layer and the cloud start thinning quickly. Two decoupling mechanisms seem to be generated by the jet: i) the negative surface buoyancy flux because the curl of the surface wind stress in the area of the wind jet supports local upwelling which results in a cold pool of sea surface temperature and ii) the enhanced entrainment at cloud top due to wind shear. The decoupling cannot be the result of solar radiation absorption by the cloud alone because it happened in a limited zone only.

Within the same project, the analysis from the previous year was continued on the breakup mechanism of the coastal stratocumulus on the coast using continuous measurements from the Marine Atmospheric Measurement Lab (MAML) at NPS. The time evolution of the boundary layer vertical profiles of wind and temperature before and after the cloud breakup was analyzed. One dimensional simulation using a simple mixed layer cloud model, modified for simulating stratocumulus clouds over the coastal land, was performed to test hypotheses formed based on the observations. The results point to increases in cloud top entrainment and the accompanied warming and drying of the boundary layer air.

PUBLICATIONS:

Kalogiros, J.A. and Wang, Q., "2002a: Calibration of a Radome-Differential GPS System on a Twin Otter Research Aircraft for Turbulence Measurements," *Journal of Atmospheric Ocean Technology*, 19, pp. 159-171.

Kalogiros, J.A. and Wang, Q., "2002b: Aerodynamic Effects on Wind Turbulence Measurements with Research Aircraft," *Journal of Atmospheric Ocean Technology*, 19, pp. 1567-1576.

Kalogiros, J.A. and Wang, Q., "2002: Observations of Stratocumulus Entrainment in the Coastal Zone," *15th Symposium on Boundary layers and Turbulence*, American Meteorological Society, Wageningen, The Netherlands, pp. 205-208, 15-19 July 2002.

Wang, Q., Helmis, C., Kalogiros J. and Rados, K., "2002: Observations of Turbulence and Break-Up of Stratocumulus Using an Acoustic Sounder," *Preprints, 11th International Symposium on Acoustic Remote Sensing and Associated Techniques of the Atmosphere and Oceans*, Rome, Italy, 24-28 June 2002.

Wang, Q., Rosenberg D.L. and Wang, S., "2002: Understanding the Processes of Stratocumulus Break-Up in the Coastal Region," *15th Symposium on Boundary Layers and Turbulence*, American Meteorological Society, Wageningen, The Netherlands, pp. 84-87, 15-19 July 2002.

Wang, S., Wang, Q. and Feingold, G., "2002: Turbulence, Condensation and Liquid Water Transport in Numerically Simulated Nonprecipitating Stratocumulus Clouds," *Journal of Atmospheric Science*, (submitted).

KEYWORDS: Coastal Clouds, Boundary Layer Evolution, Aircraft Turbulence Measurement

**COLLABORATIVE RESEARCH PROJECTS IN DIRECT SUPPORT OF FNMOC
OPERATIONAL MISSION
Carlyle H. Wash, Professor
Department of Meteorology
Sponsor: Office of Naval Research**

OBJECTIVE: The board objective of this research is to execute collaborative research projects with the Fleet Numerical Meteorology and Oceanography Center (FNMOC). The collaboration includes NPS Meteorology faculty, NPS students conducting thesis research, and FNMOC personnel. These joint projects address FNMOC operational needs and advance the understanding of marine meteorology.

SUMMARY: Two collaborative thesis projects were supported in FY02 funding. The first project was: Improving METOC Products and Services by Utilizing Net Centric Concepts by LT Keith Barnhill. NPS thesis advisor was Professor C. H. Wash and FNMOC collaborator was Mr. Dave Huff. In this study, LT Barnhill investigated approaches to make METOC products and services more interoperable using net centric concepts to improve their tactical significance and use.

The second project was: METOC and Naval Afloat Operations: Risk Management, Safety, and Readiness by LCDR Brett Martin. This surface fleet safety study was a follow-on to the previous thesis, The Role of Weather in Class A Naval Aviation Mishaps FY90-98 completed by LCDR Ruben Cantu last year. NPS thesis advisors were Professor C. H. Wash and Senior Lecturer Tom Murphree. In this study, LCDR Martin investigated five years of aloft mishaps and identified 166 mishaps that were METOC related. A relatively large number of small boat mishaps motivated the development of a training module on operating small boats under various winds and sea states.

METEOROLOGY

THESES DIRECTED:

Barnhill, T., "Improving METOC Products and Services by Utilizing Net Centric Concepts," Master's Thesis, Naval Postgraduate School, September 2002.

Martin, B., "METOC and Naval Afloat Operations: Risk Management, Safety, and Readiness," Master's Thesis, Naval Postgraduate School, December 2002.

KEYWORDS: Operational Mission, Marine Meteorology, FNMOC Support, Net Centric Operations, Fleet Safety

METOC SUPPORT FOR OPERATIONALLY FOCUSED THESIS

Carlyle H. Wash, Professor

Department of Meteorology

Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: The technical objective of this project is support NPS thesis projects focused on operationally relevant problems for Fleet Numerical METOC Center or other operational METOC centers. This year's focus was on supporting projects on defining the Virtual Natural Environment and assisting the implementation of the VNE within the new Concept of Operations developed by the Oceanographer of the Navy.

SUMMARY: Main focus of this project was conducting development studies of the use of Rapid Environmental Assessment and the Virtual Natural Environment to support naval warfare. LCDR Vic Ross is conducting the first of these studies in this thesis to be completed in FY03. LCDR Ross is simulating an Weapon of Mass Destruction event near a Navy operational unit and assimilating local observations as a test of Rapid Environmental Assessment. The goal is provide better tactical products using WMD modeling packages such as the Joint Effects Model within the REA/WMD a framework.

Support was also provided for a second effort: Improving METOC Products and Services by Utilizing Net Centric Concepts by LT Todd Barnhill. NPS thesis advisor was Professor C. H. Wash and FNMOC collaborator was Mr. Dave Huff. In this study, LT Barnhill investigated approaches to make METOC products and services more interoperable using net centric concepts to improve their tactical significance and use.

THESES DIRECTED:

Barnhill, T., "Improving METOC Products and Services by Utilizing Net Centric Concepts," Master's Thesis, Naval Postgraduate School, September 2002.

Ross, V., "A Test of Rapid Environmental Assessment for the Virtual Natural Environment," Master's Thesis, Naval Postgraduate School, September 2003.

KEYWORDS: COAMPS, Mesoscale Modeling and Forecasting, Virtual Natural Environment, Net Centric Warfare

BOUNDARY LAYER EFFECTS ON ATMOSPHERIC FRONTS

Roger Terry Williams, Professor

Department of Meteorology

Sponsor: National Science Foundation

OBJECTIVE: To improve understanding of the influence of the boundary layer frontal development and variations that are crucial in mid-latitude weather prediction.

SUMMARY: The research was carried out with two-dimensional numerical models, which neglected moisture. Frontogenesis was initiated with an Eady type basic state with a constant north-south temperature gradient. As the initial disturbance grew the boundary layer grew and a special structure developed. These solutions are compared with overland and frictionless solutions.

Unbalanced frontogenesis was studied by considering an initial disturbance with no wind and a constant static stability. In this case the initial potential vorticity was constant. The formation of fronts was determined as a function of the initial Rossby and Froude numbers.

KEYWORDS: Numerical Models, Fronts, Boundary Layer

BOUNDARY LAYER EFFECTS ON MESOSCALE PHENOMENON

Roger Terry Williams, Professor

Department of Meteorology

Sponsor: Office of Naval Research

OBJECTIVE: To improve the simulation of boundary layer effects on fronts in coastal regions.

SUMMARY: Maritime frontogenesis was investigated with a two-dimensional numerical model with K -theory boundary layer parameterization. No moisture was included. Over-the-water the roughness length z_o depended on the surface wind speed. The fixed z_o , which was over land, was much larger than any of the values used over water. The over land fronts had a limiting horizontal scale of a few hundred kms, while those over the ocean reached a few grid lengths. Some observed fronts over the ocean do have very small scales. This difference between land and the sea is related to the large differences in z_o .

KEYWORDS: Numerical Models, Fronts, Boundary Layer

**DEPARTMENT OF
METEOROLOGY**

**2002
Faculty Publications
and Presentations**

JOURNAL PAPERS

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**DEPARTMENT OF
OCEANOGRAPHY**

**MARY L. BATTEEN
CHAIR**

OCEANOGRAPHY

OVERVIEW:

The Department of Oceanography has developed a broad research program focused on physical oceanography to meet the anticipated future needs of the Navy. Our basic research themes are the development of scientific capabilities to measure, analyze, and forecast fields of littoral ocean variables, which occur in association with synoptic/mesoscale processes over limited regional temporal domains. The areas of emphasis include coastal and nearshore ocean dynamics, air-sea interaction phenomena and boundary currents. Regions of interest include the polar seas, coastal ocean regions and strategic straits of the world.

Our applied research themes are the application of analyses and forecasts of upper ocean synoptic/mesoscale variability to Naval operations. Areas of emphasis include the impact of littoral processes, eddies and boundary currents on ocean surveillance systems, the effect of storms on acoustic propagation and ambient noise, and the impact that the wave climate exerts on nearshore processes and beach character as it pertains to mine/mine countermeasure and amphibious warfare.

These research themes require the development of numerical ocean prediction models and synoptic observation capabilities. They are achieved through employment of modern dynamical and mathematical principles, numerical and statistical methods, computational and graphical facilities, and in-site and remote sensing observations.

CURRICULA SERVED:

- Meteorology and Oceanography
- Operational Oceanography
- Oceanography
- Undersea Warfare
- Space Systems Operations
- Space Systems Engineering

DEGREES GRANTED:

- Master of Science in Meteorology and Physical Oceanography
- Master of Science in Physical Oceanography
- Doctor of Philosophy in Physical Oceanography

RESEARCH THRUSTS:

- Acoustical Oceanography:
Ching-Sang Chiu, Robert Bourke, Arthur Parsons
- Air-Sea Interaction and Ocean Turbulence:
Roland Garwood, Tim Stanton, Peter Chu, Le Ly
- Coastal and Nearshore Oceanography:
Jeff Paduan, Mary Batteen, Ed Thornton, Thomas Herbers, Edith Gallagher, Pierre Poulain, Curt Collins, Steven R. Ramp, Leslie Rosenfeld
- Numerical Prediction and Data Assimilation:
Mary Batteen, Bert Semtner, Julie McClean, Robin Tokmakian, Ramsey Harcourt, Wieslaw Maslowski, Pierre Poulain, Arlene Guest, Le Ly
- GI&S and Navigation:
James Clynch, Arthur Parsons
- Polar Oceanography:
Wieslaw Maslowski, Yuxia Zhang, Robert Bourke, Roland Garwood, Ramsey Harcourt

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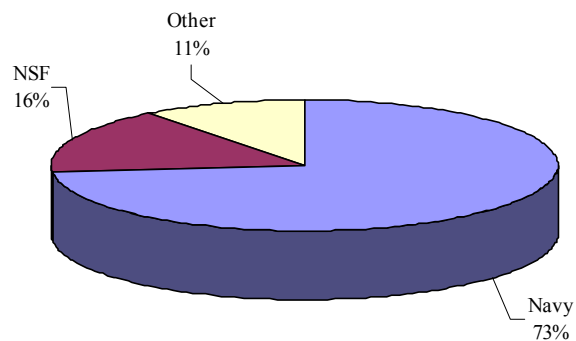
- Research Vessel Point Sur
- Rapid Environmental Assessment Laboratory
- Ocean Acoustic Observatory at Point Sur
- Computer Graphics Laboratory
- Moored Equipment Laboratory
- Calibration Laboratory
- Tactical Environmental Support Laboratory

RESEARCH CHAIR:

- Office of Naval Research Chair in Arctic Marine Science

SPONSORED RESEARCH PROGRAMS (Research and Academic)-FY2002:

The Naval Postgraduate School's sponsored program exceeded \$61 million in FY2002. 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: \$4,454K

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ONR CHAIR IN ARTIC MARINE SCIENCE

Mary L. Batteen, Associate Professor

Department of Oceanography

Sponsor: Office of Naval Research

OBJECTIVE: The Chief of Naval Research has established at the Naval Postgraduate School a Chair in Arctic Marine Science. The objectives of the Chair are to foster oceanographic research in the Arctic, acquaint naval office students with Arctic problems, reduce results of pure research to operational usage, and publicize Navy interest in the Arctic.

SUMMARY: Professors Batteen and Bourke served as administrator of the Chair handling such details as soliciting Chair candidates, writing IPA's and proposals and setting up visits and seminars for the Chair incumbent.

Professor Mark Johnson from the Institute of Marine Science at the University of Alaska was the Chairholder during FY02. While at NPS Professor Johnson continued seminal studies on Arctic climate change in response to cyclic patterns in atmospheric pressure over the Arctic Ocean. During this period he initiated or completed six papers on this subject and sea ice thickness. He participated in a number of major conferences/workshops that provided him the opportunity to focus on a new but climate-related topic, i. e., the basin-wide ice thickness distribution. In conjunction with several colleagues, he will initiate efforts to make ice thickness measurements in several key areas using upward looking sonars and airborne electromagnetic sensors.

A search was conducted for the follow-on Chairholder. Dr. Max Coon, a senior research scientist from Northwest Research Associates, Inc. in Seattle, WA, has been selected. He will be in residence at NPS from October 2002 to September 2003. Dr. Coon will continue his ground breaking research related to frazil ice production in the marginal sea ice zones of Arctic waters. He is working directly with the Naval Ice Center to incorporate his modeling efforts and their remotely sensed data into the Navy's operational ice forecasting model.

KEYWORDS: Arctic Ocean, Arctic Oscillation, Climate Change, Sea Ice Thickness

COUPLED OCEAN ACOUSTICS AND PHYSICAL OCEANOGRAPHY OBSERVATIONS IN THE SOUTH CHINA SEA: THE NPS ACOUSTIC COMPONENT

Ching-Sang Chiu, Professor

Department of Oceanography

Sponsor: Office of Naval Research

OBJECTIVE: This effort is part of a large, international program called the Asian Sea International Acoustic Experiment (ASIAEX). In collaboration and coordination with other U.S. and Asia investigators participating in ASIAEX, we are carrying out comprehensive measurements and analysis of the different oceanographic factors affecting low frequency (< 600 Hz) acoustic propagation in a shelfbreak region in the Northeastern South China Sea (SCS). Specifically, the NPS acoustic research objectives are: (1) to understand the physics, variability and predictability of low-frequency sound pulse propagation along and across the NE SCS shelfbreak, including the dependence on frequency, source depth and path orientation, and the relations to water-column, bathymetric and sub-bottom structures; (2) to expand the acoustic knowledge acquired from previous shelf-slope experiments including shelfbreak PRIMER and SWARM, with added emphases on the horizontal properties of the sound field; (3) to investigate the advantages and disadvantages of conducting shallow-water tomography using higher-frequency (> 400 Hz) transmissions, and; (4) to formulate and test a phase or time-based modal tomography inverse method for joint estimations of the water-column and sediment properties.

SUMMARY: The simultaneous, high-resolution observations of the acoustic propagation characteristics and water column properties were accomplished by a combination of moored and shipboard observations in May of 2001. The processing and analysis of the acoustic data set, in conjunction with the oceanographic data, were underway with goal to understand the influences of inherent ocean variability on acoustic propagation, coherence and predictability. Work completed in 2002 included: (1) completed pulse-

compression processing of all phase-encoded acoustic signals measured by the Woods Hole Oceanographic Institute/Naval Postgraduate School L-shaped hydrophone array in two separate days, May 8 with the passage of several huge solitons that depressed the shallow isotherms to the sea bottom, and May 4 with a much less energetic soliton field. The L-shaped hydrophone array was moored on the continental shelf that monitored a variety of signals transmitted parallel to and across the shelfbreak by fixed and towed sources; (2) developed an empirical ocean model (with three tuning parameters: soliton phase speed, decay rate and stretch rate) based on moored temperature data to provide space-time continuous sound-speed fields to facilitate both acoustic data analysis and modeling; (3) analyzed, contrasted and modeled the amplitude fluctuations in the processed signals measured by the vertical segment of the L-shaped array for May 4 and May 8, and; (4) served as the ASIAEX Associate International Coordinator to assist in the coordination of international workshops and the Main Point of Contact for dispersing the ASIAEX SCS acoustic data to the foreign ASIAEX investigators.

PUBLICATION:

Chiu, C.-S., Ramp, S.R. and Lynch, J.F., "The ASIAEX 2000 Preliminary Experiment in the East China Sea (ECS)," *Theoretical and Computational Acoustics 2001*, World Scientific, E.C. Shang, Q. Li and T.F. Gao (Eds.), 2002.

PRESENTATIONS:

Chiu, C.-S., Ramp, S., Miller, C., Lynch, J., Duda, T., Newhall, A., et al., "Measurement and analysis of acoustic intensity fluctuations induced by South China Sea Internal Solitons," First Pan-American/Iberian Meeting on Acoustics Cancun, Mexico, 2-6 December 2002, (invited).

Chiu, C.-S., Ramp, S., Miller, C., Lynch, J., Duda, T., Newhall, A., et al., "Measurement and analysis of acoustic intensity fluctuations induced by South China Sea Internal Solitons," ONR ASIAEX International Symposium Chengdu, PRC, 14-18 August 2002.

KEYWORDS: Littoral, Acoustics, Shelfbreak

DETERMINATION OF THE DETECTION AND CLASSIFICATION PROBABILITIES AND RANGE LIMITS OF INEXPENSIVE ACOUSTIC SENSORS AND DATA PROCESSING TECHNIQUES FOR MONITORING ODONTOCETI WHALES

Ching-Sang Chiu, Professor

Curtis A. Collins, Professor

Christopher W. Miller, Research Assistant Professor

Department of Oceanography

Sponsor: Chief of Naval Operations (N45)

OBJECTIVE: The objective was to evaluate and predict the performance of inexpensive passive systems for monitoring vocalizing Odontoceti whales using conditional statistical measures. These performance measures included detection and classification probabilities and range limit against false-alarm rate. The sonar devices considered included freely drifting sonobuoys and fixed, bottom-lying hydrophones, as individual sensors and in array configurations.

SUMMARY: The approach was to analyze the statistics of the detector output as a function of signal-to-noise ratio (or source level and distance) and signal type in controlled, playback experiments under contrasting environmental conditions. The analyzed performance data was also used to validate and refine a predictive model. The study focused on signals in the 1-to-8 kHz frequency band. This was in part due to the limitation of the sound source and in part due to the consideration that seawater absorption naturally low-passes sound energy.

A representative set of Odontoceti signals was collected and three playback experiments were conducted. The first was in Santa Cruz Basin in "deep water," the second on the Monterey Bay shelf in "shallow water", and the third in July 2002 at the San Clemente Island Undersea Range SCIUR (ship self

radiated noise measurement array). In all experiments, omnidirectional sonobuoys were deployed in single-sensor, horizontal-array and vertical-array configurations. The dependence of the performance statistics of both the energy detector and correlation detector/classifier on signal characteristics, number of sonobuoys, geometry, SNR, range and environmental conditions was analyzed for three of the signals by a thesis student. Analysis of other signals was conducted by a student for his thesis.

PUBLICATION:

Chiu, C.-S., Miller, C.W., Moore, T.C. and Collins, C.A., "2002, Detection and Censusing of Blue Whale Vocalizations along the Central California Coast using a Decommissioned SOSUS Receiver," (in press).

THESIS DIRECTED:

Garcia, J., "Assessing the Performance of an Omni-directional Hydrophone as a Means to Detect Vocalizing Odontocetes: Initial Analysis," Master's Thesis, Naval Postgraduate School, December 2002.

KEYWORDS: Odontocetes, Underwater Acoustics, Sonobuoys, Hydrophones

UNCERTAINTIES AND INTERDISCIPLINARY TRANSFERS THROUGH THE END-TO-END SYSTEM (UNITES)

**Ching-Sang Chiu, Professor
Department of Oceanography
Sponsor: Office of Naval Research**

OBJECTIVE: This effort was part of a multi-institutional team effort to capture uncertainty in the common tactical picture. The team's name was UNITES, which stands for UNcertainties and Interdisciplinary Transfers through the End-to-End System. The UNITES team, with expertise spanning the ocean environment, underwater acoustics and tactical sonar systems, consisted of a total of twelve principal investigators from nine different organizations including Harvard University (HU), the Naval Postgraduate School (NPS), and the OASIS, Inc. The NPS component in the UNITES team's paradigm to solve the interdisciplinary, end-to-end problem had two objectives: (1) to characterize acoustic prediction uncertainties, including their connections to the uncertainties in the ocean and geo-acoustic parameter estimates, and (2) to forecast and improve acoustic baselines and their uncertainties in a data-assimilation framework involving coupled ocean and acoustic state variables.

SUMMARY: In acoustic field uncertainty characterization, the focus of the NPS 2002 work was on the tidal and shorter-scale uncertainties. Using Shelfbreak PRIMER acoustic and oceanographic data, the acoustic uncertainty statistics and their linkages to oceanographic variability in a slope-to-shelf transmission were investigated. In particular, the Naval Postgraduate School constructed the daily probability density functions of both the transmission loss of a pulse signal (350-450 Hz) in an energy estimate and the in-band noise level to allow for a quantification of the homogeneity of the inter-daily fluctuations as well as the nonstationarity of the intra-daily statistics. Also in collaboration with OASIS, the statistics of the peaks of the corresponding matched-filtered signals were developed and analyzed.

In acoustic field uncertainty reduction and forecast, the focus of the NPS 2002 work was on the small mesoscale and longer-scale uncertainties. In collaboration with the Woods Hole Oceanographic Institute and employing the SeaSoar CTD survey and acoustic transmission data from Shelfbreak PRIMER, it was empirically demonstrated that daily (mean) transmission loss predictions could be upgraded from climatology with updated ocean field estimates with small mesoscale resolution. Additionally, in collaboration with HU, the coupled ocean and acoustic prediction model developed in the previous year for the Shelfbreak PRIMER region was upgraded to include a data-assimilation module. The improved model was tested with simulated data. Joining both acoustic and ocean variables in the state vector, the simulation experiment showed that the data-assimilative model can produce simultaneous ocean and acoustic field predictions with reduced small mesoscale errors.

PUBLICATIONS:

Abbot, P., Gedney, C., Dyer, I. and Chiu, C.-S., "Ambient noise and signal uncertainties during the Summer shelfbreak Primer Exercise," *Proceedings of the NATO SACLANT Conference on Impact of Littoral Environmental Variability on Acoustic Predictions and Sonar Performance*, Lercici, Italy, September 2002.

Lermusiaux, P.F. and Chiu, C.-S., "Four-dimensional data assimilation for coupled physical-acoustical fields," *Proceedings of the NATO SACLANT Conference on Impact of Littoral Environmental Variability on Acoustic Predictions and Sonar Performance*, Lercici, Italy, September 2002.

Lermusiaux, P.F., Chiu, C.-S. and Robinson, A.R., "Modeling Uncertainties in the Prediction of the Acoustic Wavefield in a Shelfbeak Environment," *Theoretical and Computational Acoustics 2001, World Scientific*, E.C Shang, Q. Li and T.F. Gao (Eds.), 2002.

Lynch, J., Fredricks, F., Colosi, J., Gawarkiewicz, G., Newhall, A., Chiu, C.-S., et al., "Acoustic effects of environmental variability in the SWARM, PRIMER and ASIAEX experiments," *Proceedings of the NATO SACLANT Conference on Impact of Littoral Environmental Variability on Acoustic Predictions and Sonar Performance*, Lercici, Italy, September 2002.

PRESENTATION:

Chiu, C.-S., "NPS Progress in Capturing Uncertainty in the Common Tactical Environmental Picture," Uncertainty DRI: Review and Planning Meeting, Scripps Institution of Oceanography, La Jolla, CA, 19-20 June 2002.

KEYWORDS: Environmental Uncertainties, Acoustic Uncertainties, Sonar Performance

ASSESSMENT AND RECONSTRUCT OF NAVY'S MINE IMPACT BURIAL PREDICTION MODEL

Peter C. Chu, Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: The objectives of the project were assessment of current Navy's Impact Burial Prediction Model (IBPM), and reconstruct of IBPM using the advanced hydrodynamic theory. Both efforts were closely connected to the field experiment at Corpus Christi, Texas-Louisiana shelf sponsored by the Office of Naval Research IBPM program. This effort provided guidance for field experiments such as site selection, determination of variables to be measured (e.g., ocean and sediment conditions as well as mine burial depth). Additionally, data collected from the field experiments was used to verify the reconstructed IBPM in a more realistic environmental scenario.

SUMMARY: During the performance period, this study analyzed the data collected from Naval Postgraduate School and Naval Research Laboratory mine drop experiments with various sizes, improved the Navy's mine impact burial prediction model (IMPACT28) with realistic physics, and evaluated the new model using the analyzed observational data.

Transitions:

- The results obtained from this project were transferred to the Naval Oceanographic Office, Commander Mine Warfare Command, and the Office of Naval Research Mine Impact Burial Prediction group such as the mine expert system and mine scour and liquifaction groups.
- Two major results of IMPACT28 (over predicting the impact velocity and no capability for predicting the mine orientation) were obtained. The weakness is caused by incorrect physics (tumbling of mine and no moment of momentum balance) that are well accepted by the mine warfare community.

- The datasets collected from MIDEX (1/15th size), NSW-Carderock Experiment (1/3rd size), and Corps Christi Experiment (full size) will greatly impact on the development of an accurate Mine Impact Burial Prediction Model.
- The data were also used for development of the Expert System for Mine Impact Burial at the Applied Physics Laboratory of the John Hopkins University and the Environmental Sciences Department of the University of Virginia.
- The data were also used for development of the Mine Scouring and Liquefaction modeling effort at the Scripps Oceanographic Institution (headed by Dr. Scot Jenkins).

PUBLICATIONS:

Chu, P.C., Cintron, C., Haeger, S.D. and Keenan, R.E., "Acoustic mine detection using the Navy's CASS/GRAB model," *Journal of Counter Ordnance Technology*, (in press).

Chu, P.C., Gillies, A. and Fan, C.W., "Hydrodynamic characteristics of falling cylinder in water column," *Advances in Fluid Mechanics*, Vol. 4, pp. 163-181, 2002.

Chu, P.C., Gilles, A.F. and Fleischer, P., "Hydrodynamics of Falling Mine in Water Column," *Journal of Counter Ordnance Technology*, (in press).

Chu, P.C., Smith, T.B. and Haeger, S.D., "Mine impact prediction experiment," *Journal of Counter Ordnance Technology*, (in press).

PRESENTATIONS:

Chu, P.C., "Hydrodynamics of mine impact burial," ONR Impact Burial Annual Workshop, La Jolla, CA, 15-17 January 2002, (invited).

Chu, P.C., "Mine impact burial modeling," ONR Impact Burial Modeling Workshop, Phoenix, AZ, 5-7 March 2002, (invited).

Chu, P.C., Cintron, C., Haeger, S.D. and Keenan, R.E., "Acoustic mine detection using the Navy's CASS-GRAB," Fifth International Symposium on Technology and Mine Problem, NPS, Monterey, CA, 22-26 April 2002.

Chu, P.C., Gilles, A.F., Fan, C.W. and Flescher, P., "Hydrodynamics of falling mine in water column," Fifth International Symposium on Technology and Mine Problem, NPS, Monterey, CA, 22-26 April 2002.

Chu, P.C., Gilles, A.F., Fan, C.W., Lan, J. and Flescher, P., "Hydrodynamical characteristics of falling cylinder in water column," Fourth International Symposium on Advances in Mechanics, Gent, Belgium, 15-17 May 2002.

Chu, P.C., Smith, T.B. and Haeger, S.D., "Mine impact burial experiment," Fifth International Symposium on Technology and Mine Problem, NPS, Monterey, CA, 22-26 April 2002.

THESES DIRECTED:

Evans, A., "Hydrodynamics of Mine Impact Burial," Master's Thesis, Naval Postgraduate School, September 2002.

Vares, N., "Range Dependent Mine Detection Using CASS-GRAB," Master's Thesis, Naval Postgraduate School, June 2002.

LITTORAL ZONE OCEANOGRAPHY FOR MINE WARFARE

Peter C. Chu, Professor

Department of Oceanography

Sponsor: Naval Oceanographic Office

OBJECTIVE: This was a joint research effort among the Naval Postgraduate School, KOREA Ocean R&D Institute (KORDI), University of Tokyo (Japan) and Yonsei University (South Korea) for development of the Japan Sea circulation model using POM. The DBDB5 bathymetry was replaced with higher resolution bathymetry supplied by NAVOCEANO, and the improved model was compared with the NAVOCEANO operational models for the region and development of “operational parameter” uncertainty estimates continued for models running in marginal seas.

SUMMARY: During the performance period, the investigator: (1) developed a coastal atmosphere-ocean coupled system (CAOCS) for the East Asian marginal sea prediction, (2) investigated numerically the error propagation from winds to ocean models, (3) investigated two kinds of predictability of the Lorenz system, (4) identified the temporal and spatial decorrelation scales, (5) identified the South China Sea warm-core/cool-core eddies using the Navy’s MOODS data as well as the National Meteorological Center (NCEP) sea surface temperature (SST) fields (1982-94), and (6) developed highly accurate schemes for the σ -coordinate ocean models.

PUBLICATIONS:

Chu, P.C. and Fan, C.W., “Hydrostatic correction for reducing horizontal pressure gradient errors in sigma coordinate models,” *Journal of Geophysical Research*, (in press).

Chu, P.C., Ivanov, L.M., Korzhova, T.P., Margolina, T.M. and Melnichenko, O.M., “Analysis of sparse and noisy ocean current data using flow decomposition. Part 1: Theory,” *Journal of Atmospheric and Oceanic Technology*, Vol. 20, Iss. 4, p. 478, April 2003.

Chu, P.C., Ivanov, L.M., Korzhova, T.P., Margolina, T.M. and Melnichenko, O.M., “Analysis of sparse and noisy ocean current data using flow decomposition. Part 2: Application to Eulerian and Lagrangian data,” *Journal of Atmospheric and Oceanic Technology*, Vol. 20, Iss. 4, p. 492, April 2003.

Chu, P.C. and Lan, J., “Extremely strong thermohaline source/sinks generated by diagnostic initialization,” *Geophysical Research Letters*, (in press).

Chu, P.C., Li, R.F. and Fan, C.W., “Determination of the current system on isopycnal surface between Mindanao and New Guinea from GDEM,” *Chinese Journal of Oceanology and Limnology*, (in press).

Chu, P.C., Li, R.F. and You, X.B., “Northwest Pacific subtropical countercurrent on isopycnal surface in Summer,” *Geophysical Research Letters*, 29, 10.1029/2002GLO14831.

Chu, P.C., Li, R.F. and You, X.B., “Northwest Pacific subtropical counter current on isopycnal surface in June,” *Geophysical Research Letters*, 29, 10.1029/2002GLO14831.

Chu, P.C., Liu, Q.Y., Jia, Y.L. and Fan, C.W., “2002: Evidence of barrier layer in the Sulu and Celebes Seas,” *Journal of Physical Oceanography*, 32, pp. 3299-3309, 2002.

Chu, P.C., Mar, B.B. and Chen, Y.C., “South China Sea thermohaline structure and circulation,” *Chinese Journal of Oceanology*, 21, pp. 227-261, 2002.

Chu, P.C. and Wang, G.H., “Seasonal variability of thermohaline front in the central South China Sea,” *Journal of Oceanology*, (in press).

Chu, P.C., Wang, G.H. and Chen, Y.C., “Japan/East Sea (JES) circulation and thermohaline structure, Part 3, Autocorrelation Functions,” *Journal of Physical Oceanography*, 32, pp. 3596-3615, 2002.

Noh, C.J., Jang, Y., Yamagata, T., Chu, P.C. and Kim, C.H., "Simulation of more realistic upper ocean process from an OGCM with a new ocean mixed layer model," *Journal of Physical Oceanography*, 32, pp. 1284-1307, 2002.

CONFERENCE PAPERS:

Chu, P.C. and Ivanov, L.M., "Linear and nonlinear perspectives of forecast error estimate using the first passage time," Symposium on Observations, Data Assimilation, and Probabilistic Prediction, American Meteorological Society, Orlando, FL, pp. 127-132, 2002.

Chu, P.C., Ivanov, L.M. and Fan, C.W., "Determination of model valid prediction period using the backward Fokker-Planck equation," 16th Conference on Probability and Statistics in the Atmospheric Sciences, American Meteorological Society, Orlando, FL, 70-77, 2002.

Chu, P.C., Wang, J. and Qi, Y., "South China Sea elevation variability determined from TOPEX/POSEIDON data," 6th Symposium on Integrated Observing Systems, American Meteorological Society, Orlando, FL, 12-17, 2002.

CONFERENCE PRESENTATIONS:

Chu, P.C., "Low latitude Pacific western boundary current system," Ocean Sciences Meeting, American Geophysical Union, Honolulu, HI, 11-15 February 2002, (invited).

Chu, P.C., "C-vector for identification of oceanic secondary circulations across arctic forrms in Fram Strait," Chapman Conference on High Latitude Ocean Processes, American Geophysical Union, L'Esteral, Quebec, Canada, 26-29 August 2002, (contributed).

Chu, P.C., Cintron, C.J., Haeger, S.D., Schneider, D., Keenan, R.E. and Fox, D.N., "Yellow Sea acoustic uncertainty caused by hydrographic data errors," International Conference on Impact of Littoral Environment Variability on Acoustic Prediction and Sonar Performance, Lerici, Italy, 16-20 September 2002.

Chu, P.C. and Fan, C.W., "A finite volume ocean model," Oceans 2002, Marine Technology Society – IEEE, Biloxi, MS, 29-31 October 2002.

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Chu, P.C., Wang, J. and Qi, Y., "South China Sea elevation variability determined from TOPEX/POSEIDON data," 6th Symposium on Integrated Observing Systems, American Meteorological Society, Orlando, FL, 13-17 January 2002.

THESES DIRECTED:

Obino, R., "Simulation of Bohai Sea Circulation and Thermohaline Structure Using COHERENS Model," Master's Thesis, Naval Postgraduate School, June 2002.

Vares, N., "Range Dependent Mine Detection Using CASS-GRAB," Master's Thesis, Naval Postgraduate School, June 2002.

KEYWORDS: P-vector, Geostrophic Velocity, Beta-spiral, Inverse Method, Primitive Equation Model, Turbulence Closure, High-order Difference Schemes, Predictability

LITTORAL ZONE OCEANOGRAPHY FOR MINE WARFARE

Peter C. Chu, Professor

Department of Oceanography and Institute of Joint Warfare Analysis

Sponsor: Naval Oceanographic Office

OBJECTIVE: The objectives of the project were to improve current Navy's Impact Burial Prediction Model (IBPM) and Mine acoustic detection model (CASS-GRAB) using the advanced hydrodynamic theory and littoral zone oceanography. The efforts were closely connected to the field experiment at Corpus Christi, Texas-Louisiana shelf sponsored by ONR IBPM program. This effort provided guidance for field experiments such as site selection, determination of variables to be measured (e.g., ocean and sediment conditions as well as mine burial depth). Additionally, data collected from the field experiments were used to verify the reconstructed IBPM in a more realistic environmental scenario.

SUMMARY: During the performance period, the investigator's research improved the U.S. Navy's mine acoustic detection model and mine burial prediction models using realistic marginal sea ocean models and data.

PUBLICATIONS:

Chu, P.C., "C-vector for identification of oceanic secondary circulation across Arctic fronts in Fram Strait," *Geophysical Research Letters*, 29, 10.1029/2002GLO15978, 2002.

Chu, P.C., Cintron, C.J., Haeger, S.D. and Keenan, R.E., "Acoustic mine detection using the Navy's CASS/GRAB model," *Journal of Counter-Ordnance Technology*, [CD Rom].

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Chu, P.C. and Fan, C.W., "Hydrostatic correction for reducing horizontal pressure gradient errors in sigma coordinate models," *Journal of Geophysical Research*, (in press).

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Chu, P.C., Ivanov, L., Kantha, L., Melnichenko, O. and Poberezhny, Y., "Power law decay in model predictability skill," *Geophysical Research Letters*, 29 (15), 10.1029/2002GLO14891, 2002.

Chu, P.C., Ivanov, L.M., Korzhova, T.P., Margolina, T.M. and Melnichenko, O.M., "Analysis of sparse and noisy ocean current data using flow decomposition. Part 1: Theory," *Journal of Atmospheric and Oceanic Technology*, (in press).

Chu, P.C., Ivanov, L.M., Margolina, T.M. and Melnichenko, O.V., "On probabilistic stability of an atmospheric model to various amplitude perturbations," *Journal of the Atmospheric Sciences*, 59, pp. 2860-2873, 2002.

Chu, P.C. and Lan, J., "Extremely strong thermohaline source/sinks generated by diagnostic initialization," *Geophysical Research Letters*, (in press).

Chu, P.C., Li, R.F. and Fan, C.W., "Determination of the current system on isopycnal surface between Mindanao and New Guinea from GDEM," *Chinese Journal of Oceanology and Limnology*, (in press).

Chu, P.C., Li, R.F. and You, X.B., "Northwest Pacific subtropical countercurrent on isopycnal surface in Summer," *Geophysical Research Letters*, 29, 10.1029/2002GLO14831, 2002.

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Chu, P.C., Mar, B.B. and Chen, Y.C., "South China Sea thermohaline structure and circulation," *Chinese Journal of Oceanology*, 21, pp. 227-261, 2002.

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Chu, P.C., Wang, G.H. and Chen, Y.C., "Japan/East Sea (JES) circulation and thermohaline structure, Part 3, Autocorrelation Functions," *Journal of Physical Oceanography*, 32, pp. 3596-3615, 2002.

Noh, C.J., Jang, Y., Yamagata, T., Chu, P.C. and Kim, C.H., "Simulation of more realistic upper ocean process from an OGCM with a new ocean mixed layer model," *Journal of Physical Oceanography*, 32, pp. 1284-1307, 2002.

Chu, P.C. and Ivanov, L.M., "Linear and nonlinear perspectives of forecast error estimate using the first passage time," *Proceedings of the Symposium on Observations, Data Assimilation and Probabilistic Prediction*, American Meteorological Society, Orlando, FL, pp. 127-132, 2002.

Chu, P.C., Ivanov, L.M. and Fan, C.W., "Determination of model valid prediction period using the backward Fokker-Planck equation," *Proceedings of the 16th Conference on Probability and Statistics in the Atmospheric Sciences*, American Meteorological Society, Orlando, FL, pp. 70-77, 2002.

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CONFERENCE PRESENTATIONS:

Chu, P.C., "Hydrodynamics of mine impact burial," ONR Impact Burial Annual Workshop, La Jolla, CA, 15-17 January 2002, (invited).

Chu, P.C., "Low latitude Pacific western boundary current system," Ocean Sciences Meeting, American Geophysical Union, Honolulu, HI, 11-15 February 2002, (invited).

Chu, P.C., "Mine impact burial modeling," ONR Impact Burial Modeling Workshop, Phoenix, AZ, 5-7 March 2002, (invited).

Chu, P.C., "C-vector for identification of oceanic secondary circulations across arctic fornts in Fram Strait. Chapman Conference on High Latitude Ocean Processes," American Geophysical Union, L'Esteral, Quebec, Canada, 26-29 August 2002, (contributed).

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Chu, P.C., Cintron, C.J., Haeger, S.D., Schneider, D., Keenan, R.E. and Fox, D.N., "Yellow Sea acoustic uncertainty caused by hydrographic data errors," International Conference on Impact of Littoral Environment Variability on Acoustic Prediction and Sonar Performance, Lerici, Italy, 16-20 September 2002.

Chu, P.C. and Fan, C.W., "A finite volume ocean model," Oceans 2002, Marine Technology Society – IEEE, Biloxi, MS, 29-31 October 2002.

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Chu, P.C., Gilles, A.F., Fan, C.W., Lan, J. and Flescher, P., "Hydrodynamical characteristics of falling cylinder in water column," Fourth International Symposium on Advances in Mechanics, Gent, Belgium, 15-17 May 2002.

Chu, P.C. and Ivanov, L.M., "Linear and nonlinear perspectives of forecast error estimate using the first passage time," Symposium on Observations, Data Assimilation and Probabilistic Prediction, American Meteorological Society, Orlando, FL, 13-17 January 2002.

Chu, P.C., Ivanov, L.M. and Fan, C.W., "Determination of model valid prediction period using the backward Fokker-Planck equation," 16th Conference on Probability and Statistics in the Atmospheric Sciences, American Meteorological Society, Orlando, FL, 13-17 January 2002.

Chu, P.C., Smith, T.B. and Haeger, S.D., "Mine impact burial experiment," Fifth International Symposium on Technology and Mine Problem, NPS, Monterey, CA, 22-26 April 2002.

Chu, P.C., Wang, J. and Qi, Y., "South China Sea elevation variability determined from TOPEX/POSEIDON data," 6th Symposium on Integrated Observing Systems, American Meteorological Society, Orlando, FL, 13-17 January 2002.

THESES DIRECTED:

Evans, A., "Hyrdodynamics of Mine Impact Burial," Master's Thesis, Naval Postgraduate School, September 2002.

Obino, R., "Simulation of Bohai Sea Circulation and Thermohaline Structure Using COHERENS Model," Master's Thesis, Naval Postgraduate School, June 2002.

Vares, N., "Range Dependent Mine Detection Using CASS-GRAB," Master's Thesis, Naval Postgraduate School, June 2002.

VALUE-AIDED OF ALTIMETRY DATA TO UNDERSEA WARFARE

Peter C. Chu, Professor

Department of Oceanography and Institute of Joint Warfare Analysis

Sponsor: Space and Naval Warfare Command, PMW 155

OBJECTIVE: The Navy's Modular Ocean Data Assimilation System (MODAS) provides critical input to real-time environmental conditions such as the sound velocity profiles (SVP) with high time and spatial fidelity. An important building block of MODAS is the real-time satellite altimetry. The superiority of MODAS products versus climatological data (i.e., the Navy's GDEM) should be first verified before investment on the improvement of satellite altimetry.

SVPs from Mark-48 table group are generally used in undersea warfare operations. Difference of SVPs between MODAS (or GDEM) and Mark-48 table reflects the SVP errors in undersea warfare. If SVP errors are less using MODAS than using GDEM, MODAS is thought to be superior to GDEM, and therefore update of the satellite altimetry becomes necessary for undersea warfare.

SUMMARY: During the performance period, the investigator and a student worked with the scientists at NUWC Keyport WA to get the weapon acoustic preset, developed a statistical package of quantitative measures on MODAS (or GDEM) SVP errors (i.e., deviation from Mark-80 table group SVPs) and skill score and investigated the statistical characteristics of the MODAS errors in various scenarios.

PUBLICATIONS:

Chu, P.C., Cintron, C.J., Haeger, S.D. and Keenan, R.E., "Acoustic mine detection using the Navy's CASS/GRAB model," *Journal of Counter-Ordnance Technology*, [CD Rom], 2002.

Chu, P.C., Cintron, C.J., Haeger, S.D., Schneider, D., Keenan, R.E. and Fox, D.N., "Yellow Sea acoustic uncertainty caused by hydrographic data error," *Impact of Littoral Environmental Variability on Acoustic Predictions and Sonar Performance*, Kluwer Science Publishing Co., pp. 563-570, 2002.

CONFERENCE PRESENTATIONS:

Chu, P.C., Cintron, C.J., Haeger, S.D. and Keenan, R.E., "Acoustic mine detection using the Navy's CASS-GRAB," Fifth International Symposium on Technology and Mine Problem, NPS, Monterey, CA, 22-26 April 2002.

Chu, P.C., Cintron, C.J., Haeger, S.D., Schneider, D., Keenan, R.E. and Fox, D.N., "Yellow Sea acoustic uncertainty caused by hydrographic data errors," International Conference on Impact of Littoral Environment Variability on Acoustic Prediction and Sonar Performance, Lercici, Italy, 16-20 September 2002.

Chu, P.C., Gilles, A.F., Fan, C.W. and Flescher, P., "Hydrodynamics of falling mine in water column," Fifth International Symposium on Technology and Mine Problem, NPS, Monterey, CA, 22-26 April 2002.

Chu, P.C., Smith, T.B. and Haeger, S.D., "Mine impact burial experiment," Fifth International Symposium on Technology and Mine Problem, NPS, Monterey, CA, 22-26 April 2002.

THESIS DIRECTED:

Perry, M., "Value-Aided Satellite Altimetry to Weapon Acoustic Preset," Master's Thesis, Naval Postgraduate School, in progress.

OCEANOGRAPHY

GPS ANTARCTIC LANDING SYSTEM: LANDING SYSTEMS COMMITTEE STUDIES

**James R. Clynch, Research Professor
Department of Oceanography**

Sponsor: Space and Naval Warfare Systems Command, Charleston, SC

OBJECTIVE: The aircraft landing system at the U.S. bases in Antarctica must be replaced in the next few years. Global Positioning System (GPS) is the primary candidate system for use in this remote site. There are several special features about the local environment in polar latitudes that must be studied and validated before flight safety can be assured. The investigator advises the Antarctic Landing Systems committee as a member and their scientific advisor.

SUMMARY: The technical capability of a differential GPS system to meet the landing requirements in the Antarctic has been demonstrated in an ongoing effort over five years. During 2002 the effort focused on following the Federal Aviation Administration (FAA) and vendors implementation for the Local Area Augmentation System (LAAS). During this year the FAA LAAS contracts were let for the government funded systems and installation plans were made for the first of 144 government systems.

KEYWORDS: GPS, Aircraft Landing Systems

STUDENT EXPERIENCE TOUR – DIFFERENTIAL GPS AT AUTECH

**James R. Clynch, Research Professor
Department of Oceanography**

Sponsor: Naval Undersea Warfare Center/Newport Division

OBJECTIVE: Naval Undersea Warfare Center (NUWC)/Newport used differential global positioning system (GPS) at their AUTECH range to survey the positions of underwater sensors. They are currently using U.S. Coast Guard signal outside the nominal range of applicability. Two students studied the impact of using the current system or other alternatives.

SUMMARY: The initial intent was to have the students visit the Atlantic Undersea Test and Evaluation Center (AUTECH) in November 2001. Scheduling and other factors prevented this. A field experiment was carried out on the RV PT SUR from November 27 to December 11 2001. Data was acquired on the ship and on land to simulate several typical at sea differential GPS positioning systems. This data was analyzed and used in the following thesis completed in September 2002:

THESIS DIRECTED:

Lindy, R., "Differential Solutions Using Long-Range Dual-Frequency GPS Correction Data," Master's Thesis, Naval Postgraduate School, September 2002.

Valascho, D., "The Use of USCG Differential GPS Beyond Nominal Range," Master's Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: GPS, Differential GPS

CENTRAL CALIFORNIA HYDROGRAPHIC SURVEYS

**Curtis A. Collins, Professor
Department of Oceanography**

Sponsors: Naval Oceanographic Office, San Jose State University Foundation

OBJECTIVE: The objective of this effort was to aid in the planning, calibration, collection and processing of hydrographic data collected on the *R/V Point Sur* for the Naval Oceanographic Office.

SUMMARY: Semi-annual surveys of Central California began in 1997 as part of a systematic effort by the Naval Oceanographic Office to improve the data bases that are used to generate warfare support products for coastal defense. The program ended with a 15-day survey in October 2002. Data from the last survey were used by a student for her Master's thesis. Data from the December 1999 survey were used by a student as part of his Ph.D. dissertation.

PUBLICATIONS:

Castro, C.G., Baumgartner, T.R., Bograd, S., Castro, R., Chavez, F.P., Collins, C.A., et al., "Introduction to 'The 1997-8 El Niño Atlas of oceanographic conditions along the west coast of North America (23°N-50°N)'," *Progress in Oceanography*, 54(1-4), pp. 503-511, 2002.

Castro, C., Collins, C., Walz, P., Pennington, J., Michisaki, R., Frederich, G., et al., "Nutrient Variability during El Niño 1997-9 off Central California," *Progress in Oceanography*, 54(1-4), pp. 171-184, 2002.

Chavez, F.P., Collins, C.A., Huyer, A. and Mackas, D.L., "El Niño along the west coast of North America," *Progress in Oceanography*, 54(1-4), pp. 1-5, 2002.

Chavez, F., Pennington, J., Castro, C.G., Ryan, J.P., Michisaki, R.P., Schlining, B., et al., "Biological and chemical consequences of the 1997-98 El Niño in central California waters," *Progress in Oceanography*, 54(1-4), pp. 205-232, 2002.

Collins, C., Castro, C.G., Asanuma, H., Rago, T., Han, S.-K., Durazo, R., et al., "Changes in the Hydrography of Central California Waters associated with the 1997-8 El Niño," *Progress in Oceanography*, 54(1-4), pp. 129-148, 2002.

Collins, C., Castro, C.G., Pennington, J.T., Rago, T.A. and Chavez, F.P., "Seasonal Variability off Central California," *Deep-sea Research*, (submitted).

Wilkerson, F.P., Dugdale, R.C., Marchi, A. and Collins, C.A., "Hydrography, Nutrients and Chlorophyll Measured During El Niño, La Niña Compared to Normal Years in the Gulf of the Farallones, CA," *Progress in Oceanography*, 54(1-4), pp. 293-310, 2002.

MEETING ABSTRACT:

Jones, H., Batteen, M.L., Collins, C.A., Nuss, W.A. and Miller, D.K., "Sensitivity of a Navy Regional Ocean Model to Nested High-Resolution Atmospheric Model and Scatterometer Wind Forcing," abstract OS21E-84 in *EOS, Transactions, American Geophysical Union*, 83(4), Ocean Sciences Meeting Supplement, 2002.

KEYWORDS: California Current System, Hydrographic Data, El Niño

OCEAN CURRENT AND SEDIMENT TRAP MEASUREMENTS

Curtis A. Collins, Professor

Department of Oceanography

Sponsor: Monterey Bay Aquarium Research Institute

OBJECTIVE: To make long-term measurements of ocean currents and sedimentation rates on the upper slope off Monterey Bay, California.

SUMMARY: This observational program supplements ongoing measurements of near-surface conditions at a surface mooring at 36-40N, 122-25W. An intermediate mooring, which provides a stable platform for measurements of currents and sedimentation rates, has been moored just outside the watch circle of the surface mooring since February, 1998. The mooring is instrumented with current meters at 305 m depth and 615 meters above the bottom and with an upward looking acoustic Doppler current profiler at 300 m

depth as well as with sediment traps at 320 m and 600 meters above the bottom. Bottom depth is about 1800 m. The mooring is replaced at twice a year. A student is analyzing these data for his thesis.

PUBLICATION:

Collins, C., Castro, C.G., Asanuma, H., Rago, T., Han, S.-K., Durazo, R., et al., "Changes in the Hydrography of Central California Waters associated with the 1997-8 El Niño," *Progress in Oceanography*, 54(1-4), pp. 129-148, 2002.

CONFERENCE PRESENTATION:

Chavez, F.P., Pennington, J.T., Collins, C.A., Paduan, J.D. and Marinovich, B., "Ocean Observatory efforts in and around Monterey Bay, California, 1930 to the present," abstract OS71F-03 in *EOS, Transactions, American Geophysical Union*, 83(47), Fall Meeting Supplement, 2002.

KEYWORDS: Ocean Currents, Monterey Bay, Ocean Sediments

NONHYDROSTATIC MODELING OF WEST FLORIDA SHELF FLOW AND TRACERS

Roland W. Garwood, Jr., Professor

Department of Oceanography

Sponsors: Office of Naval Research, Naval Postgraduate School

OBJECTIVE: The objective in the final year of this project was to calculate nonstationary three-dimensional solutions for the turbulent nonhydrostatic flow regime on the West Florida shelf using large-eddy simulation (LES). These solutions were used to explain the three-dimensional optical properties of the water column by understanding the behavior of tracers and drifters deployed during field experiments. The long range scientific goal of the Oceanic Planetary Boundary Layer (OPBL) Laboratory is to understand the role of the OPBL in the coupled exchange of energy, momentum and mass between the upper ocean, the atmosphere and the cryosphere.

SUMMARY: Mathematical models for turbulent entrainment, shear production, buoyancy flux, transport and dissipation were developed and verified by comparison with observations and full-physics nonhydrostatic LES. Coupling with atmosphere and/or cryosphere was intrinsic to system prediction. Turbulent processes found to be of importance to the coupled system were parameterized for implementation in hydrostatic oceanic general circulation models (OGCM) for research and operational use. The solutions for the turbulent flow on the shelf were contrasted with the turbulent flow solutions for the deep ocean, including the Labrador Sea. Animated GIFS of the turbulent boundary layer in both shelf and deep ocean regimes were produced with the assistance of a National Research Council Postdoctoral Associate, Pascale Lherminier.

These animations were most useful in displaying the three-dimensional unsteady evolution of the turbulent fluxes and turbulent kinetic energy attributable to different boundary conditions: forced convection caused by wind stress and bottom drag and to free convection associated with surface cooling. A movie was prepared, which may be viewed at <http://www.oc.nps.navy.mil/opbl/my4413movie.gif>.

PUBLICATION:

Harcourt, R.R., Steffan, E.L., Garwood, R.W., Jr., and D'Asaro, E.A., "Fully Lagrangian floats in Labrador Sea deep convection: Comparison of numerical and experimental results," *Journal of Physical Oceanography*, 32, pp. 493-510, 2002.

CONFERENCE PAPERS:

Garwood, R.W., Jr., "Predicting Mixed Layer-Ice Interactions and Catastrophic Thermobaric Overturning," Chapman Conference on High Latitude Ocean Processes, L'Estérel, Québec, Canada, 26-28 August 2002.

Garwood, R.W., Jr., "Thermobaricity and the High-Latitude Mixed Layer System," Courant Institute for Mathematical Sciences, New York, NY, 22 November 2002, (invited).

Garwood, R.W., Jr., "Thermodynamics Critical to Arctic Mixed Layer Systems," Small-Scale Sea Ice and Ocean Modeling, International Arctic Research Center, Fairbanks, AK, 7-9 August 2002, (invited).

Garwood, R.W., Jr. and Maslowski, W., "Implications of Thermobaricity on Buoyancy, Mixing, and Ice Thermodynamics for the Arctic System," Arctic System Science All-Hands Workshop, Seattle, WA, 20-23 February 2002.

KEYWORDS: Environmental Effects, Ocean Turbulence, Modeling and Simulation

COLLABORATIVE RESEARCH: NEARSHORE CANYON EXPERIMENT

Thomas H. C. Herbers, Professor

Department of Oceanography

Sponsor: National Science Foundation

OBJECTIVE: The objective of this research was to understand the effect of complex continental-shelf bathymetry on surface gravity waves and on the breaking-wave-driven circulation onshore of the irregular bathymetry.

SUMMARY: Abrupt shelf bathymetry can cause dramatic alongshore variations in waves, resulting in beaches with large waves located only a few hundred meters away from beaches with small waves. These along-coast changes in wave height and direction can force complicated circulation patterns, including alongshore flows that reverse direction across the surf zone and along the shoreline, and strong offshore-directed rip currents that may be an important mechanism for transport of water, sediment, and pollution between the surf zone and inner shelf. Comprehensive observations of waves and currents were collected on the southern California coast near two steep submarine canyons. This project was a collaborative effort with Woods Hole Oceanographic Institution (Principal Investigator Dr. Steve Elgar) and Scripps Institution of Oceanography (Principal Investigator Dr. Robert T. Guza). Additional field measurements and modeling studies of wave transformation across submarine canyons are funded by the Office of Naval Research.

During 2002 several coordinated pilot experiments were conducted in Monterey Bay and La Jolla Bay to test instruments and collect a preliminary data set for analysis. Three different instruments were tested: the FSI 3D-Wave (equipped with an acoustic travel time meter), and the Sontek Triton and Nortek Vector (both use acoustic Doppler current meters). Analysis of pressure-velocity transfer functions and intercomparisons with a co-located Datawell Directional Waverider buoy generally showed good agreement for all three instruments. A light mooring system using a fiberglass tripod for easy deployment and maintenance also performed well during these tests. The test results demonstrated the feasibility of obtaining accurate pressure and velocity measurements with the large array of instruments that will be deployed in the Nearshore Canyon Experiment. Preliminary observations of wave variability across the steep canyon walls are now being analyzed by ENS Tim Ray at NPS. Graduate student Rudy Magne (University of Brest) is working on a comparison of different theories for wave reflection from idealized steep topography, and a numerical implementation for the study region.

PUBLICATIONS:

Arduin, F., Herbers, T.H.C., Jessen, P.F. and O'Reilly, W.C., "Swell transformation across the continental shelf. Part II. Validation of a spectral energy balance equation," *Journal of Physical Oceanography*, (in press).

Arduin, F., O'Reilly, W.C., Herbers, T.H.C. and Jessen, P.F., "Swell transformation across the continental shelf. Part I. Attenuation and directional broadening," *Journal of Physical Oceanography*, (in press).

Elgar, S., Raubenheimer, B. and Herbers, T.H.C., "Bragg reflection of ocean waves from sandbars," *Geophysical Research Letters*, 30(1), 1016, doi:10.1029/2002GL016351, 2003.

Herbers, T.H.C., Orzech, M., Elgar, S. and Guza, R.T., "Shoaling transformation of wave frequency-directional spectra," *Journal of Geophysical Research*, 108(C1), 3013, doi:10.1029/2001JC001304, 2003.

KEYWORDS: Ocean Surface Waves, Surf Zone, Continental Shelf

NEARSHORE CANYON EXPERIMENT

Thomas H. C. Herbers, Professor

Department of Oceanography

Sponsors: Office of Naval Research, Naval Postgraduate School

OBJECTIVE: The objective of this research was to understand the effect of complex continental-shelf bathymetry on surface gravity waves and on the breaking-wave-driven circulation onshore of the irregular bathymetry.

SUMMARY: Recent studies have shown that waves propagating across a continental shelf are strongly affected by both dissipation in the bottom boundary layer and scattering by small-scale seabed irregularities. Our ability to forecast accurately wave conditions on the shelf and beach is hampered by a lack of understanding of the small scale bottom variability (sand ripples and ridges) that evolves under the influence of large storm waves and strong currents. This study analyzed data from a large array of surface following buoys and pressure transducers which were deployed on the North Carolina continental shelf during the fall of 1999 as part of the SHOWEX Experiment. This dataset contained unique observations of wave evolution across the shelf, including large swells from Hurricanes Floyd, Gert, and Irene. Supporting measurements of seabed characteristics, including sediment samples and side-scan sonar surveys of wave-induced sand ripples were also collected. Predictions of swell decay were obtained with the spectral wave prediction model CREST (Ardhuin, et al., *Journal of Physical Oceanography*, 31, pp. 1498-1516, 2001) that included state of the art formulations of bottom drag and scattering effects. Predicted strong damping of energetic swell across the shelf was in good agreement with the observed swell decay. Widespread sand ripples observed in side scan sonar images of the sea floor supported the hypothesis that the damping is caused by enhanced bottom friction over rough bed forms.

Results of this research confirmed the critical importance of rough bed-forms in swell transformation across a wide continental shelf. Analysis of swell decay showed that as much as 80% of the incident wave energy flux can be dissipated on the shelf and the variable dissipation rates appeared consistent with existing bed roughness models. This dramatic sheltering of a coastline with a wide, sandy shelf has important implications for nearshore hydrodynamics and sediment transport. Parameterizations of bottom friction were evaluated in hindcasts of all swell events that occurred during the DUCK94 and SHOWEX experiments.

PUBLICATIONS:

Ardhuin, F., Drake, T.G. and Herbers, T.H.C., "Observations of wave-generated vortex ripples on the North Carolina continental shelf," *Journal of Geophysical Research*, 107(C10), 3143, doi:10.1029/2001JC000986, 2002.

Ardhuin, F. and Herbers, T.H.C., "Bragg scattering of random surface gravity waves by irregular sea bed topography," *Journal of Fluid Mechanics*, 451, pp. 1-33, 2002.

Ardhuin, F., Herbers, T.H.C., Jessen, P.F. and O'Reilly, W.C., "Swell transformation across the continental shelf. Part II. Validation of a spectral energy balance equation," *Journal of Physical Oceanography*, (in press).

Ardhuin, F., O'Reilly, W.C., Herbers, T.H.C. and Jessen, P.F., "Swell transformation across the continental shelf. Part I. Attenuation and directional broadening," *Journal of Physical Oceanography*, (in press).

Elgar, S., Raubenheimer, B. and Herbers, T.H.C., "Bragg reflection of ocean waves from sandbars," *Geophysical Research Letters*, 30(1), 1016, doi:10.1029/2002GL016351, 2003.

Herbers, T.H.C., Elgar, S., Sarap, N.A. and Guza, R.T., "Nonlinear dispersion of surface gravity waves in shallow water," *Journal of Physical Oceanography*, 32(4), pp. 1181-1193, 2002.

Herbers, T.H.C., Orzech, M., Elgar, S. and Guza, R.T., "Shoaling transformation of wave frequency-directional spectra," *Journal of Geophysical Research*, 108(C1), 3013, doi:10.1029/2001JC001304, 2003.

Noyes, T.J., Guza, R.T., Elgar, S. and Herbers, T.H.C., "Comparison of methods for estimating nearshore shear wave variance," *Journal of Atmospheric and Oceanic Technology*, 19(1), pp. 136-143, 2002.

Sheremet, A., Guza, R.T., Elgar, S. and Herbers, T.H.C., "Observations of nearshore infragravity waves. Part 1: Seaward and shoreward propagating components," *Journal of Geophysical Research*, 107(C8), 10.1029/2001JC000970, 2002.

KEYWORDS: Ocean Surface Waves, Surf Zone, Nearshore Processes

ARCTIC OCEAN MODEL INTERCOMPARISON PROJECT (AOMIP)

Wieslaw Maslowski, Research Associate Professor

Department of Oceanography

Sponsor: Woods Hole Oceanographic Institute

OBJECTIVE: To examine qualitative/quantitative behavior of different models, their ability to simulate variability of the Arctic Ocean climate and the major processes maintaining the observed variability.

SUMMARY: A web site for the AOMIP project was created and can be accessed at <http://fish.cims.nyu.edu/project/aomip/overview.html>. This site serves as the focal point for electronic exchange of all modeling related intercomparison activities. A description of the various contributing models, the forcing data sets, the seasonal climatology, and the interannual variability runs were served and archived at the site. Additionally, reports on the various AOMIP workshops were provided. Two workshops were organized, the fourth (virtual electronic), and fifth AOMIP workshops. Further details about the workshops may be found at the AOMIP web site. AOMIP intercomparison efforts have been focused on the seasonal variability of certain quantities of the Arctic Ocean. Modelers have performed a set of comparisons of the major integrated oceanic and cryospheric parameters. Striking discrepancies among model results were observed practically in all model outputs. The underlying cause for these discrepancies may be due to a variety of factors such as differing atmospheric forcing, model resolution, bathymetric features, water mass structures, and ice conditions. All of these factors were under investigation.

PUBLICATIONS:

Maslowski, W., Marble, D.C., Walczowski, W., Schauer, U. and Semtner, A.J., "Simulated annual mass, heat and salt transport through the Barents Sea from an eddy-permitting pan-Arctic coupled ice-ocean model," *Journal of Geophysical Research*, 2002, (provisionally accepted).

Steiner, N., Holloway, G., Hakkinen, S., Holland, D., Karcher, M., Maslowski, W., et al., "Comparing Modeled Streamfunction, Heat and Freshwater Content in the Arctic Ocean," *Elsevier Science, Ocean Modeling*, 2002, (accepted).

PRESENTATIONS:

Maslowski, W., "Modeling the Arctic Ocean and its sea ice: from a local to basin scale," Small Scale Sea Ice and Ocean Modeling Workshop, Fairbanks, AK, August 2002.

Maslowski, W., Lipscomb, W.H. and Hunke, E.C., "Towards an Improved Representation of Sea Ice in Regional and Global Models," WCRP-ACSYS/CliC Sea Ice Extent Workshop, Apr 2002.

Maslowski, W., Marble, D.C. and Walczowski, W., "NPS Model Intercomparison Study," Arctic Ocean Model Intercomparison Project (AOMIP) Workshop, Washington D.C., May 2002.

Maslowski, W., Marble, D.C., Walczowski, W., Okkonen, S.R. and Schauer, U., "On the Feasibility of Using Models to Guide Future Observing Systems in the Arctic Ocean," Workshop on Measurements and Modeling of the Arctic Ocean Circulation, Palisades, NY, Jun 2002.

Maslowski, W., Marble, D.C., Walczowski, W. and Stark, D., "Development of PIPS 3.0," PIPS 3.0 IPT Meeting, Monterey, CA, Jan 2002.

Maslowski, W., Stark, D., Marble, D.C. and Walczowski, W., "The U.S. Navy Polar Ice Prediction System (PIPS 3.0) - Model Development and Preliminary Results," Oceanology International, ExCeL, London, UK, Mar 2002.

KEYWORDS: Numerical Modeling, Arctic Ocean, Sea Ice, Model Intercomparison

CARBON CYCLING IN THE CHUKCHI AND BEAUFORT SEAS-FIELD AND MODELING STUDIES

**Wieslaw Maslowski, Research Associate Professor
Department of Oceanography
Sponsor: National Science Foundation**

OBJECTIVE: The main goal of this collaborative project was to determine the impacts of the impacts of decadal-scale environmental regime shifts in the northern high latitudes on carbon cycling in the Western Arctic Ocean.

SUMMARY: A 9-km and 45-level coupled ocean and sea ice model of the Pan-Arctic Ocean was developed. After an initial 48-year spinup, a 15-year integration forced with realistic atmospheric data followed with realistic atmospheric forcing. The model allowed proper exchanges from the Pacific Ocean, through Bering and Chukchi seas into the Arctic Ocean to more realistically account for the upstream conditions to the SBI study region. The high resolution improved representation of bottom bathymetry and land geometry, which is most critical over the shelves and slopes. Large-scale but narrow boundary currents of order (100 km) were realistically simulated along the continental slope in the Chukchi and Beaufort seas. Given the model resolution, small eddies of order 40-50 km in diameter are resolved in the Western Arctic. Since the baroclinic radius of deformation is of order 0(10 km) in the region, further increases in simulated total kinetic and eddy kinetic energy fields are expected with further increases of resolution.

PUBLICATIONS:

Maslowski, W., "Basin-scale Arctic sea-ice modeling and its role in climate change studies," *Special Edition of Arctic Ocean Sciences Board Newsletter*, 15-18 July 2002.

Maslowski, W. and Lipscomb, W.H., "High-resolution Simulations of Arctic Sea Ice During 1979-1993," *Polar Research*, 2002, (provisionally accepted).

Maslowski, W., Marble, D.C., Walczowski, W., Schauer, U. and Semtner, A.J., "Simulated annual mass, heat and salt transport through the Barents Sea from an eddy-permitting pan-Arctic coupled ice-ocean model," *Journal of Geophysical Research*, 2002, (provisionally accepted).

Maslowski, W. and Walczowski, W., "On the circulation of the Baltic Sea and its connection to the Pan-Arctic region – a large scale and high-resolution modeling approach," *Boreas Environmental Research*, 7, 319-325, 2002.

Preller, R.H., Maslowski, W., Stark, D., Posey, P. and Pham, T.T.C., "Navy sea Ice Prediction systems," *The Oceanographic Society*, Vol. 15, No. 1, pp. 44-56, 2002.

Steiner, N., Holloway, G., Hakkinen, S., Holland, D., Karcher, M., Maslowski, W., et al., "Comparing Modeled Streamfunction, Heat and Freshwater Content in the Arctic Ocean," *Elsevier Science, Ocean Modeling*, 2002, (accepted).

PRESENTATIONS:

Maslowski, W., "Are predicted changes in the arctic system detectable? Detecting changes in the Arctic Marine Environment," NSF-ARCSS All Hands Meeting, Seattle, WA, Feb 2002.

Maslowski, W., "Basin-scale Arctic Sea Ice Modeling," Arctic Ocean Sciences Board Meeting, Groningen, The Netherlands, Apr 2002.

Maslowski, W., "Modeling the Fate of Pacific Water in the Arctic Ocean," Chapman Conference on High Latitude Processes, L'Estereel, Canada, Aug 2002.

Maslowski, W., "Understanding the Arctic Environment, Its Variability, and Interactions with Lower Latitudes (Modeling Approach)," Arctic Sciences Summit Week Meeting, Groningen, The Netherlands, Apr 2002.

Maslowski, W., "Understanding the Ocean Circulation, Ice Conditions, and Communications Among Alaska's Three Sea," AAAS Arctic Division, 53rd Arctic Science Conference, Sep 2002.

Maslowski, W., Marble, D.C., Walczowski, W., Okkonen, S.R. and Schauer, U., "On the Feasibility of Using Models to Guide Future Observing Systems in the Arctic Ocean," Workshop on Measurements and Modeling of the Arctic Ocean Circulation, Palisades, NY, Jun 2002.

KEYWORDS: Oceanography, Sea Ice, Numerical Modeling, Arctic Ocean

COUPLED BIOPHYSICAL MODELING OF THE ARCTIC OCEAN

Wieslaw Maslowski, Research Associate Professor

Department of Oceanography

Sponsor: National Science Foundation

OBJECTIVE: Use coupled ice-ocean models at increasingly high resolutions to synthesize, integrate and guide future observations of shelf basin interactions in the Western Arctic Ocean.

SUMMARY: A 20-year integration of the coupled ice-ocean model configured at 18-km and 30-layer has been completed using 1979-1998 reanalyzed and operational atmospheric data from the European Centre for Medium-range Weather Forecast (ECMWF). Pacific Water distribution in the Chukchi and Beaufort seas and the Canadian Basin has been tracked by use of a numerical tracer. Similar approach for modeling Atlantic Water and river runoff was used. Results from this work and publications are available at www.oc.nps.navy.mil/sbi. Numerous CD-ROM copies of animated model results focusing on the shelf basin interactions in the Arctic Ocean have been distributed to Shelf-Basin Interactions (SBI) principal investigators, other scientists, schools and colleges. In addition, a 9-km and 45-level model with an extended domain into the North Pacific was developed to more realistically account for the upstream conditions to the SBI study region. An integration of this model has continued under support of the SBI Phase II program.

PRESENTATIONS:

Maslowski, W., "Are Predicted Changes in the Arctic System Detectable?," NSF/ARCSSS All-Hands Workshop, Seattle, WA, 20-23 February 2002.

Maslowski, W., Okkonen, S.R. and Walczowski, W., "Towards an Improved Model Representation of Oceanic and Sea Ice Conditions in the Bering and Chukchi Seas," Ocean Sciences Meeting, Honolulu, HI, 11-15 February 2002.

Maslowski, W., Walczowski, W. and Marble, D.C., "Advanced ocean and sea ice modeling of the pan-Arctic region in support of the NSF/ARCSS program," NSF/ARCSSS All-Hands Workshop, Seattle, WA, 20-23 February 2002.

KEYWORDS: Oceanography, Sea Ice, Numerical Modeling, Arctic Ocean

INTERANNUAL VARIABILITY OF BIOPHYSICAL LINKAGES BETWEEN THE GULF OF ALASKA AND BERING SEA

Wieslaw Maslowski, Research Associate Professor

Department of Oceanography

Sponsor: University of Alaska Fairbanks

OBJECTIVE: To investigate interannual and decadal variations in exchanges of properties and nutrients between the North Pacific Ocean and the basin and shelves of the Bering Sea, using a 9-km and 45-level, coupled ice-ocean model.

SUMMARY: A 60-year integration of the coupled 9-km ice-ocean model has been completed, including a 45-year spinup and a 15-year interannual run forced with realistic 1979-1993 atmospheric data from the European Centre for Medium-range Weather Forecasts (ECMWF) 1979-1993 reanalysis. Many improvements, such as the seasonal cycle of sea ice advancement and retreat, leads and polynyas, and the ice edge position in the Bering/Chukchi Seas, are shown to be a result of more realistic high resolution modeling of the upper ocean currents and hydrography. The model yields realistic predictions of the net northward transport through Bering Strait and consequently the oceanic circulation and variability upstream in the Bering Sea and the Gulf of Alaska. Large anticyclonic eddies (200-300 km in diameter) are simulated propagating to the west along the southern slopes of the Alaska Peninsula and the Aleutian Islands. Those eddies are shown to significantly influence water mass and property exchanges between the Gulf of Alaska and the Bering Sea as they slowly propagate from the northeastern Gulf of Alaska westward towards the central North Pacific.

In addition, a state-of-the-art sea ice model has been developed to replace the existing 'old' sea ice model in the coupled 9-km ice-ocean model. It contains an improved calculation of ice growth/decay and it has been configured to use five sea ice categories with 4 layers per category, a snow layer in each category, the elastic-viscous-plastic rheology, the remapping of sea ice transport and ice thickness. Further model evaluations are planned as results from integration of the new sea ice model coupled to the pan-Arctic ocean model become available.

PRESENTATIONS:

Maslowski, W. and Okkonen, S.R., "Interannual variability of biophysical linkages between the basin and shelf in the Bering Sea," Steller Sea Lion Principal Investigators Orientation and Coordination Meeting, Anchorage, AK, 19-21 March 2002.

Maslowski, W., Okkonen, S.R. and Walczowski, W., "Towards an Improved Model Representation of Oceanic and Sea Ice Conditions in the Bering and Chukchi Seas," Ocean Sciences Meeting, Honolulu, HI, 11-15 February 2002.

Okkonen, S.R., Maslowski, W., Walczowski, W. and Whitledge, T.E., "Eddy Kinetic Energy in the Western Gulf of Alaska and Bering Sea: Comparative Estimates From TOPEX Altimeter Data and Coupled Ice Ocean Model Simulations," 2002 Ocean Sciences Meeting, Honolulu, HI, 11-15 February 2002.

KEYWORDS: Oceanography, Sea Ice, Numerical Modeling, Sub-polar Pacific

EVALUATION OF THE POP MODEL FOR NAVY FORECASTING USE

Julie L. McClean, Research Associate Professor

Robin Tokmakian, Research Assistant Professor

Albert J. Semtner, Professor

Ching-Sang Chiu, Professor

Department of Oceanography

Sponsor: Office of Naval Research

OBJECTIVE: To continue high-resolution simulations and analyses of the Los Alamos National Laboratory (LANL) Parallel Ocean Program (POP) model for global Navy forecasting needs. This project is ongoing.

SUMMARY: Fifteen years (1979-1994) of a 0.1°, 40-level global ocean simulation using the Parallel Ocean Program (POP) were completed. Assessments of the realism of the simulation were made by comparing statistics from data sets such as velocities from surface drifting buoys and sea level height from satellite altimeters with equivalent model quantities. Sensitivity studies were conducted to understand and improve unrealistic aspects of the model solution. Also sensitivity runs using an eddy-permitting configuration of POP were performed to improve the representation of mixed layer processes.

PUBLICATIONS:

Chassignet, E.P.M., Bell, J., Brasseur, P., Evensen, G., Griffies, S.M., Hurlburt, H.E., et al., "The Modeling Component of Ocean Forecasting," *Proceedings of the International Symposium "En route to GODAE,"* Biarritz, France, pp. 41-46, 13-15 June 2002.

McClean, J. and Maltrud, M., "Towards a High-resolution Global Coupled Navy Prediction System: the Ocean Component," *Navigator*, pp. 14-17, Spring 2002.

McClean, J.L. and Maltrud, M., "Towards a High-Resolution Global Coupled Prediction System: the Ocean Component," *Proceedings, DOD User Group Conference*, Austin, TX, June 2002.

McClean, J.L., Poulain, P.-M., Pelton, J.W. and Maltrud, M., "Eulerian and Lagrangian Statistics From Surface Drifters and a High Resolution POP Simulation in the North Atlantic," *Journal of Physical Oceanography*, 32, pp. 2472-2491, 2002.

Tokmakian, R. and McClean, J.L., "How Realistic is the High Frequency Signal of a 0.1° Resolution Ocean Model," *Journal of Geophysical Research*, (in press).

PRESENTATIONS:

McClean, J.L., "How have WOCE Observations Challenged Ocean Models?" WOCE and Beyond, San Antonio, TX, 18-22 November 2002, (invited).

McClean, J.L., "Towards a Global Coupled Prediction System: the Ocean Component," brief to Oceanographer of the Navy, Naval Postgraduate School, Monterey, CA, November, 2002.

McClean, J.L., "Towards the Use of POP in a Global Coupled Navy Prediction System," 6.2 ONR Joint Internal Program Review, Naval Research Laboratory, Monterey, CA, March 2002.

OCEANOGRAPHY

McClean, J.L. and Maltrud, M.E., "High Resolution POP and Observations," abstract OS31S-03 *EOS, Transactions, American Geophysical Union*, 83 (4), Ocean Sciences Meeting Supplement, 2002.

McClean, J.L. and Maltrud, M.E., "Towards a High Resolution Global Coupled Navy Prediction System," DoD HPCMO Users Group Conference, Austin, TX, June 2002.

McClean, J.L. and Maltrud, M.E., "Towards a High-resolution Global Coupled Navy prediction system: the ocean component," abstract OS31-05 in *EOS, Transactions, American Geophysical Union*, 83 (22), West. Pac. Geophys. Meeting Supplement, 2002, (invited).

MEETING ABSTRACT:

Ivanova, D.P., McClean, J.L., Sprintall, J., Maltrud, M. and Wijffels, S.E., "Indonesian Throughflow Variability from WOCE IX1 and Two POP Simulations," abstract OS12C-162 in *EOS, Transactions, American Geophysical Union*, 83 (4), Ocean Sciences Meet. Suppl., 2002.

KEYWORDS: Ocean Circulation, Model Validation, Model/data Synthesis

MESOSCALE VARIABILITY AND PROCESSES IN AN EDDY-RESOLVING GLOBAL POP SIMULATION

**Julie L. McClean, Research Associate Professor
Department of Oceanography
Sponsor: National Science Foundation**

OBJECTIVE: To quantify and understand the dynamics, particularly of the eddy variability and mesoscale processes, in a high-resolution global configuration of the Parallel Ocean Program (POP) model. This project is continuing.

SUMMARY: Preliminary assessments of biases in the global high-resolution solution were assessed in a suite of sensitivity runs. Statistics from data sets such as velocities from surface drifting buoys and sea level height from satellite altimeters were compared with equivalent model quantities. The spatial-temporal sampling of these data resolved mesoscale ocean processes providing a standard by which to evaluate the representation of these processes and associated variability in the model.

PRESENTATION:

McClean, J.L., "How Have WOCE Observations Challenged Ocean Models?" WOCE and Beyond, San Antonio, TX, 18-22 November 2002, (invited).

KEYWORDS: Ocean Circulation, Model Validation, Model/Data Synthesis

ANALYSIS OF HF RADAR DATA FROM THE NORTHERN ADRIATIC SEA

**Jeffrey D. Paduan, Associate Professor
Department of Oceanography
Sponsor: Consiglio Nazionale delle Ricerche Istituto per lo Studio delle Dinamica delle Grande Masse**

OBJECTIVE: This agreement will involve analysis of surface ocean velocity maps from a network of high frequency (HF) radar systems deployed along the northern coast of the Adriatic Sea near Venice, Italy.

OCEANOGRAPHY

DIURNAL TO SEASONAL VARIABILITY OF SURFACE OCEAN CURRENTS FROM HIGH FREQUENCY RADAR

Jeffrey D. Paduan, Associate Professor
Department of Oceanography

Sponsors: National Science Foundation and Naval Postgraduate School

OBJECTIVE: The goals of this project are to describe the wind and tide forcing of the upper ocean currents around Monterey Bay and to develop optimized high frequency (HF) radar current algorithms.

SUMMARY: This research is drawing on data from a unique array of five high frequency (HF) radar systems around Monterey Bay: three CODAR-SeaSonde direction-finding systems and two multi-frequency phased array systems. Focus is on the 2-D surface currents and how they vary, both seasonally and daily, compared with measured winds and satellite AVHRR images. Data from the multi-frequency radar sites is being used to measure near-surface shear, which is difficult to do with in situ instrumentation. In addition, data from these systems, as well as simulations, is being used to examine the sensitivity of radar algorithms to varying current and wave conditions.

PUBLICATIONS:

Vesecky, J.F., Drake, J., Teague, C.C., Ludwig, F., Paduan, J. and Davidson, K., "Measurement of wind speed and direction using MCR radar," *Proceedings of the IEEE IGARSS Conference*, IEEE Press: Piscataway, NJ, 2002.

PRESENTATIONS:

Vesecky, J.F., Drake, J., Teague, C.C., Fernandez, D.M., Whelan, C., Plume, M.A., et al., "Comparison of surface current measurements by different HF radar systems with each other and with ADCP current measurements," abstract OS12A-97 *EOS, Transactions, American Geophysical Union*, Vol. 83 (4), Ocean Sciences Meeting Supplement, 2002.

THESIS DIRECTED:

Meadows, L.A., "High Frequency Radar Measurements of Friction Velocity in the Marine Boundary Layer," Doctor of Philosophy Dissertation, University of Michigan, November 2002 (partly supported through this project).

KEYWORDS: HF Radar, Ocean Currents, Air-sea Interaction

GLOBEC MAPPING THE EVOLUTION OF MESOSCALE JETS AND EDDIES IN THE UPWELLING ECOSYSTEM OFF CAPE BLANCO, OR USING LONG-RANGE HIGH FREQUENCY RADAR

Jeffrey D. Paduan, Associate Professor
Department of Oceanography

Sponsor: National Science Foundation

OBJECTIVE: The goal of this project is to demonstrate the viability of long range high frequency radar for mapping ocean currents out to 200 km from shore.

SUMMARY: This research deployed a new application of High Frequency (HF) radar instruments for extended range coverage of filaments and eddies in the California Current System with specific application to the mesoscale jets and eddies in the upwelling system of Cape Blanco, OR, in support of GLOBEC processes studies sited in that area.

PUBLICATIONS:

Gacic, M., Kovacevic, V., Mazzoldi, A., Paduan, J., Arena, J., Mancero, F., et al., "Measuring water exchange between the Venetian Lagoon and the open sea," *EOS, Transactions, American Geophysical Union*, Vol. 83, pp. 217-222, 2002.

CONFERENCE PRESENTATION:

Kosro, P.M., Allen, J.S., Egbert, G., Erofeeva, S., Kurapov, A., Waldorf, W., et al., "Mapping Oregon coastal circulation: HF radar and data assimilating models," Eastern Pacific Ocean Conferences, Timberline Lodge, Mt. Hood, OR, 25-28 September 2002.

MEETING ABSTRACT:

Kosro, P.M. and Paduan, J.D., "Shore-based mapping of ocean surface currents at long range using 5 MHz HF backscatter," abstract OS21E-101 in *EOS, Transactions, American Geophysical Union*, Vol. 83 (4), Ocean Science Meeting Supplement, 2002.

KEYWORDS: HF Radar, Ocean Currents, Air-Sea Interaction

AN INNOVATIVE COASTAL-OCEAN OBSERVING NETWORK (ICON)-RENEWAL

Jeffrey D. Paduan, Associate Professor

Steven R. Ramp, Research Professor

Leslie Rosenfeld, Associate Research Professor

Curtis A. Collins, Professor

Ching-Sang Chiu, Professor

Department of Oceanography

Sponsor: Office of Naval Research

OBJECTIVE: The objective of this project is to show that real-time data from HF radars and acoustic tomography can improve the performance of coastal circulation and biological productivity models.

SUMMARY: A concept demonstration has been conducted by a consortium of government, academic, and industrial partners to show how a diverse suite of modern, innovative ocean instrumentation can be successfully integrated into a functional, real-time ocean observation network. The plan utilized both creative application of well established observational techniques and the development of new instrumentation and algorithms, which were utilized in the network for the very first time. Moored, single-point time series observations, remotely-sensed data, ocean acoustic tomography, and two-dimensional vector fields obtained from HF radars were integrated into a cohesive picture of the coastal environment via a nested, high resolution numerical model. The sensor data and model output were made available via Internet web pages for immediate application by coastal managers, defense analysts, emergency response teams, and commercial and recreational use.

PUBLICATIONS:

Chao, Y., Li, Z., Kindle, J., Paduan, J. and Chavez, F., "A high-resolution surface vector wind product for coastal oceans: Blending satellite scatterometer measurements with regional mesoscale atmospheric model simulations," *Geophysical Research Letters*, 2002, (in press).

Kindle, J.C., Hodur, R., deRada, S., Paduan, J., Rosenfeld, L.K. and Chavez, F., "A COAMPS reanalysis for the Eastern Pacific: Properties of the diurnal sea breeze along the central California coast," *Geophysical Research Letters*, 2002 (in press).

Shulman, I., Wu, C.-R., Lewis, J.K., Paduan, J.D., Rosenfeld, L.K., Kindle, J.D. et al., "High resolution modeling and data assimilation in the Monterey Bay area," *Continental Shelf Research*, Vol. 22, pp. 1129-1151, 2002.

TECHNICAL REPORT:

Batteen, M., Blier, W., Burk, S., Clancy, M., Merilees, P., Miller, D., et al., "Report from the First Central California Environmental Prediction Initiative (CCEPI) Workshop," Naval Research Laboratory Technical Report, Monterey, CA, 4-6 February 2002.

MODELING THE CENTRAL CALIFORNIA COASTAL UPWELLING SYSTEM: PHYSICS, ECOSYSTEMS AND RESOURCE MANAGEMENT

Jeffrey D. Paduan, Associate Professor

Department of Oceanography

Sponsor: Monterey Bay Aquarium Research Institute

OBJECTIVE: The goal of this project is to incorporate a multi-component ecosystem model within a circulation model of the central California coastal region.

SUMMARY: This project is modeling the oceanographic processes within the Monterey Bay National Marine Sanctuary (MBNMS) at high resolution (kms). A large body of observations is available from the region for model validation. The high-resolution coastal model will be nested within basin-scale and regional models. The model will include physical, chemical and biological properties and be capable of assimilating data from satellites and in situ sensors. The model will focus on simulating the observed strong seasonal and interannual variations on oceanographic processes. NPS scientists will participate through quality control and interpretation of physical oceanographic data sets from the Monterey Bay region.

CONFERENCE PRESENTATIONS:

Paduan, J., Cook, M.S. and Atwater, D., "Lagrangian beaching and exiting statistics from Monterey Bay HF radar-derived surface velocities," Eastern Pacific Ocean Conference, Timberline Lodge, Mt. Hood, OR, 25-28 September 2002.

Vesecky, J.F., Drake, J., Paduan, J.D., Teague, C.C., Fernandez, D.M. and Cook, M.S., "MCR an SeaSonde comparison," 2nd Radiowave Oceanography Workshop (ROW-2), Aber Wrach, France, 15-18 April 2002.

MEETING ABSTRACT:

Chavez, F.P., Barber, R., Chai, F., Chao, Y., DeVogelaere, A., Kindle, J., et al., "On the need for simulations of coastal ocean physics and ecosystems (SCOPE)," abstract OS110-07 in the *EOS, Transactions, American Geophysical Union*, Vol. 83 (4), Ocean Science Meeting Supplement, 2002.

OTHER:

Paduan, J., "Physical oceanography: What is it, why is it so hard, and how does it relate to me?" lecture for docents training series, Monterey Bay Aquarium, 26 March 2002.

KEYWORDS: HF Radar, Ocean Currents, Air-Sea Interaction

OCEANOGRAPHY

ADRIATIC MESOSCALE EXPERIMENT

Pierre-Marie Poulain, Assistant Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: An observational program to quantify the mesoscale variability in the northern subbasins of the Adriatic Sea is proposed.

KEYWORDS: Circulation, Lagrangian Drifters, Mediterranean Sea

MEDITERRANEAN DRIFTER DATA ANALYSIS

Pierre-Marie Poulain, Assistant Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: More than 500 surface drifters have been used between 1986 and 1999 to measure the sea surface circulation and temperature in the Mediterranean Sea. The velocity statistics estimated from this dataset are affected by instrumental and sampling errors. The most important instrument error is due to the action of wind/waves on the drifters, causing it to “slip” with respect to the water. We propose to assess the water-following capabilities of commonly-used surface drifters by performing sea tests in which prototype drifters equipped with acoustic velocity statistics, such as the “array” bias, an important error when the Lagrangian data are not distributed uniformly in space, will be estimated using statistical models for the prediction of drifter trajectories. Optimized drifter deployment strategies will also be sought.

KEYWORDS: Circulation, Lagrangian Drifters, Remote Sensing, Mediterranean Sea

AERIAL SURVEYS OF THE OCEAN AND ATMOSPHERE OFF CENTRAL CALIFORNIA

Steven R. Ramp, Research Professor
Jeffrey D. Paduan, Associate Professor
Curtis A. Collins, Professor
Department of Oceanography
Wendell A. Nuss, Associate Professor
Department of Meteorology
Sponsor: Office of Naval Research

OBJECTIVE: The objective of this project is to observe the half-dozen or so “characteristic states” of Monterey Bay air/sea system and the associated adjacent coastal ocean and atmosphere. These states include onset and retreat of summer upwelling, the advance and retreat of the Monterey Bay Eddy, the passage of winter fronts and storms, the diurnal monsoon, poleward propagating events in the atmosphere and ocean, and the occasional anomalous passing atmospheric systems. The observations will be used to enhance and improve existing and future coupled models of the coastal air/sea system.

SUMMARY: A time series of forty (40) aircraft flights will be made over the Monterey Bay and adjacent waters between March 2003 and March 2004 to make high resolution maps of critical parameters in the ocean and atmosphere. The mapping portion of the flight path will be flown at a constant altitude of 33 m off the sea surface, beneath the usual regional stratus deck. Additionally, two sawtooth transects, elevating offshore, will be flown to map the height of the atmospheric inversion layer at the northern and middle sections of the region. The flights will be conducted nominally every two weeks, with a concentration of flights during August 2003 in support of the Office of Naval Research (ONR) Autonomous Ocean Sensing Network – II (AOSN-II) experiment in the Monterey Bay. Flight times will be adjusted slightly to coordinate with cruises in the bay, primarily on the research vessel POINT SUR, which will provide ground truthing for remote sensors, and support operational education for U.S. Navy Officer Students at the Naval Postgraduate School. The aircraft will be provided the NPS Center for Remotely-Piloted Aircraft Studies (CIRPAS), housed locally at the Marina Municipal Airport. The Twin Otter aircraft will be used

when available (but definitely during August 2000) and the smaller payload "Pelican" aircraft (a modified Cessna Skymaster) will be used when the Twin Otter is deployed out of town. A basic suite of sensors will be deployed on all flights to include air temperature, dew point temperature, atmospheric pressure, and sea surface temperature. The Twin Otter will additionally carry a LIDAR altimeter, atmospheric turbulence sensors, aerosol sensors, and a new hyperspectral radiometer. The flights will produce an unprecedented time series of high-resolution air/sea observations for use in verifying Navy models such as COAMPS. Investigators will cooperate with the Naval Research Laboratory (NRL) Monterey and NRL SSC on model initialization and verification issues.

PUBLICATIONS:

Ramp, S.R., Paduan, J.D., Shulman, I. and Bahr, F.L., "Observations and modeling of upwelling and relaxation events in the northern Monterey Bay during August 2000," 2003, (in advanced preparation).

Shulman, I., Wu, C.-R., Lewis, J.K., Paduan, J.D., Rosenfeld, L.K., Kindle, J.D., et al., "High resolution modeling and data assimilation in the Monterey Bay area," *Continental Shelf Research*, 22, pp. 1129-1151, 2002.

CONFERENCE PRESENTATIONS:

Ramp, S.R., "Science issues for AOSN-II in the Monterey Bay," AOSN-II Executive Team Meeting, Washington, D.C., 2002.

Ramp, S.R., Paduan, J.D., Bahr, F.L. and R. Bluth, "The utility of aircraft in coastal ocean observing systems," EPOC Annual Meeting, Timberline Lodge, OR, September 2002.

Ramp, S.R., Paduan, J.D., Collins, C.A., Nuss, W., Healey, A. and Rosenfeld, L.K., "NPS priority research and education activities during AOSN-II," ONR AOSN-II Planning Workshop, MBARI, Moss Landing, CA, 6-7 April 2002.

OTHER:

Member of the AOSN-II Executive Team.

Convened special symposium on Coastal Ocean Observing Systems, EPOC Meeting, Timberline Lodge, OR, September 2002.

KEYWORDS: Real-time Observations, Ocean Currents, Air-sea Interaction, Bioluminescence

GLOBEC: MOORED CURRENT OBSERVATIONS ALONG THE EUREKA LTOP TRANSECT

**Steven R. Ramp, Research Professor
Department of Oceanography**

Sponsor: National Oceanic and Atmospheric Administration Coastal Ocean Program

OBJECTIVE: The over-arching goal of the Global Ocean Ecosystems Dynamics (GLOBEC) Northeast Pacific Program (NEP) is to understand the effects of climate variability and climate change on the distribution, abundance and production of marine animals in the eastern North Pacific Ocean. The objective of the five-year Long-Term Observation Program (LTOP) moorings is to monitor the temporal and spatial variability of the currents and bottom temperature over the continental shelf off Oregon, from tidal to interannual scales, and relate this physical variability to long-term changes in the ecosystem.

SUMMARY: Oceanographic moorings to measure temperature, salinity, and velocity at the 73 m isobath 6.5 nm off the mouth of the Rogue River near Gold Beach, OR have been maintained by the Naval Postgraduate School since May 2000. Instrument recovery has been 100% so far with most instruments working well. The moorings are still in the ocean and will be recovered and redeployed again during

OCEANOGRAPHY

March 2003 with final recovery set for October 2003. The data were analyzed in conjunction with other moorings off Coos Bay and Newport, OR, maintained by other GLOBEC investigators. Early results indicate significant differences in the environment north (Coos Bay) and south (Rogue River) of Cape Blanco, OR, where the coastal jet separates from the coast. The physical changes apparently propagate through the ecosystem as larger numbers of salmon, birds, and marine mammals were also observed south of Cape Blanco than north. Occasional onshore advection events of Columbia River Plume water have also been noted. We are working with the GLOBEC biologists to understand these results. The first journal publications from the GLOBEC NEP program are targeted for a special issue of Deep Sea Research – II with submissions due 1 July 2003.

PUBLICATIONS:

Batchelder, H., Strub, T., Peterson, W., Barth, J.A., Kosro, P.M., Brodeur, R., et al., "The GLOBEC Northeast Pacific Program: California Current System," *Oceanography Magazine*, 15, pp. 36-48.

Ramp, S.R., Bahr, F.L. and Strub, T., "Seasonal variability of the upwelling process south of Cape Blanco, OR," *DSR-II Special Issue*, 1 July 2003, (in advanced preparation).

PRESENTATION:

Ramp, S.R., Kosro, P.M., Huyer, A. and Strub, T., "Seasonal variability of the upwelling process south of Cape Blanco, OR," GLOBEC Annual PI Meeting, Corvallis, OR, Nov 2002.

OTHER:

Two oceanographic research cruises per year on the R/V WECOMA off the Oregon coast.

KEYWORDS: Coastal Oceanography, Upwelling Fronts, Ecosystem Dynamics, GLOBEC

PROCESSES IN MARGINAL SEAS – AND – ASIAEX PROJECT MANAGEMENT

Steven R. Ramp, Research Professor

Ching-Sang Chiu, Professor

Department of Oceanography

Sponsor: Office of Naval Research

OBJECTIVE: The objective of these two closely-related projects is to plan and execute a multi-national oceanographic field program in the East and South China Seas to investigate how the complex littoral environment (i.e., its water column, boundary, sediment and sub-bottom structure and inhomogeneities) affects the ray paths, mode structure, propagation loss, and temporal and spatial (both vertical and horizontal) coherence for low-to-intermediate frequency (50-4000 Hz) acoustic transmissions in shallow water. The work is part of a continuing project.

SUMMARY: Several years of advance planning and hard work came to fruition with the successful execution of the ASIAEX main field program during April –June 2001. The South China Sea (SCS) portion took place during April – May 2001 on the Chinese continental shelf and slope between Dongsha Island and Taiwan. The East China Sea (ECS) portion took place during May and June in the region bounded by 28-30°N and 126° 30' to 128°E. The SCS program was executed during eight cruises from three Taiwanese research vessels. Eight oceanographic moorings, eight acoustic source/receiver moorings, and numerous smaller, experimental moorings were deployed and recovered. The area was also surveyed using the SeaSoar towed undulating vehicle and a chirp sonar sub-bottom profiling system. This was the largest simultaneous, high-resolution physical oceanography and acoustic propagation data set ever collected. The result from the program was the discovery of the world's largest nonlinear internal waves which are generated in the Luzon Strait and propagate WNW towards the Chinese continental shelf. The dynamics of these features and their impact on acoustic propagation was analyzed.

PUBLICATIONS:

Kim, H.-R., Ramp, S.R., Duda, T. and Liu, A.K., "Solitons in the Northeastern South China Sea Part II: Transformation in Shallow Water," *IEEE/JOE*, May 2003 special issue, (in advanced preparation).

Ramp, S.R., Bahr, F.L., Ashjian, C.J. and Talley, L.D., "The upper-ocean circulation in the Ulleung Basin during June-July 1999," *Deep-Sea Research, II*, (submitted).

Ramp, S.R., Chiu, C.S., Bahr, F.L. and Qi, Y., "The Shelf-Edge Environment in the Central East China Sea and its Impact on Low Frequency Acoustic Propagation," *IEEE/JOE*, May 2003 special issue, (in advanced preparation).

Ramp, S.R., Chiu, C.S., Kim, H.-R., Bahr, F.L., Tang, T.-Y., Yang, Y.J., et al., "Solitons in the Northeastern South China Sea Part I: Sources and Propagation Through Deep Water," *IEEE/JOE*, May 2003 special issue, (in advanced preparation).

Ramp, S.R., Lynch, J., Chiu, C.S., Dahl, P. and Simmen, J., "ASIAEX Fosters Advances in Shallow Water Acoustics," *EOS*, (submitted).

PRESENTATIONS:

Ramp, S.R. and Chiu, C.S., "The shelf-edge environment in the East China Sea and its impact on acoustic propagation," ASIAEX International Symposium, Chengdu, PRC, October 2002.

Ramp, S.R., et al., "Moored observations of internal solitons in the northeastern South China Sea," AGU Ocean Sciences Meeting, Honolulu, HI, February 2002.

Ramp, S.R., et al., "Moored observations of internal solitons in the northeastern South China Sea," ASIAEX international symposium, Chengdu, PRC, October 2002.

Ramp, S.R., et al., "Operational impacts of internal solitons in the northeastern South China Sea," COMSUBPAC Pearl Harbor, HI, June 2002.

Ramp, S.R., et al., "Physical Oceanography of the Yellow and East China Sea," COMSUBPAC Pearl Harbor, HI, June 2002.

Ramp, S.R., et al., "Tracking the generation sites and packet variability of internal solitons in the South China Sea," Acoustical Society of America (ASA) Bi-annual Meeting, Cancun, Mexico, December 2002.

TECHNICAL REPORT:

Tang, D.J., Ramp, S.R., Dahl, P.H., Lynch, J., Zhou, J., Zhang, R., et al., "Proceedings, the Asian Seas International Acoustics Experiment (ASIAEX) International Symposium, Chengdu, PRC, October 14-18 2002," APL-UW Technical Report TR 0201, November 2002.

THESIS DIRECTED:

Rocha, J.D., "2001 SeaWiFS Analysis of the Japan and East China Sea Air/Sea Environment," Master's Thesis, Naval Postgraduate School, December 2001.

KEYWORDS: Marginal Seas, Mesoscale Dynamics, Environmental Acoustics, ASIAEX, Coastal Oceanography, Internal Waves, Acoustic Propagation

OCEANOGRAPHY

A RELOCATABLE REAL-TIME COASTAL OCEAN OBSERVING SYSTEM

Steven R. Ramp, Research Professor
Jeffrey D. Paduan, Associate Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: This is a Defense University Research Instrumentation Program grant to purchase equipment for use in present and future Navy-sponsored research programs. The proposal was for: 1) Two complete Acoustic Doppler Current Profilers (ADCPs) in Trawl Resistant Bottom Mounts (TRBMs), including acoustic releases and other ancillary equipment; and 2) Two fully portable CODAR SeaSonde HF radar sites including electronics, 13 mHz transmit and receive antennas, portable housings, generators, and wireless internet links.

SUMMARY: The equipment was purchased as proposed. The ADCP/TRBM systems was tested during June 2003 and used in the Monterey Bay AOSN-II experiment in August 2003. One new CODAR site was established at the NPS beach lab facility. The other will be set up at Santa Cruz when the Long Marine Lab construction is completed.

KEYWORDS: Coastal Oceanography, Ocean Instrumentation

DEVELOPMENT OF TRAINING MATERIALS FOR USERS OF NAVY OPERATIONAL OCEAN CIRCULATION AND TIDE MODELS

Leslie Rosenfeld, Research Associate Professor
Department of Oceanography
Sponsor: Naval Meteorology and Oceanography Professional Development Center

OBJECTIVE: To develop a short course and training materials on numerical ocean circulation analysis and prediction systems, with emphasis on how to appropriately interpret and use Navy operational circulation and tide models.

KEYWORDS: Ocean Circulation Models, Training

INVESTIGATION OF SOURCE OF HUNTINGTON BEACH SEWAGE CONTAMINATION

Leslie Rosenfeld, Research Associate Professor
Department of Oceanography
Sponsor: Orange County Sanitation District

OBJECTIVE: The goal of this project was to determine whether Orange County Sanitation District's (OCSD) ocean outfall could be the source of sewage contamination to the surf zone off Huntington Beach, California.

SUMMARY: During 2001, a multi-agency field project was undertaken to determine whether OCSD's ocean outfall could be the source of bacterial contamination to the Huntington Beach surf zone. Data analysis, interpretation, and report writing was accomplished in 2002. A number of coastal ocean transport processes, including internal tides, seabreeze-driven flow, upwelling, and topographic steering, were examined. Additionally, the spatial and temporal patterns of the beach contamination were determined and compared with the coastal ocean processes. It was concluded that it was very unlikely that OCSD's ocean outfall was the source of the beach contamination. Rather, it was suggested that the contamination most likely comes from a land source, and it was confirmed that the contamination was related to the fortnightly tidal cycle.

PRESENTATION:

Rosenfeld, L.K., et al., "Field Study of Possible Cross-Shelf Transport Mechanisms for a Treated Wastewater Plume Discharged on the Continental Shelf off Huntington Beach, CA," Ocean Sciences, Honolulu, HI, 11-15 Feb 2002.

THESIS DIRECTED:

Taylor, K., "An Investigation of Diurnal Variability in Winds and Ocean Currents off Huntington Beach, CA," Master's Thesis, Naval Postgraduate School, February 2003, (December 2002 graduate).

KEYWORDS: Coastal Circulation, Sewage Outfalls, Huntington Beach

SEDIMENT TRANSPORT IN MONTEREY CANYON

Leslie Rosenfeld, Research Associate Professor

Department of Oceanography

Sponsor: U.S. Geological Survey

OBJECTIVE: The objective of this project was to investigate the deep current structure and sediment transport in the region of a significant bend in Monterey Submarine Canyon.

SUMMARY: In the fall of 2002, the mooring array was designed, parts were ordered, and instruments were prepared. In December of 2002, three moorings supporting instrumentation to measure temperature, salinity, velocity, light transmission, and particle settling were deployed in Monterey Submarine Canyon. These moorings will be recovered in December of 2003.

PUBLICATIONS:

Bjorkstedt, E.P., Rosenfeld, L.K., Grantham, B.A., Shkedy, Y. and Roughgarden, J., "Distributions of larval rockfish (*Sebastes* spp.) across nearshore fronts in a coastal upwelling region," *Marine Ecology Progress Series*, 242: pp. 215-228.

Kunze, E., Rosenfeld, L.K., Carter, G.S. and Gregg, M.C., "Internal waves in Monterey Submarine Canyon," *Journal of Physical Oceanography*, 32: pp. 1890-1913.

Petruncio, E.T., Paduan, J.D. and Rosenfeld, L.K., "Numerical simulations of the internal tide in a submarine canyon," *Ocean Modeling*, 4: pp. 221-249.

Shulman, I., Wu, C.-R., Lewis, J.K., Paduan, J.D., Rosenfeld, L.K., Kindle, J.C., et al., "High resolution modeling and data assimilation in the Monterey Bay area," *Continental Shelf Research*, 22, pp. 1129-1151.

Xu, J.P., Noble, M.A., Eitrem, S.L., Rosenfeld, L.K., Schwing, F.B. and Pilskaln, C.H., "Distribution and transport of suspended particulate matter in Monterey Canyon, California," *Marine Geology*, 181: pp. 215-234.

CONFERENCE PRESENTATION (with abstract):

Rosenfeld, L., Noble, M., Jones, B., Robertson, G., Largier, J., Hamilton, P., "Field study of possible cross-shelf transport mechanisms for a treated wastewater plume discharged on the continental shelf off Huntington Beach, CA," abstract OS42R-01 in *EOS, Transactions, American Geophysical Union*, 83, Ocean Sciences Meeting Supplement.

KEYWORDS: Submarine Canyon, Monterey Bay, Sediment Transport

OCEANOGRAPHY

APPLICATION OF PARALLEL OCEAN AND CLIMATE MODELS TO DECADE/CENTURY PREDICTION

Albert J. Semtner, Professor

Wieslaw Maslowski, Research Associate Professor

Julie L. McClean, Research Associate Professor

Robin Tokmakian, Research Assistant Professor

Department of Oceanography

Sponsors: U.S. Department of Energy, Naval Postgraduate School

OBJECTIVE: To use ocean, atmosphere, and ice models developed during earlier research under the Department of Energy (DOE) Computer Hardware, Advanced Mathematics and Model Physics Program in order to simulate realistic climate states using advanced parallel computers. To understand physical processes that affect oceanic predictability and climatic fluctuations or change.

SUMMARY: This project is in its fifth of six years. It uses various advanced models to understand the variability of ocean and ocean-ice circulation at relatively high resolution. The Naval Postgraduate School group collaborates with large climate modeling efforts at Los Alamos and at the National Center for Atmospheric Research. Extensive simulations were carried out last year, and analysis is underway.

PRESENTATIONS:

Semtner, A.J., "Evaluating geodesic-coordinate ocean and sea-ice models," DOE Cooperative Agreement meeting, Denver, CO, 19-20 February 2002.

Semtner, A.J., "High-resolution global ocean and sea-ice simulations," U.S.-Japan Climate and Computing Workshop, Boulder, CO, 11-14 March 2002.

Semtner, A.J., "Ocean and sea-ice components of NCAR climate models, 1975-2000," American Geophysical Union meeting, San Francisco, CA, 7-8 December 2002.

KEYWORDS: Numerical Modeling, Ocean Prediction, Parallel Computing

DEVELOPMENT OF A GEODESIC CLIMATE MODEL WITH QUASI-LAGRANGIAN VERTICAL COORDINATE

Albert J. Semtner, Professor

Department of Oceanography

Sponsor: Colorado State University

OBJECTIVE: To participate in a Cooperative Agreement between Colorado State University and the U.S. Department of Energy in order to build a new climate model in which the vertical coordinate will be better suited to represent physical processes and minimize spurious computational diffusion. The horizontal gridding of all model components was based on approximately equal area subdivisions of the faces of an icosahedral decomposition of the earth's surface.

SUMMARY: This was the first year of a five-year project. The Naval Postgraduate School (NPS) Oceanography Department took the lead in designing numerically consistent operators of the gradient and divergence operators in hexagonal coordinates for use with the stress tensor of the sea-ice model's dynamics. This study interacted with other studies in the cooperative activity to produce a geodesic sea-ice model, which will be coupled to Los Alamos's geodesic ocean model for tests in an Arctic context by NPS investigators.

PRESENTATION:

Stark, D., "Consistent gradient and divergent operators with second-order accuracy for hexagonal grids, with application to elastic-viscous-plastic ice dynamics," Cooperative Agreement Meeting, Fort Collins, CO, 19-20 August 2002.

KEYWORDS: Numerical Modeling, Ocean Prediction, Parallel Computing

COLLABORATIVE RESEARCH: THE ROLE OF ICE-OCEAN EXCHANGE IN ICE-ALBEDO FEEDBACK

Timothy P. Stanton, Research Associate Professor

Wieslaw Maslowski, Research Associate Professor

Department of Oceanography

Sponsor: National Science Foundation

OBJECTIVE: This study proposed to utilize data sets collected during the Sheba Field Program and other related program; (e.g. SCIECEX) to study the processes controlling the ICE Albedo Feedback (IAF) mechanism over an annual cycle and their role in the ice-ocean-atmosphere interactions. This study quantified the impact of these interactions, developed, implemented and tested parameterizations of most critical processes using a series of models ranging from local process models to basin and global sea ice and ocean models. The main goal of these activities was to improve simulation of the pan-arctic region in global climate models to advance their skill in climate change prediction.

MODELING THERMOBARIC EFFECTS IN ANTARCTIC DEEP OCEAN CONVECTION

Timothy P. Stanton, Research Associate Professor

Department of Oceanography

Sponsors: National Science Foundation, Office of Polar Programs

OBJECTIVE: The objectives of this research are to assess the role of thermobaric compressibility of sea water in providing an internal source of turbulent kinetic energy that can result in deep convection. Many of the T/S profile observations near Maud Rise in the Weddell Sea during the Antarctic Zone Flux Experiment (ANZFLUX) show that the water column is only marginally stable to thermobaric convection. The objective of this research was to perform numerical modeling of this upper ocean system, to further understand the process, and to guide the development of a future observational program.

SUMMARY: If water parcels from the deep mixed layer are moved by strong surface forcing below a weak, preconditioned pycnocline typical of the Maud Rise area, the parcel can become negatively buoyant due to a nonlinearity in the equation of state for sea water. If this happens, the water parcel could continue to descend through the water column, generating further turbulence as it falls, potentially causing full overturning of the whole water column. A massive overturning event is known to have occurred during the late 1970's when the Weddell Polyna remained ice-free for two winters, causing a massive ventilation of the ocean interior.

During the first year of this program, a high resolution Large Eddy Simulation (LES) model was used to simulate the evolution of the water column using ANZFLUX profiles for an initial condition, with wind forcing timeseries measured during the ANZFLUX experiment forcing the models ice-covered surface. The modeling work demonstrated that thermobaric terms do indeed contribute to the negative buoyancy flux in the water column. These results are now being used to design an observational program in the Weddell Sea. In March 2003, a postdoc joined the turbulence group to further analyze the existing model runs and work on improved entrainment formulations in the LES.

KEYWORDS: Ocean Mixed Layer, Polar Oceans, Mixed Layer Dynamics

OBSERVATION OF VELOCITY FIELDS UNDER WIND-FORCED WAVES

**Timothy P. Stanton, Research Associate Professor
Department of Oceanography**

Sponsor: Office of Naval Research Coupled Boundary Layers and Air-Sea Transfer Program

OBJECTIVE: The objectives of this research were to measure and model the transfer of wind-stress through surface turbulence and waves at the air-sea interface. This momentum transfer via surface gravity waves remains poorly understood due primarily to the difficulties of measuring turbulence immediately below the wave surface.

SUMMARY: A one year delay in the Martha's vineyard field experiment occurred due to construction problems for the MV research tower. However instrument development and prototype measurements of sub-wave stresses continued during FY02. Prototype measurements of velocity fields below surface gravity waves were made in shallow water offshore from the Naval Postgraduate School Marine Operations facility in Monterey Bay. A unique small scale coherent Doppler velocity profiler, the BCDVSP, was directed up under waves from a stable platform in 3.5m depth. Three component velocity profiles were measured every 1.5cm over a 1.5m range spanning the wave crest/trough region. These data sets have allowed a surface-following analysis technique to be developed to measure timeseries of vertical Reynolds stresses along with near-surface shear profiles, allowing shear production rates of turbulent kinetic energy to be estimated. These results were presented at the February ocean Sciences meeting and at an invited talk at Woods Hole Oceanographic Institute (WHOI). A scanned laser/imaging system has also undergone laboratory testing in preparation for the summer 2003 main deployment WHOI Martha's Vineyard tower.

PUBLICATION:

Stanton, T.P., "High Resolution Acoustic Doppler Profiling of Velocity, Reynolds Stresses and Sediment Concentration in Wave Forced Boundary Layers," *Journal of Atmospheric and Oceanic Technology*, (submitted).

CONFERENCE PRESENTATIONS:

Stanton, T.P., "Measuring turbulence under wind waves," Woods Hole Oceanographic Institute, July 2002, (invited).

Stanton, T.P., "Velocity structure and turbulent stresses directly below wind-forced ocean waves," Ocean Sciences Meeting, February 2002.

KEYWORDS: Wave Dissipation, Shoaling Waves, Bottom Boundary Layers

**UPPER OCEAN EFFECTS ON THE SURFACE HEAT BUDGET OF THE ARCTIC
AUTONOMOUS OCEAN FLUX BOUY**

**Timothy P. Stanton, Research Associate Professor
Department of Oceanography**

Sponsors: National Science Foundation, Office of Polar Programs

OBJECTIVE: The objectives of this research were to measure the mixed layer and upper ocean heat content and heat fluxes in the central Arctic Ocean. This work was a component of the multidisciplinary Surface Heat Budget of the Arctic Ocean (SHEBA) program that has the objectives of improving parameterizations of the coupled atmosphere-ice-ocean system in the Arctic to improve the predictive capabilities of Global Climate Models. A shorter process study focused on the role of ice keels in the surface heat balance. The one year manned ice camp observations of upper ocean fluxes are extended with the deployment of a series of autonomous buoys at the North Pole as a component of the SEARCH program.

SUMMARY: Between October 1997 and October 1998 the SHEBA ice camp was deployed in the Central Beaufort Sea. An automated CTD and microstructure profiler inferred turbulent fluxes from thermal microstructure measurements and the temperature/salinity structure of the upper ocean throughout a year as the ice camp drifted in response to surface wind forcing. The microstructure package was designed and built at the Naval Postgraduate School for this experiment. A paper describing the upper ocean structure and comparisons with historical data was submitted to the *Journal of Geophysical Research*. Techniques to improve thermal dissipation rates in the presence of strong interleaving were developed exploiting the dual microthermistors deployed on the microstructure profiling package. This method reduced noise levels in the vertical flux estimates which otherwise result in over-estimates of pycnocline fluxes. On-going comparisons were made between the SHEBA timeseries and Wieslow Maslowski's high resolution Arctic Basin model now integrated through the SHEBA years to understand recent changes in pycnocline heat content.

An autonomous ocean heat, salt and momentum flux buoy was developed under National Science Foundation funding. The first of three buoys was successfully deployed at the North Pole in April 2002 as a component of the SEARCH program. These measurements will extend the SHEBA observations at a time of significant changes in ice coverage and upper ocean heat content in the Arctic Basin.

PUBLICATION:

Stanton, T.P., Morison, J., McPhee, M., Martinson, D. and Tyner, R., "Upper Ocean Structure and heat content during the SHEBA ice camp drift," *Journal of Geophysical Research*, (submitted).

KEYWORDS: Ocean Mixed Layer, Polar Oceans, Mixed Layer Dynamics

**EVOLUTION OF RIP CURRENTS AND MORPHOLOGY: FIELD EXPERIMENTS AND
NUMERICAL MODELING**

Edward B. Thornton, Distinguished Professor
Timothy P. Stanton, Research Associate Professor
Department of Oceanography
Sponsor: National Science Foundation

OBJECTIVE: Predict the evolution of rip current systems and underlying morphology given the offshore wave conditions.

SUMMARY: Field data was acquired for comparison with the numerical model. The Rip Current Experiment (RIPEX) was conducted in the spring of 2001 at Sand City, California, to obtain high-resolution wave, current and morphology data over rip current systems. Long-term observations were obtained of morphology and waves at three sites (Monterey, Sand City, and Marina, California) using time-lapse video and concurrent directional wave data. The bathymetry at these sites was measured monthly using a global positioning system (GPS) and sonar mounted on a jetski.

These measurements were analyzed and compared with numerical predictions. The morphodynamics of rip current systems on an initially alongshore uniform barred beach with directionally broad spectral wave forcing with a mean angle of normal incidence is initially perturbed by VLF's and/or self organized motions that determine the alongshore length scale of the rip channels. The rip channels are enhanced by a positive feedback of the wave group forcing and rip currents themselves. The alongshore scale of the rip channel spacing is shown to be a function of the directional bandwidth. (Reniers et al., 2002).

PUBLICATION:

Reniers, A.J.H.M., Roelvink, J.A. and Thornton, E.B., "Morphodynamic modeling of an embayed beach under wave group forcing," *Journal of Geophysical Research*, (submitted).

THESIS DIRECTED:

Welsch, C.A., "Assessment of Delft3D Morphologic Model During Duck94," Master's Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: Rip Currents, Waves, Morphology

MODELING AND TORREY PINES BEACH NOURISHMENT

Edward B. Thornton, Distinguished Professor

A. Reniers, Visiting Professor

Department of Oceanography

Sponsor: Scripps Research Institute

OBJECTIVE: The scientific objective was to examine if a state-of-the-art hydrodynamics model, coupled with a sediment transport module, could predict aspects of a beach nourishment evolution under wave and current action. Owing to computation times, only selected periods of nourishment evolution were modeled. The selected period was a time when morphology changed significantly, and was at least two weeks in duration since that was the survey interval. Comparisons of model computations and measurements were reported in a scientific paper or report.

KEYWORDS: Nearshore, Beach Nourishment, Waves, Sediment Transport

NEAR SHORE WAVE PROCESSES

Edward B. Thornton, Distinguished Professor

Timothy P. Stanton, Research Associate Professor

Department of Oceanography

Sponsor: Office of Naval Research

OBJECTIVE: Predict the wave-induced three-dimensional velocity field and induced sediment transport over arbitrary bathymetry in the near shore given the offshore wave conditions.

SUMMARY: Work completed included an analysis of the SteepBeach/RIPEX data, improved techniques for determining reflection, and modeling the hydrodynamics and large-scale morphodynamics in the nearshore with an advanced Delft3D model. The generation of infragravity waves by directionally spread short waves incident on an alongshore uniform beach was investigated using an advanced version of Delft3D. The infragravity wave response was examined using linear shallow water equations, taking into account the presence of bottom friction, set-up, rollers and the longshore current. The infragravity energy density spectrum and surface elevation at the infragravity band time scale was generated by summing all difference interaction frequency pairs of the input short-wave directional spectra obtained. Model results were compared with the data from the Delilah experiment (Reniers et al., 2002), and the results of the SteepBeach/RIPEX experiment (Reniers et al., 2002)

Data obtained during the SteepBeach/RIPEX was analyzed. Pulsations of the rip currents at infragravity frequencies were found to be the result of wave group forcing (MacMahan et al., 2002). Significant very low frequency energy (VLF's) outside the region of zero-mode edge waves was found and shown to be attributed to directionally broad wave group forcing and/or instabilities of the rip current itself, resulting in large-scale vortices (MacMahan et al., 2002). A new technique for determining wave reflection in the nearshore using PUV measurements as an extension of the work by Dixon et al. (1995) was developed (Thornton et al., 2002)

PUBLICATIONS:

MacMahan, J., Reniers, A.J.H.M., Thornton, E.B. and Stanton, T.P., "Infragravity Motions on a Complex Beach, Part 1: Observations," *Journal of Geophysical Research*, (submitted).

Reniers, A.J.H.M, MacMahan, J., Thornton, E.B. and Stanton, T.P., "Infragravity Motions on a Complex Beach, Part 2: Modeling," *Journal of Geophysical Research*, (submitted).

Reniers, A.J.H.M., Van Dongeren, A., Battjes, J. and Thornton, E.B., "Linear modeling of infragravity waves during Delilah," *Journal of Geophysical Research* 107(C10), 3137, doi:10.1029/2001JC001083, 2002.

PRESENTATION:

Thornton, E., Stanton, T. and Reniers, A., "Wave reflection on a steep beach," 28th International Conference on Coastal Engineering, Cardiff, Wales, UK, July 2002.

THESES DIRECTED:

Cutshaw, C., "Verification of a One-dimensional Surf Prediction Model for Steep Beach Conditions," Master's Thesis, Naval Postgraduate School, June 2002.

Egley, L., "An Application of LIDAR to Examine Erosion in Southern Monterey Bay During the 1997-98 El Nino," Master's Thesis, Naval Postgraduate School, March 2002.

KEYWORDS: Nearshore, Waves, Surf

INTERANNUAL TO DECADAL OCEAN VARIABILITY AND PREDICTABILITY

Robin Tokmakian, Research Associate Professor

Department of Oceanography

Sponsor: National Aeronautics and Space Administration

OBJECTIVE: Completed the analysis of 0.25 degree resolution ocean model and associated satellite data. Performed a joint analysis of a North Atlantic ocean model on the realism of the high frequency signal to help in understanding the ability of the ocean model to predict events. Completed and submitted a paper related to the realism of the low frequency variability of the ocean within the model with respect to altimeter and other satellite data to further understand the predictive aspects of the model. Completed, submitted a paper on the topic which is in press.

SUMMARY: Quantitative comparisons of a 0.25 degree resolution ocean model (forced with high frequency momentum, heat, and freshwater fluxes) with tide gauges and altimeter data showed the simulation produced realistic ocean circulation for large regions of the ocean. The model output was further analyzed to quantify the contribution the surface forcing made on the low frequency variability seen in the model and altimeter data and to understand the influence of subsurface layers on the variability of sea surface height (SSH). At low frequencies, greater than 1.5 years, only the heat flux made significant contribution to the SSH variability, and perhaps, the Ekman pumping in a few particular areas in the Northeast Pacific, off of Nova Scotia, and in the western Pacific tropical region. The influence of the steric and lower parts of the water column were described for both the low and interannual periods. At the low frequencies, the dynamics within the ocean itself, rather than any local forcing, largely determined the variability of the SSH measurements. The salinity variability, in addition to the temperature changes, also had significant influence on the SSH signal at high latitudes and in the tropical Atlantic. Last, examples were given which show how the SSH could be used to monitor the circulation of the oceans. The second paper described the results from a comparative wavelet analysis of a 0.1 degree, 40-level Parallel Ocean Program model simulation of the North Atlantic with coincident in situ measurements of sea surface height and temperature. The wavelet analysis was used to examine the realism of the surface's variability and its high frequency signals (less than a year). Along the coast, it showed that the model's simulated fields of SSH were realistic with the correlations to tide gauge measurements on the order of 0.8. The wavelet spectra showed that the model replicated the observations' frequency space. Comparisons of the model's temperatures to temperatures from NOAA buoys north and south of the Gulf Stream showed that, while not replicating the location of mesoscale features all the time, the model's energy in the strong mesoscale

regions compared favorably to data. Due to the TOPEX/POSEIDON's (T/P) sampling, which required large areal averages and because of the model's spontaneous eddy field, the evaluation of the simulation in the open ocean was less conclusive. The model did show similarities to the T/P data at high latitudes where the sampling by the sensor was denser and also on the eastern side of the basin with its lower mesoscale activity. Spatially, there were similarities in the amplitude of the signals between the model and the observations in areas with a significant signal in a given spectral band.

PUBLICATIONS:

Tokmakian, R. and McClean, J., "How realistic is the high frequency signal of a 0.1 degree resolution ocean model?" *Journal of Geophysical Research-Oceans*, 2003, (in press).

Tokmakian, R., "The relationships between the low frequency signals in an ocean model and altimetry data," (revising).

PRESENTATIONS:

Tokmakian, R., "Along-track analysis of JASON and TOPEX-POSEIDON altimeter & model SSH," Jason SWT, New Orleans, LA, Oct 2002.

Tokmakian, R., "From WOCE to CLIVAR - Monitoring the Variability of the Mid-latitude North Pacific Ocean," WOCE Final Conference, San Antonio, TX, 18-22 Nov 2002.

Tokmakian, R., "Monitoring the Variability of the Subtropical Gyres," Jason SWT, Biarritz, France, June 2002.

Tokmakian, R. and McClean, J., "How realistic is the high frequency signal of a 0.1 degree resolution ocean model?" Jason SWT, Biarritz, France, June 2002.

Tokmakian, R. and McClean, J., "How realistic is the high frequency signal of a 0.1 degree resolution ocean model?" Ocean Sciences, Honolulu, HI, Feb 2002

**DEPARTMENT OF
OCEANOGRAPHY**

**2002 Faculty Publications
and Presentations**

JOURNAL PAPERS

Abbot, P., Gedney, C., Dyer, I. and Chiu, C.-S., "Ambient noise and signal uncertainties during the Summer shelfbreak Primer Exercise," *Proceedings of the NATO SACLANT Conference on Impact of Littoral Environmental Variability on Acoustic Predictions and Sonar Performance*, Lerici, Italy, September 2002.

Ardhuin, F., Drake, T.G. and Herbers, T.H.C., "Observations of wave-generated vortex ripples on the North Carolina continental shelf," *Journal of Geophysical Research*, 107(C10), 3143, doi:10.1029/2001JC000986, 2002.

Ardhuin, F. and Herbers, T.H.C., "Bragg scattering of random surface gravity waves by irregular sea bed topography," *Journal of Fluid Mechanics*, 451, pp. 1-33, 2002.

Ardhuin, F., O'Reilly, W.C., Herbers, T.H.C. and Jessen, P.F., "Spectral evolution of swell across the continental shelf," *Ocean Wave Measurement and Analysis*, B.L. Edge and J.M. Hemsley (Eds.), Amer. Soc. Civil Eng., pp. 744-753, 2002.

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Batchelder, H., Strub, T., Peterson, W., Barth, J.A., Kosro, P.M., Brodeur, R., et al., "The GLOBEC Northeast Pacific Program: California Current System," *Oceanography Magazine*, 15, pp. 36-48.

Batteen, M.L. and Martinho, A.C., "On the roles of wind forcing, wind stress curl, buoyancy and bottom topography in eastern boundary current systems, 2002 Ocean Sciences Meeting, Honolulu, HI, 11-15 February (OS22D-217)," *Transactions of the American Geophysical Union*, Vol. 83, No. 4, p.155, January 2002.

Bjorkstedt, E.P., Rosenfeld, L.K., Grantham, B.A., Shkedy, Y. and Roughgarden, J., "Distributions of larval rockfish (*Sebastes* spp.) across nearshore fronts in a coastal upwelling region," *Marine Ecology Progress Series*, 242, pp. 215-228, 2002.

Castro, C.G., Baumgartner, T.R., Bograd, S., Castro, R., Chavez, F.P., Collins, C.A., et al., "Introduction to 'The 1997-8 El Niño Atlas of oceanographic conditions along the west coast of North America (23°N-50°N)'," *Progress in Oceanography*, 54(1-4), pp. 503-511, 2002.

Castro, C., Collins, C., Walz, P., Pennington, J., Michisaki, R., Frederich, G., et al., "Nutrient Variability during El Niño 1997-9 off Central California," *Progress in Oceanography*, 54(1-4), pp. 171-184, 2002.

Chavez, F.P., Collins, C.A., Huyer, A. and Mackas, D.L., "El Niño along the west coast of North America," *Progress in Oceanography*, 54(1-4), pp. 1-5, 2002.

Chavez, F., Pennington, J., Castro, C.G., Ryan, J.P., Michisaki, R.P., Schlining, B., "Biological and chemical consequences of the 1997-98 El Niño in central California waters," *Progress in Oceanography*, 54(1-4), pp. 205-232, 2002.

Chu, P.C., "C-vector for identification of oceanic secondary circulation across Arctic fronts in Fram Strait," *Geophysical Research Letters*, 29, 10.1029/2002GLO15978, 2002.

Chu, P.C., Cintron, C.J., Haeger, S.D. and Keenan, R.E., "Acoustic mine detection using the Navy's CASS/GRAB model," *Journal of Counter-Ordnance Technology*, [CD Rom].

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Chu, P.C., Ivanov, L.M. and Fan, C.W., "Backward Fokker-Planck equation for determining model valid prediction period," *Journal of Geophysical Research*, 107, C6, 10.1029/2001JC000879.

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Elgar, S., Raubenheimer, B. and Herbers, T.H.C., "Bragg reflection of ocean waves from sandbars," *Geophysical Research Letters*, 30(1), 1016, doi:10.1029/2002GL016351, 2003.

Gacic, M., Kovacevic, V., Mazzoldi, A., Paduan, J., Arena, J., Mancero, F., et al., "Measuring Water Exchange Between the Venetian Lagoon and the Open Sea," *EOS, Transactions, American Geophysical Union*, Vol. 83, pp. 217-222, 2002.

Harcourt, R.R., Steffan, E.L., Garwood, R.W., Jr. and D'Asaro, E.A., "Fully Lagrangian floats in Labrador Sea deep convection: Comparison of numerical and experimental results," *Journal of Physical Oceanography*, 32, pp. 493-510, 2002.

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Herbers, T.H.C., Orzech, M., Elgar, S. and Guza, R.T., "Shoaling transformation of wave frequency-directional spectra," *Journal of Geophysical Research*, 108(C1), 3013, doi:10.1029/2001JC001304, 2003.

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Batteen, M.L. and Paduan, J.P., "Summary of Research 2001 Department of Oceanography," Naval Postgraduate School Technical Report, NPS-09-02-025, September 2002.

Tang, D.J., Ramp, S.R., Dahl, P.H., Lynch, J., Zhou, J., Zhang, R., et al., "Proceedings, the Asian Seas International Acoustics Experiment (ASIAEX) International Symposium, Chengdu, PRC, October 14-18, 2002," APL-UW Technical Report, TR 0201, November 2002.

**DEPARTMENT OF
PHYSICS**

**WILLIAM MAIER
CHAIR**

PHYSICS

OVERVIEW:

The Department of Physics has unique resources and faculty expertise dedicated to Weapon Systems Technologies.

CURRICULA SERVED:

- Combat Systems Science and Technology
- Applied Physics
- Engineering Acoustics

DEGREES GRANTED:

- Master of Science in Physics
- Master of Science in Applied Physics
- Master of Science in Engineering Acoustics
- Doctor of Philosophy

RESEARCH THRUSTS:

- Optical and Electromagnetic Signal Propagation, Detection and Sensor Systems
- Conventional and Nuclear Weapons and their Effects
- Underwater Acoustics
- Free Electron Laser Physics
- Physical Acoustics
- Solid State Physics

RESEARCH CHAIR:

- Lawrence Livermore National Laboratory Chair Professor
- Engineering Acoustics Chair Professor

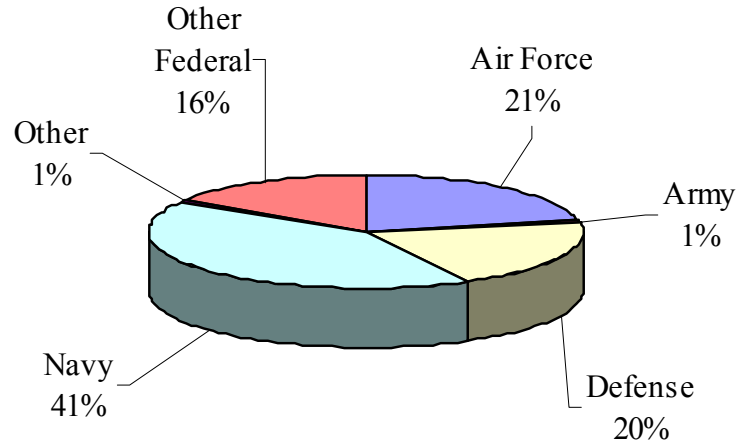
RESEARCH FACILITIES:

- The Physics Laboratories are equipped to carry on instruction and research work in acoustics, atomic, and molecular physics, electro-optics, spectroscopy, laser physics, computational physics, optical propagation, sensor physics and transient electrical discharges.
- The Optical Physics and Sensors Laboratory uses imaging, spectroscopic and sensing systems from far infrared to ultraviolet wavelengths, including instrumentation for seagoing, airborne and ground-based measurements.
- The Acoustics Laboratory equipment includes a large anechoic chamber, a small reverberation chamber and a multiple-unit acoustics laboratory for student experimentation in acoustics in air. Sonar equipment, test and wave tanks and instrumentation for investigation in underwater sound comprise the Underwater Acoustics Laboratory, a scale-model of a shallow water waveguide for the study of environmentally adaptive sonar and high-speed digital acoustic communication. The Physical Acoustics Laboratories are equipped with a variety of modern data collection and processing equipment.
- Directed Energy Lab.

PHYSICS

SPONSORED RESEARCH PROGRAMS (Research and Academic)-FY2002:

The Naval Postgraduate School's sponsored program exceeded \$61 million in FY2002. 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: \$2,664K

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ISAR IMAGING OF TARGETS IN LOW SIGNAL-TO-CLUTTER ENVIRONMENTS

Brett Borden, Associate Professor

Department of Physics

Sponsor: U. S. Ballistic Missile Defense Office

OBJECTIVE: To devise an algorithm that can be used to extract interpretable radar images from chaff-filled backgrounds; to perform initial testing on any of the devised algorithms.

SUMMARY: The principal difficulty in creating ISAR images from low signal-to-clutter data sets occurs during the range-alignment step. This phase of the standard image processing method requires the individually collected one-dimensional (time domain) radar measurements to be range-aligned to within a fraction of a wavelength across the synthetic aperture. (Misalignment leads to loss of coherence over the aperture and poor imaging performance.) The PI successfully exploited the dynamical differences between rigid body (target) motion and chaff behavior to separate the signal and clutter components in the total aperture data space. A dynamics-matching algorithm was then devised which efficiently fits the relevant target image parameters to the reduced data set. The algorithm was coded in Matlab and successfully tested on synthetic data. More extensive testing using classified synthetic data sets is scheduled for later in FY03.

PUBLICATION:

Borden, B. and Cheney, M., "Microlocal ISAR for Low Signal-to-Noise Environments," *IEEE Transactions on Image Processing*, (in review).

KEYWORDS: ISAR, Chaff, Clutter

RADAR IMAGE ESTIMATION AND MODEL ASSESSMENT BY SUBSPACE FITTING

Brett Borden, Associate Professor

Department of Physics

Sponsors: Office of Naval Research, Rennsalaer Polytechnic Institute

OBJECTIVE: To examine the nature of radar image artifacts and their relationship to scattering model mismatch with radar measurements; to develop a fitting scheme that will map these artifacts to corresponding components of correlation receiver data; to implement the scheme in appropriate (i.e., practicable) computational assets.

SUMMARY: This research is part of a continuing 6.1 effort to build a unified theory of radar imaging. The PI's 2002 goals focused on examining the mismatch between the scattering model implicitly used by the correlation receiver and the actual behavior of wave/target interactions. (More accurately, on examining the image artifacts associated with this mismatch.) The investigation concentrated on multiple scattering events and structural dispersion, since both of these problems are of immediate practical interest to all-weather automatic target identification systems. A connection between the PI's earlier work and the methods of Microlocal Analysis was demonstrated and rigorously explored as part of a collaboration with Professor M. Cheney. In addition, several promising and novel ancillary schemes were identified for possible application to the problem of target imaging through dense foliage. Some problematic issues associated with a previous analysis were examined and resolved.

PUBLICATIONS:

Borden, B., "Mathematical Problems in Radar Inverse Scattering," *Inverse Problems*, Vol. 18, pp. R1-R28, 2002 (invited Topical Review).

Cheney, M. and Borden, B., "Microlocal Structure of Inverse Synthetic Aperture Radar Data," *Inverse Problems*, 2003, (accepted).

KEYWORDS: ISAR, Microlocal

PHYSICS

UNDERWATER WARHEAD TECHNOLOGY

Ronald E. Brown, Research Professor

Department of Physics

Sponsor: Office of Naval Research

OBJECTIVE: Proposed research for the exploration of detonation merging and reactive liner materials for shaped charge performance enhancement.

SUMMARY:

Outline of Project Objectives:

- Software Development
- Analyses of Underwater Experiment
- Literature Review
- Facilities Exploration
- Continuation of Detonation Merging Investigation

Software Developments and Collaboration: The Century Dynamics Inc., AUTODYN finite difference code was purchased, at a special 90 percent discounted rate for university usage. The code has been installed and a training program completed. Sample setups have been completed to simulate shaped charge penetration through water targets.

An interdepartmental collaboration between the Departments of Physics, Mechanical Engineering and Electrical and Computer Engineering has been organized, bringing together strong analytical and computational resources to support the research objectives of the UWT/EM and other NPS programs. NPS faculty members include Drs. Ronald Brown (PH), Ashok Gopinath (ME) and Donald Wadsworth (EE). The group has secured computer hardware resources, and software including the Sandia CTH code and other finite element structural codes useful for simulating many of the mechanisms of interest to the program, and for independent evaluation of design progress. The above-mentioned computational capabilities, with the exception of AUTODYN, are available through the efforts of the ME and EE department, at no expense to this research program. We expect to formalize this activity into a Shock Hydrodynamics Center of Excellence within NPS during the first quarter of CY03.

Analyses of Underwater Experiment: A preliminary assessment of deformation gauge data from sub-scale underwater tests conducted earlier in the year at Aberdeen Proving Grounds was performed. A presentation of this and other data collected during the last two years by Indian Head and DE Technologies was prepared and presented at an Energetics Research Workshop, conducted at LLNL in September 2002.

Literature Review: It should be possible to incorporate a reactive material in a shaped charge liner without affecting penetration capability. This can be done by strategically emplacing the reactive material in locations of the liner that do not alter the shaped charge jet, or by using dual-use materials that offer effective chemical energy as well as kinetic energy potential. Three intermetallic hafnium-based materials have been identified, based on phase diagrams, density and potential chemical release. The second components of these alloys are titanium, tantalum and zirconium. Hafnium is attractive because of its relatively high density and chemical reactivity. Titanium and zirconium are reactive metals. Tantalum is attractive because of its high density and the fact that we will be considering it as a basic liner material for purposes of meeting penetration requirements.

Literature reviews have also been conducted for the purposes of understanding the syntheses and morphology of the two titanium-aluminide variants.

Resource Development: In addition to the aforementioned interdepartmental collaboration, we are exploring the possibilities of forming a joint student research project in support of experimental and computational program objectives with the LLNL Energetic Materials Center. LLNL has excellent experimental facilities and they are interested in complex detonation shaping that might be synergistic with the UWT program. They are also active in the study of non-explosive reactive materials. More intensive exchanges with respect to technical and administrative agendas will be required before an operational working relationship can be formulated. In addition to the necessity of identifying overlapping interests, that can be afforded by LLNL, some modifications to the NPS course structure might be required in order to accommodate student activity at LLNL within the current structured course work demanded by student military NPS assignment.

PHYSICS

Detonation Merging Experiment: A plan has been put together to experimentally determine the effect of supra-pressures from the detonation merging mechanism on coherent jetting. As originally postulated, the limitations of coherent jet flow should be governed by the dynamic sound speed within the liner material as it flows into the high pressure stagnation region during jet formation. Since these pressures can reach as much as twice those caused by the impact of a diverging front across the shaped charge liner, expectation is that jetting limits can be pushed much higher by the sustained peripheral initiation process. This could be extremely important for elevating the performance of tantalum, which has a relatively slow rate of sound propagation, as well as for other more traditional liner materials.

Program Planning: Per the request of ONR, a five-year program leading to a demonstration of key concepts for a featherweight torpedo warhead subsystem was recommended with decision milestones. This plan was constructed based on interviews with co-participants and the ONR program officer.

PRESENTATION:

Brown, R.E., "Energetic Materials Workshop," Lawrence Livermore National Laboratory, September 2002.

KEYWORDS: Shaped Charge, Reactive Materials, Detonation Physics, Terminal Ballistics

A 100KW FREE ELECTRON LASER DESIGN

W. B. Colson, Distinguished Professor

Department of Physics

Sponsor: Defense Advanced Research Projects Agency

OBJECTIVE: Simulation and analysis was used to study the free electron laser interaction for a MW class System.

SUMMARY: Substantial progress was made in the design of MW level FELs for use on navy platforms.

PUBLICATIONS:

Christodoulou, A., Lampiris, D., Polykandriotis, K., Colson, W.B., Crooker, P.P., Benson, S.V., et al., "Study of an FEL Oscillator with a Linear Taper," *Physical Review E*, 2002, (accepted).

Colson, W.B., Blau, J. and Armstead, R.L., "The Free Electron Laser Interaction with a Short-Rayleigh-Length Optical Mode," *Nuclear Instruments and Methods in Physics Research*, AXXX, xxx, 2003, (accepted).

Colson, W.B., Johnson, E.D., Kelley, M.J. and Schwettman, H.A., "Putting Free Electron Lasers to Work," *Physics Today*, p. 35, January 2002, (invited).

PRESENTATIONS:

Campbell, T., Ossenfort, W., Blau, J., Colson, W.B., Crooker, P.P., Benson, S.V., et al., "A High-power Megawatt-class Free Electron Laser Using a Short Rayleigh Length," Fifth Annual Directed Energy Symposium, Naval Postgraduate School, November 2002.

Colson, W.B., "NPS FEL Analysis, Modeling, and Simulation," Joint Technology Office at the Pentagon, Washington D.C., April 2002, (invited).

THESES DIRECTED:

Campbell, T.E., "Simulations of a Short Rayleigh Length 100kW Free Electron Laser and Mirror Stability Analysis," Master's Thesis, Naval Postgraduate School, September 2002.

PHYSICS

Ossenfort, W.J., Jr., "MegaWatt Class Free Electron Lasers for Naval Application: Short Rayleigh Length and Stability Analysis," Master's Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: Free Electron Laser, Directed Energy Weapons

A 100KW FREE ELECTRON LASER DESIGN

W. B. Colson, Distinguished Professor

Department of Physics

Sponsor: Office of Naval Research

OBJECTIVE: Simulation and analysis are used to develop a point design for a 100 kW average power free electron laser for ship defense.

SUMMARY: A system design for a high power FEL was developed for naval applications. Numerical simulations were used to characterize the operation of the proposed 100 kW FEL at TJNAF.

PUBLICATIONS:

Blau, J., Bouras, V., Colson, W.B., Polykandriotis, K., Kalfoutzos, A., Benson, S.V., et al., "Simulations of the 100kW TJNAF FEL Using a Step-tapered Undulator," *Nuclear Instruments and Methods in Physics Research*, A483, p. 138, 2002.

Blau, J., Campbell, T., Colson, W.B., Ng, I., Ossenfort, W., Benson, S.V., et al., "Simulations of the 100kW TJNAF FEL Using a Short Rayleigh Length," *Nuclear Instruments and Methods in Physics Research*, A483, p. 142, 2002.

PRESENTATIONS:

Colson, W.B., "FEL Modeling and Simulation," Strategic Studies Group, Naval Postgraduate School, 4 November 2002, (invited).

Todd, A.M.M., Bluem, H., Hughes, M., Douglas, D.R. and Colson, W.B., "High-power Free-Electron Laser (FEL) Point Design," Fifth Annual Directed Energy Symposium, Naval Postgraduate School, November 2002.

THESES DIRECTED:

Blau, J., "Multimode Simulations of Free Electron Lasers," Doctor of Philosophy Dissertation, Naval Postgraduate School, December 2002.

Bouras, V., "High Energy Lasers for Ship Defense and Maritime Propagation," Master's Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: Free Electron Laser, Directed Energy Weapons

COMPUTATIONAL FREE ELECTRON LASER RESEARCH

W. B. Colson, Distinguished Professor

Department of Physics

Sponsor: Naval Sea Systems Command

OBJECTIVE: Develop computer simulation techniques and methods for the study of MW-class FELs.

SUMMARY: Computational methods have been identified that allow simulation of a rapidly expanding optical mode with a short Rayleigh length at high power levels.

PHYSICS

PUBLICATIONS:

Colson, W.B., Blau, J. and Armstead, R.L., "The Free Electron Laser Interaction with a Short-Rayleigh-Length Optical Mode," *Nuclear Instruments and Methods in Physics Research*, AXXX, xxx, 2003, (accepted).

Crooker, P.P., Campbell, T., Ossenfort, W., Miller, S., Blau, J. and Colson, W.B., "A Study of the Stability of a High-power Free Electron Laser Utilizing a Short Rayleigh Length," *Nuclear Instruments and Methods in Physics Research*, AXXX, xxx, 2003, (accepted).

PRESENTATIONS:

Bouras, B., Kalfoutzos, A., Blau, J., Colson, W.B., Crooker, P.P., Benson, S.V., et al., "Simulations of the 100kW Jefferson Laboratory Free Electron Laser," Fifth Annual Directed Energy Symposium, Naval Postgraduate School, November 2002.

Colson, W.B., "Free Electron Lasers," Fifth Annual Directed Energy Symposium, Naval Postgraduate School, November 2002, (invited short course).

Colson, W.B., "NPS Free Electron Laser Analysis, Modeling, and Simulation," Institute for Advanced Technology, University of Texas, Austin, TX, 7 August 2002, (invited).

THESES DIRECTED:

Blau, J., "Multimode Simulations of Free Electron Lasers," Doctor of Philosophy Dissertation, Naval Postgraduate School, December 2002.

Ossenfort, W.J., Jr., "MegaWatt Class Free Electron Lasers for Naval Application: Short Rayleigh Length and Stability Analysis," Master's Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: Free Electron Laser, High Energy Laser

HIGH ENERGY LASER WEAPONS: MODELING AND SIMULATIONS

W. B. Colson, Distinguished Professor

Department of Physics

Sponsor: Joint Technology Office

OBJECTIVE: Develop modeling and simulation of the operational maritime use of high-energy laser directed energy weapons.

SUMMARY: An NPS laboratory for the study of directed energy weapons was developed. The lab would concentrate on the systems physics of directed energy weapons. An FEL course was prepared describing the systems engineering associated with the development of a directed energy FEL for naval applications.

PUBLICATIONS:

Colson, W.B., "Short Wavelength Free Electron Lasers in 2001," *Nuclear Instruments and Methods in Physics Research*, A483, II-67, 2002.

Colson, W.B. and Blau, J., "Short Wavelength Free Electron Lasers in 2002," *Nuclear Instruments and Methods in Physics Research*, AXXX, xxx, 2003, (accepted).

PHYSICS

Todd, A.M.M., Colson, W.B. and Neil, G.R., "High Power, Compact, Free Electron Laser Concepts," *Twenty Third International Free Electron Laser Conference Proceedings*, Darmstadt, Germany, August 2001, Elsevier Science, II-5, 2002.

PRESENTATIONS:

Colson, W.B., "Free Electron Lasers," Fifth Annual Directed Energy Symposium, Naval Postgraduate School, November 2002, (invited short course).

Todd, A.M.M., Colson, W.B. and Douglas, D.R., "FEL Systems Analysis Application," Fifth Annual Directed Energy Symposium, Naval Postgraduate School, November 2002.

THESES DIRECTED:

Bouras, V., "High Energy Lasers for Ship Defense and Maritime Propagation," Master's Thesis, Naval Postgraduate School, September 2002.

Kalfoutzos, A., "Free Electron and Solid State Lasers Development for Naval Directed Energy," Master's Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: Free Electron Laser, High Energy Laser

TJNAF HIGH POWER FREE ELECTRON LASER RESEARCH

W. B. Colson, Distinguished Professor

Department of Physics

Sponsor: Thomas Jefferson National Accelerator Facility

OBJECTIVE: Simulation and theoretical analysis are used to study the high-average-power free electron laser at Thomas Jefferson National Accelerator Facility, Newport News, VA.

SUMMARY: Numerical simulations were used to characterize the operation of the proposed 100 kW FEL at TJNAF. Several design options would not reach the goal, but some designs would reach the goal.

PUBLICATIONS:

Blau, J., Bouras, V., Colson, W.B., Polykandriotis, K., Kalfoutzos, A., Benson, S.V., et al., "Simulations of the 100kW TJNAF FEL Using a Step-tapered Undulator," *Nuclear Instruments and Methods in Physics Research*, A483, p. 138, 2002.

Colson, W.B., Todd, A. and Neil, G.R., "A High Power Free Electron Laser Using a Short Rayleigh Length," *Twenty Third International Free Electron Laser Conference Proceedings*, Darmstadt, Germany, August 2001, Elsevier Science, II-5, 2002.

PRESENTATIONS:

Bouras, B., Kalfoutzos, A., Blau, J., Colson, W.B., Crooker, P.P., Benson, S.V., et al., "Simulations of the 100kW Jefferson Laboratory Free Electron Laser," Fifth Annual Directed Energy Symposium, Naval Postgraduate School, November 2002.

Colson, W.B., "NPS FEL Research," Jefferson Laboratory, Newport News, VA, 2 May 2002, (invited).

THESES DIRECTED:

Campbell, T.E., "Simulations of a Short Rayleigh Length 100kW Free Electron Laser and Mirror Stability Analysis," Master's Thesis, Naval Postgraduate School, September 2002.

PHYSICS

Kalfoutzos, A., "Free Electron and Solid State Lasers Development for Naval Directed Energy," Master's Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: Free Electron Laser, Directed Energy Weapons

UMD/NPS FREE ELECTRON LASER RESEARCH

W. B. Colson, Distinguished Professor

Department of Physics

Sponsor: University of Maryland

OBJECTIVE: Simulations and theoretical analysis will be used to study the development of high-average-power free electron laser systems for directed energy weapons.

SUMMARY: Many system tolerances for free electron lasers operating in a ship environment were determined.

PUBLICATIONS:

Blau, J., Bouras, V., Kalfoutzos, A., Allgaier, G., Fontana, T., Crooker, P.P., et al., "Simulations of High-power Free Electron Lasers With Strongly-focused Electron and Optical Beams," *Nuclear Instruments and Methods in Physics Research*, AAXXX, xxx, 2003, (accepted).

Crooker, P.P., Campbell, T., Ossenfort, W., Miller, S., Blau, J. and Colson, W., "A Study of the Stability of a High-power Free Electron Laser Utilizing a Short Rayleigh Length," *Nuclear Instruments and Methods in Physics Research*, AAXXX, xxx, 2003, (accepted).

PRESENTATIONS:

Todd, A.M.M., Bluem, H., Hughes, M., Douglas, D.R. and Colson, W.B., "High-power Free-Electron Laser (FEL) Point Design," Fifth Annual Directed Energy Symposium, Naval Postgraduate School, November 2002.

Todd, A.M.M., Colson, W.B. and Douglas, D.R., "FEL Systems Analysis Application," Fifth Annual Directed Energy Symposium, Naval Postgraduate School, November 2002.

THESES DIRECTED:

Campbell, T.E., "Simulations of a Short Rayleigh Length 100kW Free Electron Laser and Mirror Stability Analysis," Master's Thesis, Naval Postgraduate School, September 2002.

Ossenfort, Jr., W.J., "MegaWatt Class Free Electron Lasers for Naval Application: Short Rayleigh Length and Stability Analysis," Master's Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: Free Electron Laser, High Energy Laser

INFRA-RED RESEARCH - THERMAL IMAGING MODELS

A.W. Cooper, Professor

Department of Physics

Sponsor: Naval Sea Systems Command (PEO-Theater Surface Combatants)

OBJECTIVE: To improve the modeling of Forward Looking InfraRed (FLIR) systems, particularly the modeling of Minimum Resolvable Temperature Difference for new-generation FLIR systems, to evaluate the potential of polarization filtering in target discrimination range improvement in FLIR imagery, and to

PHYSICS

compare Tactical Decision Aid FLIR range prediction models for potential joint service use. This project is continuing.

SUMMARY: The NPS-VISMODII formulation of the FLIR performance parameter MRTD (Minimum Resolvable Temperature Difference) has been compared with experimental staring thermal imager measurements to evaluate image artifacts due to sampling and data processing. VISMODII for second-generation systems includes observer-independent sampling and aliasing effects and models both objective and subjective measurements. Objective MRTD measurements are made by oscilloscope display of single display line signal from the FLIR. Directly measured RMS noise and signal at constant temperature field of view gave signal to noise ratio (S/N) in the image of a standard four-bar calibration target as a function of bar-to-background temperature difference and of spatial frequency (dimensional scale) of the target. Minimum target thermal contrast at fixed S/N gave MRTD directly as a function of the target spatial frequency, independent of observer. The minimum observed threshold target-background temperature difference was input to the VISMOD model for comparison with the measured MRTD. Objective MRTD model predictions were found to be in better agreement with observation (to about 10%) for the higher S/N cases. Objective MRTD values typically exceed subjective measured values for all spatial frequencies, indicating relatively high efficiency of the human eye-brain system for signal identification in noise.

PUBLICATIONS:

Celik, M., Kenter, Y., Cooper, A. and Pieper, R., "Aliasing Effects in Thermal Images of Four-bar Patterns Above and Below the Nyquist Limit," *Proceedings of the 35th Annual Asilomar Conference on Signals, Systems and Computers*, Pacific Grove, CA, 4-7 November 2001, (published February 2002).

Pieper, R.J. and Cooper, A.W., "Objective MRTD Experimental Measurements Compared with Predictions Based on the Visibility Model," *Infrared Imaging Systems; Design, Analysis, Modeling and Testing XIV, SPIE Conference Proceedings #5076*, 2003, (accepted).

PRESENTATION:

Pieper, R.J. and Cooper, A.W., "Objective MRTD Experimental Measurements Compared with Predictions Based on the Visibility Model," SPIE Annual Symposium on Aerospace/Defense Sensing, Simulation and Controls, Orlando, FL, 21-25 April 2003.

KEYWORDS: Atmospheric Optics, Infrared Sensors, FLIR, TDA, MRT, MDT

SPECTRAL IMAGERY IN THE NEAR-ULTRAVIOLET

D. S. Davis, Associate Professor

Department of Physics

Sponsor: National Reconnaissance Office

OBJECTIVE: Completion, calibration and field-testing of the new Naval Postgraduate School Lineate Imaging Near-ultraviolet Spectrometer (LINUS).

SUMMARY: All of the projects objectives for CY02 were met. The optical and opto-mechanical components of LINUS were completed, installed and aligned. The instrument was then deployed on its first field trials during two expeditions to the geothermal areas of Lassen Volcanic National Park in northern California, to observe sulfur dioxide gas plumes in the atmosphere. As could have been expected, a few minor problems were uncovered during those field trips, and we have been addressing them in anticipation of additional field deployments during 2003. In particular, the development of an improved, fully integrated LabVIEW control and image acquisition software package was recently finished, so that LINUS' available observation time and duty cycles are both flexible and optimized.

PHYSICS

PUBLICATIONS:

Davis, D.S., "Field Tests of LINUS System, Research report for the National Park Service," available online at U.S. National Park website, <https://science1.nature.nps.gov/permits/research/>, report #00608.

Davis, D.S., "The LINUS Ultraviolet Imaging Spectrometer," *The SPIE Proceedings*, (submitted).

Davis, D.S., "The LINUS UV Instrument," Conference Paper Abstract 5093-77, SPIE Aerosense Conference, April 2003.

OTHER:

Davis, D.S., Briefing on the LINUS project to the Honorable Susan Livingston, Undersecretary of the Navy, Naval Postgraduate School, December 2002.

KEYWORDS: Sensors, Optics, Ultraviolet, Remote Sensing, Atmospheric Gases

ACTIVE MIRROR ALIGNMENT FOR FREE-ELECTRON LASERS ON SHIPS

Bruce Denardo, Associate Professor

Department of Physics

Sponsor: Naval Sea Systems Command and Naval Postgraduate School

OBJECTIVE: Sufficient alignment of the cavity mirrors of any type of laser is critical for the proper operation of the laser. Misalignment of the mirrors causes the gain of the laser to be reduced, and can lead to the laser shutting off. This will be a problem for the proposed free-electron laser weapons on ships, due to vibrations resulting from sea motion, ship machinery, and battlefield environment. The objective is to investigate the use of active control methods to stabilize the vibrations of the mirrors such that the laser continues to operate at full power. A portable milliwatt laser system is planned for construction that can be used to demonstrate the effectiveness of active alignment, and to investigate the feasibility of using active alignment methods for the mirrors of free-electron lasers to be employed on ships at sea.

SUMMARY: This is a new research area for the principal investigator. Progress to date includes a general study of control systems (employing feedback) and the gathering of information on the current use of active control of free-electron mirrors at several laboratories. An experimental system is also being constructed to test the active control of a mirror subject to random external vibrations. A laser beam is reflected off the mirror onto a position-sensitive detector, whose output is fed to a control system that reduces the vibrations of the mirror. Reduction of an impressed vibration of the mirror by a factor of five was achieved.

THESIS DIRECTED:

Fiorani, F., "Active Alignment for Free-electron Laser Mirrors," Master's Thesis, Naval Postgraduate School, December 2002.

KEYWORDS: Free-electron Lasers, Active Control, Vibration Stabilization

NONRADIATING WAVE SOURCES

Bruce Denardo, Associate Professor

Department of Physics

Sponsor: Naval Postgraduate School (Research Initiation Program)

OBJECTIVE: A *nonradiating wave source* is one that generates waves over some region, but where no waves propagate outside the region as a result of complete destructive interference of the waves at the boundary of the region. Surprisingly, nonradiating sources have been predicted to exist, although there have not yet been any experimental observations. In the past, we constructed several types of vibrating wire

PHYSICS

apparatus and observe nonradiating sources in one dimension. The work is important because it indicates the extent to which nonradiating sources can occur in actual systems. The current objective was to perform numerical simulations in which the realistic effects of dissipation, nonuniformity, and nonlinearity are included. A possible future objective is to theoretically investigate nonradiating sources in two and three dimensions, and to explore the possibility applying the results to reduce the acoustical and electromagnetic emissions of vehicles such as submarines.

SUMMARY: Extensive numerical simulations were conducted of nonradiating sources in a one-dimensional mass-and-spring lattice with dissipation, nonuniformity, and nonlinearity. The presence of any of these effects causes radiation to “leak” from the driven region. This radiation was quantified, and analytical calculations were accomplished in some cases. It was found that the relative radiation is reduced for sources that are distributed over a fixed length, rather than being lumped. In addition, adjustments of the drive frequency and amplitude were shown to minimize this radiation in some cases.

PUBLICATION:

Denardo, B. and Miller, G.L., “Quasi-nonpropagating Wave Sources in One Dimension,” *American Journal of Physics*, 2002, (submitted).

KEYWORDS: Nonradiating Waves, Noise Cancellation, Inverse Radiation Problem

PARAMETRIC EXCITATION

Bruce Denardo, Associate Professor

Department of Physics

Sponsor: Naval Postgraduate School (Research Initiation Program)

OBJECTIVE: *Parametric excitation* of an oscillatory system can occur when a source modulates a parameter upon which the resonance frequency depends. In the past, we investigated the feasibility of parametrically exciting a sound mode in a gas-filled resonator. The current work involves an oscillatory mode of a molecule parametrically driving another mode, which may occur due to the nonlinearity of the oscillations. If this parametric instability indeed occurs, it may be possible to utilize it to create a population inversion and thus a laser. Such a laser may have significantly different characteristics than other lasers, for example, in the power output. The main objective was to ascertain whether one of the vibrational modes of a classical molecule could parametrically excite another.

SUMMARY: An extensive literature search indicated that a laser operating on an internal parametric instability has not yet been considered. The system of interest was a rectilinear symmetric triatomic molecule (for example, CO₂). For the classical system, we found that the parametric instability occurs for a sufficiently large amplitude of one of the two longitudinal vibrational modes. This was shown by analytical calculations, by numerical simulations of the fundamental equations of motion, and by two different experimental arrangements. All of these were in agreement. Future work includes investigation of the quantum mechanical effects of the parametric instability, and the feasibility of constructing a laser that operates due to the instability.

THESIS DIRECTED:

Wilson, S., “Nonlinear Oscillations of a Triatomic Molecule,” Master’s Thesis, Naval Postgraduate School, June 2002.

KEYWORDS: Parametric Excitation, Parametric Instability, Nonlinear Oscillations

PHYSICS

DEVELOPMENT OF NETWORK VULNERABILITY ANALYSIS TRAINING SYSTEM (VATS)

**Richard Harkins, Lecturer
Department of Physics**

Sponsor: Department of the Navy Chief Information Officer

OBJECTIVE: Develop prototype DON IW/IT training program with an emphasis on current vulnerabilities, cyber tools and infrastructure Information hardening methodologies.

SUMMARY: This research looks into the requirements to develop a distributed vulnerability assessment capability to the Department of the Navy. A prototype has been developed and now the task is to scale the DON CIO/NPS prototype VATS project from 10 to 100 users. This will include training content for evaluation. Emphasis will include current vulnerabilities, cyber tools and infrastructure Information hardening methodologies.

THESIS DIRECTED:

Devlin, T. and Harper, A., "Developing a Distributed Network Vulnerability Assessment Capability Throughout the Department of the Navy," Master's Thesis, Naval Postgraduate School, June 2002.

KEYWORDS: Information Warfare, Cyber Risk Management, Information Technology, IW Training

LASER BEACON PROTOTYPE

**Capt Ed Hospodar, USA
Andrés Larraza, Associate Professor
Department of Physics
Sponsor: Office of Naval Research**

OBJECTIVE: Use portable Laser Beacon Prototype (LBP) to demonstrate enhancements to missile defense and other related technology.

SUMMARY: Two different LBPs had been designed and built to provide in-scene references to reduce the bias of sensors supporting missile defense activities. Sensor bias is a significant source of target location error. Both LBPs were tested in the field but have unresolved problems. Unit 2 does not point the laser beam correctly and was transferred to NPS in order to diagnose problems in the laser and the pointing system and implementing hardware and software changes to bring the system into pointing and tracking specifications. With a working unit, performing end-to-end demonstrations is expected with operational commands, as well as to determine the value of modulating the beam.

KEYWORDS: Laser, Sensor, Missile

LASER BEACON PROTOTYPE FOR MISSILE DEFENSE

**Capt Ed Hospodar, USA
Andrés Larraza, Associate Professor
Department of Physics
Sponsor: Secretary of the Air Force**

OBJECTIVE: Demonstrate the value of in-scene laser beacon to current and future missile defense operations.

SUMMARY: Two different LBPs had been designed and built to provide in-scene references to reduce the bias of sensors supporting missile defense activities. Sensor bias is a significant source of target location error. Both LBPs were tested in the field but have unresolved problems. Unit 2 does not point the laser beam correctly and was transferred to NPS in order to diagnose problems in the laser and the pointing

system. Preliminary azimuth and elevation data indicates the possibility that the pointing system has random errors that exceed the pointing specification. These errors are probably caused by corrosion in the bearings. Two possible, cost-effective, strategies to correcting this problem have been identified. One consists in diverging the beam. However, this has the negative effect of reducing the output power. Another one is to build a new beam director based on an inexpensive design.

KEYWORDS: Laser, Sensor, Missile

INFRARED FACE RECOGNITION SYSTEM FOR HUMAN IDENTIFICATION USING UNCOOLED INFRARED IMAGER

Gamani Karunasiri, Associate Professor

Department of Physics

Monique P. Fargues, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Department of Justice

OBJECTIVE: The objective of the research is to develop an infrared face recognition system using a highly sensitive, uncooled infrared camera for identification of human subjects.

SUMMARY: An infrared face recognition system was successfully developed using an uncooled infrared camera. The analysis of images using linear discrimination algorithms (LDA and PCA) showed that the uncooled IR image resolution is sufficient to discriminate between the 14 human subjects currently enrolled in our database. The work is continuing to include a larger database as well as non-linear algorithms to further enhance the recognition. The successful implementation of this approach for a larger database will allow us to perform the identification user a complete darkness.

THESIS DIRECTED:

Pereira, D., "Face Recognition Using Infrared Imaging," Master's Thesis, Naval Postgraduate School, December 2002.

KEYWORDS: Infrared, Face Recognition, Uncooled

OPTICAL SENSORS OPERATING SIMILAR TO BIOLOGICAL VISION SYSTEMS

Gamani Karunasiri, Associate Professor

Department of Physics

Sponsor: Naval Postgraduate School (Research Initiation Program)

OBJECTIVE: The objective of the research is to investigate novel infrared and optical sensors using multi-layer semiconductor structures.

SUMMARY: The research on multi-layer semiconductor device that can convert incident light to a series of large voltage pulses was continued. The generation and termination of pulses were understood using the device parameters. Experimental studies were also carried out to probe the infrared transitions in step quantum well structures to probe the normal incident detection. In addition, tunable spectral bandwidth and dual-band infrared detectors have been designed using asymmetric quantum well structures for applications in laser-guided weapons. The work is continuing to experimentally demonstrate the performance of these detectors.

PUBLICATIONS:

Cheah, C.W., Karunasiri, G. and Tan, L.S., "Analysis of AlGaAs/GaAs/InGaAs n-type Step Multiple Quantum Wells for the Optimization of Normal Incident Absorption," *Semiconductor Science and Technology*, Vol. 17, pp. 1028-1037, 2002.

PHYSICS

Cheah, C.W., Karunasiri, G., Tan, L.S. and Zhou, L.F., "Responsivities of n-type GaAs/InGaAs/AlGaAs Step Multiple-quantum-well Infrared Detectors," *Applied Physics Letters*, Vol. 80, pp. 145-147, 2002.

THESES DIRECTED:

Herdlick, B.E., "Development of Computer Controlled Photocurrent Spectroscopy System," Master's Thesis, Naval Postgraduate School, December 2002.

Hickey, T.R., "Characterization of Performance of Quantum Well Photodetector at Various Temperatures," Master's Thesis, Naval Postgraduate School, June 2002.

Konukbay, A., "Design of Quantum Well Photodetector with Variable Bandwidth," Master's Thesis, Naval Postgraduate School, June 2002.

Lantz, K.R., "Two-color Photodetector Using Semiconductor Heterostructures," Master's Thesis, Naval Postgraduate School, June 2002.

KEYWORDS: Photoreceptors, Biological, Multi-color IR Sensors, Quantum Well Detectors

LASER PLASMA RADIATION SOURCE DEVELOPMENT

William L. Kruer, Lawrence Livermore National Lab Chair Professor

William B. Maier, Senior Lecturer and Chair

Department of Physics

Sponsor: Defense Threat Reduction Agency

OBJECTIVE: The overall objective of this program is the continuation of a multi-year effort to perform a series of laser-plasma experiments and calculations designed to develop laser-plasma x-ray source for NWET. The Naval Postgraduate School's (NPS) collaboration with the University of California, Los Angeles (UCLA) Physics Department will design, model and evaluate the ability of multiple frequency laser light to generate abundant hot x-rays for simulating and stimulating various nuclear weapons related effects.

KEYWORDS: Lasers, Plasmas, X-ray Sources

BILGE WATER SEPARATION COLUMN USING SOUND

Andres Larraza, Associate Professor

Department of Physics

Sponsor: Office of Naval Research

OBJECTIVE: This is a proposal for research on acoustic techniques for separation of oil and water. The proposed design has no moving parts and offers potential applications for the extraction of water in both fuel and lube oil systems and extraction of oil in bilge water.

KEYWORDS: Bilge Water, Oil-water Separation

PHYSICS

LASER BEACON PROTOTYPE F/MISSILE DEFENSE

Andres Larraza, Associate Professor

Capt Ed Hospodar, USA

Department of Physics

Sponsor: Naval Engineering Logistics Office

OBJECTIVE: Demonstrate value of in-scene laser beacon to current and future missile defense operations. Provide the student with an opportunity to fix the laser beacon to bring it into calibrated operations. Allow the student to plan and organize proof of concept demonstrations with operational DoD systems and commands for concept of operations (CONOPS) development. Provide NPS with mission-capable laser beacon for future student work and technology development and demonstrations.

KEYWORDS: Laser, Sensor, Missile

ULTRA-VIOLET FILAMENTS TO SURFACE WAVE PROPAGATION

Andres Larraza, Associate Professor

Department of Physics

Sponsor: Naval Air Warfare Center-Weapons Division

OBJECTIVE: To conduct a feasibility study on the application of UV atmospheric filaments to microwave propagation along the conductive path.

KEYWORDS: UV Filaments, Surface Waves, Microwave

RAILGUN TECHNOLOGY: INTERFACE BETWEEN RAIL AND PROJECTILE

William B. Maier, Senior Lecturer and Chair

Department of Physics

Sponsor: Naval Sea Systems Command

OBJECTIVE: To provide the Navy with a working shipboard railgun suitable for long-range bombardment. Two research areas are addressed at NPS: improvements in barrel technology and integration into the all-electric ship.

SUMMARY: Railguns are an advanced technology explicitly designated in the Naval Power 21 documents. Their potential for long-range bombardment without the use of rocket assists and explosive propellants is attractive from the perspectives of cost, ship damage control, and compatibility with the projected all-electric ship. Outstanding technology issues include power supply, projectile design, and rail life.

This work centers on finding an interface between the rail and projectile that will maximize the useful mass of the projectile and extend useful rail life by minimizing rail degradation during firing. Work at NPS seeks to find an interface between projectile and rail that will reduce electrical and frictional erosion during a shot. Several student theses have established the efficacy of soft electrically conducting material as an intermediate material that both lubricates and conducts large electrical current densities without significant damage to projectile or rail. Rail and projectile configurations are also under investigation.

There is a need to test these concepts for higher speed projectiles than can currently be obtained at NPS in a railgun.

THESES DIRECTED:

Adamy, M.T., "Contact in Rail Guns and the Development of Groved-rail Liquid-metal Interfaces," Master's Thesis, Naval Postgraduate School, December 2001.

Culpeper, W.E., "Rail Erosion Projectile Diagnostics for an Electromagnetic Railgun," Master's Thesis, Naval Postgraduate School, June 2002.

PHYSICS

Feliciano, A.S., "The Design and Optimization of a Power Supply for a One-meter Electromagnetic Railgun," Master's Thesis, Naval Postgraduate School, December 2001.

Gurhan, O., "A Methodology to Measure the Metal Erosion on Recovered Armatures," Master's Thesis, Naval Postgraduate School, December 2001.

Smith, M.W., Jr., "Barrel Wear Reduction in Railguns: An Investigation of Silver Paste Liquid-metal Interface," Master's Thesis, Naval Postgraduate School, December, 2002.

KEYWORDS: Railgun, All-electric Ship, Non-conventional Weapons, High-velocity Weapons

THIRD FLEET-NPS FACULTY RESEARCH DESK

Xavier K. Maruyama, Professor

Department of Physics

Sponsor: Naval Postgraduate School

OBJECTIVE: This project is the assignment of Naval Postgraduate School Faculty to the staff of the Third Fleet so that NPS faculty may gain experience concerning fleet activities and needs. Reciprocally, the fleet is afforded close interactions with the NPS faculty. The assignment lasted for a period of one quarter.

SUMMARY: The assignment period was from April to July 2003 on board the *USS Coronado*, AGF 11, flagship of the United States Navy Third Fleet. This period of stay probably involved more time at sea (approximately four weeks at sea) than for other NPS faculty who have been on assignment in this position.

In particular, this period allowed interactions with METOC, resulting in ideas for a Senior METOC Observer Evaluation Guideline; Force Protection, participating in JTFEX WMD scenario and proposing a suggestion for a Radiological Bomb exercise; and Medical, working on a proposal to introduce awareness of the concept of Body Mass Index, BMI, especially for senior enlisted and officers nearing retirement age. The value of the experience on board the *USS Coronado* lay primarily in interacting with ship's company and with Third Fleet staff. Not only were there interactions with officers and enlisted of the regular and reserve Navy, but the opportunity to observe the contributions of the augmented reservists was unique.

The assignment allowed for participation in a tour of an attack submarine, ride a tugboat, go out to sea four times and observe activities at North Island and San Diego Naval Base. A former NPS student assigned to the Third Fleet was assisted in the completion of his thesis requirement.

THESIS DIRECTED:

Wu, P., "A Methodology for the Development of Secure Vertical Web Portals," Master's Thesis, Naval Postgraduate School, December 2002.

KEYWORDS: Third Fleet, Naval Postgraduate School, Fleet Activities

PHYSICS OF MINE DETECTION IN SURF ZONE

Thomas G. Muir, Research Professor

Department of Physics

Sponsor: Office of Naval Research

OBJECTIVE: Analyze data and report on mine detection in surf zones.

KEYWORDS: Seismic Sonar, Rayleigh Waves, Mine Detection, Surf Zone

PHYSICS

RESEARCH F/DETECTION OF BURIED MINES

Thomas G. Muir, Research Professor
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: Analyze data and complete reporting on Rayleigh wave sonar research.

KEYWORDS: Seismic Sonar, Rayleigh Waves, Mine Detection, Minefield Reconnaissance, Surf Zone

STUDY OF SEISMIC SONAR DEMONSTRATIONS

Thomas G. Muir, Research Professor
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: Prepare seismic sonar technology, for the projection of Naval power ashore.

KEYWORDS: Seismic Sonar, Rayleigh Waves, Mine Detection, Mine Avoidance, Mine Clearance

CMO R&D TECHNICAL ASSISTANCE

Richard Christopher Olsen, Associate Professor
Department of Physics
Sponsor: Defense Intelligence Agency

OBJECTIVE: Provide technical assistance to the sponsor in areas of interest as directed. This effort includes the support for the MASINT chair at NPS.

SUMMARY: Significant progress was made with the Cobra Brass studies, including work in target tracking and aerosol discrimination. Work on a new UV spectrometer was begun. The second Container and Shipping Intelligence Conference was held on 8/9 October 02. 45 participants from DOE, DOE, DOJ, Customs, USDA, LLNL, LANL, SNL, PNNL, CMO and ONI. An ONIR Architecture Study was briefed to a Washington DC organization. Briefings and reports delivered to them were key concepts to forming a recommended program.

KEYWORDS: Cobra Brass, Target Tracking, Aerosol Discrimination

MASINT SUPPORT FOR THE ARMY

Richard Christopher Olsen, Associate Professor
Department of Physics
Sponsor: Secretary of the Air Force

OBJECTIVE: Provide technical assistance to the sponsor in areas of interest as directed.

SUMMARY: Technical support was provided to the Army MASINT program.

THESIS DIRECTED:

Gray, J.M., "Design and First Operations of the Lineate Imaging Near-Ultraviolet Spectrometer (LINUS)," Master's Thesis, Naval Postgraduate School, December 2002.

Halvatzis, A., "Passive Detection of Gases in the Atmosphere, Case Study: Remote Sensing of SO₂ in the UV Using LINUS," Master's Thesis, Naval Postgraduate School, December 2002.

PHYSICS

KEYWORDS: Measurements and Signal Intelligence, Remote Sensing

OSD LIAISON AND OPERATION NOBLE EAGLE

Richard Christopher Olsen, Associate Professor

Department of Physics

Sponsor: National Reconnaissance Office

OBJECTIVE: Provide technical assistance to the sponsor in areas of interest as directed. Conduct research in the exploitation of National Technical Means.

SUMMARY: Support was provided in the exploitation of NTM. The work evolved into a study of the utility of multi-angle observations. Studies of BDRF variations in materials showed high potential for Terrain Classification.

THESIS DIRECTED:

Dantzler, H., "Classified," Master's Thesis, Naval Postgraduate School, June 2002.

KEYWORDS: National Technical Means

RESEARCH IN SPECTRAL TEMPORAL IMAGING

Richard Christopher Olsen, Associate Professor

Department of Physics

Sponsor: National Reconnaissance Office

OBJECTIVE: Provide technical assistance to the sponsor in areas of interest as directed. Conduct research in non-literal imaging techniques.

SUMMARY: The utility of high spatial-resolution multi-spectral imagery (MSI) was studied for the application of terrain classification. The utility of LWIR spectral imagery for plume detection was studied.

PRESENTATION:

Olsen, R.C., Ganer, J. and Van Dyke, E., "Terrain Classification in Urban Wetlands with High-spatial Resolution Multi-spectral Imagery," SPIE International Symposium on Remote Sensing, Agia Pelagia, Greece, 22-26 September 2003.

THESES DIRECTED:

Garner, J.J., "Scene Classification Using High Spatial Resolution Multispectral Data," Master's Thesis, Naval Postgraduate School, June 2002.

Mares, A.G., "Remotely Sensed Density Measurements of Volcanic Sulfur Dioxide Plumes Using a Spectral Long Wave Infrared Imager," Master's Thesis, Naval Postgraduate School, September 2002.

Olson, K.L., "Target Detection in LWIR Spectral Imagery," Master's Thesis, Naval Postgraduate School, December 2002.

KEYWORDS: Multi-spectral Imaging, Terrain Classification

PHYSICS

SPECTRAL POLARIMETRIC IMAGERY SUPPORT

**Richard Christopher Olsen, Associate Professor
Department of Physics**

Sponsor: Defense Intelligence Agency

OBJECTIVE: Provide technical assistance to the sponsor in areas of interest as directed. This effort includes the support for the MASINT chair at NPS. Conduct research in non-literal imaging techniques.

SUMMARY: LWIR spectral polarimetric data were studied with respect to their utility for target detection. A new display approach was developed and applied, with the goal of providing a more ergonomic display of the information.

PUBLICATION:

Tyo, S., Konsolakis, A., Diersen, D.I. and Olsen, R.C., "Principal Components-based Display Strategy for Spectral Imagery," *IEEE Transactions on Geoscience and Remote Sensing*, 2003, (in press).

THESIS DIRECTED:

Bonitz, G.M., "Spectral Polarimetric LWIR Analysis," Master's Thesis, Naval Postgraduate School, December 2002.

KEYWORDS: Remote Sensing, Hyperspectral, Polarimetry

TERRAIN CATEGORIZATION VIA SENSOR FUSION

**Richard Christopher Olsen, Associate Professor
Department of Physics**

Sponsor: National Reconnaissance Office

OBJECTIVE: Provide technical assistance to the sponsor in areas of interest as directed. Conduct research in ship detection.

SUMMARY: Analysis was initiated on a project exploiting NTM for the problem of Naval Order of Battle (NOB). The primary purpose is to support the counter-drug efforts at JIATF-East. Data analysis procedures were begun.

THESIS DIRECTED:

Faust, A., "Classified," Master's Thesis, Naval Postgraduate School, June 2002.

KEYWORDS: Ship Detection, Terrain Categorization

ANALYSIS OF ACOUSTIC NAVIGATION SUBSYSTEM FOR TRIDENT SUBMARINES

**Kevin B. Smith, Associate Professor
Department of Physics**

Sponsor: Strategic Systems Program Office

OBJECTIVE: The objective of this project is to interface and consult with the technicians and engineers who develop the acoustic navigational subsystems for the Trident submarines. New approaches to acoustic navigation and data processing will be examined.

SUMMARY: The Strategic Systems Programs office in Washington, D.C. has contacted NPS for support and guidance on new approaches for acoustic navigation of Trident submarines. They desire an NPS expert in underwater acoustics to meet with the appropriate engineers and technicians to examine potentially new

approaches to subsystem navigation using hull-mounted acoustic sources/receivers. Professor Kevin Smith will serve in this capacity.

Through the POC at the Strategic Systems Program, Professor Smith will coordinate a meeting with the appropriate engineering and technical personnel involved with the acoustic navigation subsystem of the Trident platform. Such a meeting will involve an examination of current methods, pros and cons of such methods, and a discussion of alternative approaches. Numerical analysis using acoustic models available at NPS may also be employed to help examine potential approaches. Subsequent work and/or follow-on meetings will be considered as appropriate.

KEYWORDS: Acoustic Navigation

REVERBERATION MODELING AND DATA ANALYSIS IN ASIAEX (FY02)

Kevin B. Smith, Associate Professor

Department of Physics

Sponsor: Office of Naval Research

OBJECTIVE: The objective of this research was to continue the development of a model capable of computing the influence of propagation on both interface and volume reverberation from a broadband pulse. Spatial correlations and statistics of the predicted reverberant signal were examined. The results from further analysis will be used to compare such predictions with data collected in the recent ASIAEx experiments. By understanding the role of the acoustic propagation in such signals, a clearer description of the underlying dominant scattering mechanisms should emerge. Further objectives also included a study of the impact of bottom variability on effective geoacoustic parameters, most notably compressional attenuation, and a study of the influence of water column variability on short range, water-borne propagation.

SUMMARY: In FY02, the PE reverberation model was upgraded with the inclusion of sediment density fluctuations, as well as the introduction of measured sound speed profile data, a subbottom interface, and geoacoustic parameters as measured during the East China Sea part of ASIAEX. Both interface roughness and sediment sound speed/density fluctuations were computed based on characteristic spectral models of such perturbations. The effects of the variations of the different perturbations on each type of reverberation were examined. From broadband pulse calculations, vertical spatial correlations of the reverberation field were computed. The influence of varying bandwidth on vertical correlation was also examined. The results indicated that the model correctly predicted the response of correlation to bandwidth for the interface and volume reverberation structures.

For the effective attenuation studies, the same types of bottom perturbations were included. Subsequent to these calculations, a corresponding set of data was computed for the average environment (without perturbations) with varying levels of sediment attenuation. By correlating the results of the perturbed and unperturbed data, the effective sediment attenuation as a function of frequency was estimated. It was found that low frequency signals may undergo enhanced attenuation for highly variable bottom volume fluctuations, but that higher frequency signals are more sensitive to interface fluctuations. In both cases, a non-linear variation of attenuation with frequency was observed.

In order to study the variability of the water-borne propagation path, it was necessary to adapt the model to compute the same type of source response function as used during the experiment. This was done, and the data was computed at approximately the appropriate range and depths of the short aperture arrays employed. The basic vertical coherence structures were computed using range-independent versions of typical water column sound speed profiles, as well as range-dependent profiles modified by simple, single-scale internal wave perturbations, more complex multi-scale internal wave perturbations, and small-scale turbulent-like perturbations. It was found that the internal wave scale perturbations had little effect on the vertical coherence over such short ranges. However, the turbulent-like perturbations could significantly influence the correlation measures depending on the strength scaling of the turbulence. More accurate versions of turbulent fluctuations are being incorporated into the model to provide more realistic predictions of the expected measurable results.

PHYSICS

PUBLICATIONS:

Karpi, S., Smith, K.B., Ramp, S. and Dahl, P.H., "Direct Path Fluctuations Due to Shallow Water Variability," *Journal of the Acoustical Society of America*, Vol. 112, pp. 2363, 2002.

Smith, K.B., Miller, C.W., D'Agostino, A., Sperry, B., Miller, J.H. and Potty, G.R., "Three-dimensional Propagation Effects Near the Mid-Atlantic Bight," *Journal of the Acoustical Society of America*, Vol. 112, pp. 373-376, 2002.

Smith, K.B. and Nickila, J.D., "Environmental Influences on the Frequency Dependence of Effective Bottom Attenuation," *Journal of the Acoustical Society of America*, Vol. 112, pp. 2310, 2002.

PRESENTATIONS:

Karpi, S., Smith, K.B., Ramp, S. and Dahl, P.H., "Direct Path Fluctuations Due to Shallow Water Volume Variability," *Proceedings of the ONR-ASIAEX International Symposium*, Chengdu, China, 14-18 October 2002.

Smith, K.B. and Nickila, J.D., "Frequency Dependence of Effective Bottom Attenuation Due to Environmental Variability," *Proceedings of the ONR-ASIAEX International Symposium*, Chengdu, China, 14-18 October 2002.

Smith, K.B. and Nickila, J.D., "Influence of Bottom Variability on Sediment Attenuation Inversions," *Proceedings of the First International Conference on Inverse Methods: Modeling and Simulation*, Fethiye, Turkey, 14-21 July 2002.

THESES DIRECTED:

Karpi, S., "The Influence of Shallow Water Variability on Short Range Water-borne Propagation," Master's Thesis, Naval Postgraduate School, December 2002.

Lee, B., "Environmental Influence on Bottom Interface and Volume Reverberation in Shallow Water," Master's Thesis, Naval Postgraduate School, March 2002.

KEYWORDS: Shallow Water Reverberation, Shallow Water Bottom Attenuation, Shallow Water Volume Variability, Parabolic Equation Modeling

STUDY OF DOMESTIC INFRASTRUCTURE VULNERABILITY TO HIGH POWER MICROWAVES

Ryan J. Umstattd, Assistant Professor

Department of Physics

Sponsor: U. S. Air Force Research Laboratory

OBJECTIVE: Assess the vulnerability of a specific domestic infrastructure target to a specific high power microwave attack. A small team of NPS students will carry out this work (under supervision) in order to assess the feasibility of such an attack by a hypothetical terrorist group.

SUMMARY: An HPM attack on the electronic devices used to monitor and/or control domestic water systems could disrupt the systems ability to provide water. Timed properly, targeted to a specific site, and in conjunction with a physical attack such as a fire, such an attack could be easily and inexpensively carried out. This research effort found it easy to obtain information about the local water system, the particular infrastructure target selected. Information about how the system operated was obtained through a series of reconnaissance visits to potential target sites. These visits were not noticed in any way. Information on the commercial equipment that was targeted for electronic attack was readily available from manufacturers. Initial tests at NPS proved successful at using HPM to disrupt duplicates of the radio equipment required to

operate the local water distribution. Additional tests will be performed using some equipment items that are still in transit. The tests will be concluded in the Spring and Summer quarters of 2003. The general conclusion found is that water systems are vulnerable to HPM attack. Especially effective would be a coordinated attack with the primary objective being to destroy a facility by fire by denying water to firefighters using HPM interruption of its control system. Defense against such an attack would require restriction of key information on the system's operations, electronic components operating frequency, and restricted access to potential target sites. These changes might not be welcomed by the water system operator due to increased operating costs, but are perhaps a necessary cost of doing business in today's environment.

PUBLICATION:

Carter, B., Shifflet, D., Arnold, T., Aronson, W., Benford, J. and Umstattd, R., "Domestic Water System Vulnerability to HPM Scenarios and Tests," *Fifth Annual Directed Energy Symposium*, Monterey, CA, pp. 12-15, November 2002.

KEYWORDS: Directed Energy, Threat Assessment, High Power Microwaves, Infrastructure Vulnerability

THRESHOLD CATHODE TEST FACILITY (TCTF)

**Ryan J. Umstattd, Assistant Professor
Department of Physics**

Sponsor: Naval Postgraduate School (Research Initiation Program)

OBJECTIVE: Improve the electron emission properties of cathodes used in High Power Microwave Directed Energy weapons.

SUMMARY: The Threshold Cathode Test Facility (TCTF) has been successfully moved from its original location at Kirtland AFB, New Mexico, to the basement of Spanagel Hall (003F). The existing equipment (on loan from the Air Force Research Lab) has been supplemented with new diagnostics and safety materials using funding from the NPS Research Initiation Program. The power requirements of the facility were accomplished in June of 2002 with the successful installation of two 208V, 3-phase circuits to power the high voltage DC supplies. Thus, the infrastructure is now in place to continue cathode testing that was initiated using TCTF in New Mexico. While accomplishing the assembly of the experimental hardware, the PI continued theoretical and simulation veins of research that support the planned experiments (see publications below). Initial cathode experiments are scheduled to take place in the Spring quarter of 2003.

PUBLICATIONS:

Haworth, M., Cartwright, K., Golby, K., LaCour, M., Luginsland, J., Ralph, D., et al., "Experimental Test of Focusing Electrodes on Repetitively Pulsed MILO Cathodes," *Proceedings of IEEE 29th International Conference on Plasma Sciences*, Banff, Canada, p. 182, 26-30 May 2002.

Luginsland, J.W., Lau, Y.Y., Umstattd, R.J. and Watrous, J.J., "Beyond the Child-Langmuir Law: A Review of Recent Results on Multidimensional Space-charge-limited Flow," *Physics of Plasmas*, Vol. 9, No. 5, pp. 2371-2376, 2002.

Shiffler, D.A., Ruebush, M., Zagar, D., LaCour, M., Golby, K., Collins, K., et al., "Emission Uniformity and Emittance of Explosive Field-emission Cathodes," *IEEE Transactions on Plasma Science*, Vol. 30, No. 4, Pt. 2, pp. 1592-1596, 2002.

Shiffler, D., Ruebush, M., Zagar, D., LaCour, M., Sena, M., Golby, K., et al., "Cathode and Anode Plasmas in Short-pulse Explosive Field Emission Cathodes," *Journal of Applied Physics*, Vol. 91, No. 9, pp. 5599-5603, 2002.

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Umstatted, R.J., Haworth, M.D., Luginsland, J.W., Shiffler, D.A. and Spencer, T.A., "Fine Tuning Non-uniform Space Charge-limited Emission in High Power Microwave Devices," *Proceedings of IEEE 29th International Conference on Plasma Sciences*, Banff, Canada, p. 283, 26-30 May 2002.

Umstatted, R.J., Luginsland, J.W., Watrous, J.J. and Lau, Y.Y., "Space Charge-limited Emission Above the 1-D Child-Langmuir Limit," *Third IEEE International Vacuum Electronics Conference*, Monterey, CA, pp. 131-132, 23-25 April 2002.

KEYWORDS: Directed Energy, Cathodes, High Power Microwaves, Explosive Emission

DISPARATE SENSOR INTEGRATION

**Philip L. Walker, Research Associate Professor
Department of Physics**

Sponsor: U.S. Army Soldier and Biological Chemical Command

OBJECTIVE: Analyze collected field data to distinguish between biochemical and high-energy explosive rounds. Determine effects of burst altitude, range and environmental conditions on burst identification.

SUMMARY: Forty-three GB of data were downloaded from the sponsor's archive for analysis. These data are a collection of acoustic and optical data. For the present study it was decided to concentrate on the acoustical data. Near simultaneous acoustical recordings for air-burst bio, and air and ground burst high energy detonations were compared visually. The recordings are not always visually distinct. The distinction deteriorates with range due to inverse square loss of signal strength. Based on these observations it may not be possible to consistently identify biochemical artillery bursts.

KEYWORDS: Chemical and Biological Detection, Discrimination, Classification

DUAL IR COLLECTION AND CALIBRATION

**Philip L. Walker, Research Associate Professor
Department of Physics**

Sponsor: Aeronautical Systems Center

OBJECTIVE: Determine the sensitivity of the DoDSat sensor to calibrated ground-based explosion flashes. DoD Sat sensor calibrated by comparison with ground-based and air-based duplicate sensors.

SUMMARY: Calibrated explosions, ground-based sensor measurements and aircraft over-flights were to take place at the Naval Air Warfare Center, China Lake, California. The experiment was performed 11 December 2002. The aircraft was not available. The small particle aerosol sizer, a LASX, was not working. Analysis of atmospheric influence on observed flash strength is being performed at the Naval Postgraduate School. The absence of the LASX data will lead to some error. The report will be available 1 April 2003. It is expected that this is one of a series of tests.

KEYWORDS: Environment, Transmission

PREDICTING ELECTRO-OPTICAL PERFORMANCE FROM SPACE

**Philip L. Walker, Research Associate Professor
Department of Physics**

Sponsor: Tactical Exploitation of National Capabilities (TENCAP) Office

OBJECTIVE: To develop methods and procedures for predicting Electro-Optical systems performance in deserts from satellite imagery.

SUMMARY: Two optical depth retrieval algorithms were being tested: The first is an algorithm developed

PHYSICS

previously by Professor Durkee (NPS Meteorology Department) for use with AVHRR. This algorithm should work equally well with DoDSat. The AVHRR algorithm uses loss of contrast between light and dark areas to estimate dust concentration. The disadvantage of this algorithm is that inherent ground albedo must be known. The second approach is to use the MISR retrieval algorithm. In this approach photographs of a ground site are from several fixed angles as MISR cameras pass over it. Differing ground contrast per slant path is used to extract atmospheric optical depth. The advantage of the MISR algorithm is that inherent ground albedo need not be known in advance. It turns out that neither the AVHRR nor MISR retrieval algorithms work against a bright, desert background; although, both work well over the dark ocean. However, if image resolution is high enough then lightening of dark areas, such as of lakes and vegetated areas, might be used with either algorithm to retrieve atmospheric optical depth. This is a topic for future investigation.

The research report, in writing, includes comparison of ground-based and satellite-derived atmospheric optical depths. Satellite-derived extinction is also compared with our extensive ground-based measurements. In collaboration with China Lake we operate a "Multi-Filter Rotating Shadow Band Radiometer," MFR-7 and three aerosol sizers at China Lake. The MFR-7 directly measures the optical depth of the atmosphere from ground to space providing an almost direct band-for-band comparison with satellite-derived optical depths in the coincident parts of their response spectra. Aerosol size measurements from the three particle sizers along with Mie calculations are used to extend the spectral comparison. NAWC also shares data from two nephelometers and other air quality instruments and meteorology instruments.

PRESENTATIONS:

Walker, P.L. and Blomshield, F.S., "Determining Drivers of Atmospheric Dust Concentration," *Annual Meeting of the American Association for Aerosol Research*, Charlotte, NC, October 2002.

Walker, P.L. and Blomshield, F.S., "Optical Characteristics of Desert Dust," *Proceedings of SPIE*, Vol. 4718, Orlando, FL, April 2002.

Walker, P.L. and Blomshield, F.S., "Satellite-derived Extinction at a Desert Site," *AGU Fall Meeting*, San Francisco, CA, 6-10 December 2002.

KEYWORDS: Environment, Transmission, Remote Sensing

ATMOSPHERIC OPTICAL TURBULENCE MODELING

Donald L. Walters, Professor

Department of Physics

Douglas Miller, Research Assistant Professor

Department of Meteorology

Sponsor: Classified

OBJECTIVE: Atmospheric numerical models provide the wind and temperature fields that can be used to simulate the turbulent atmosphere. The USN COAMPS model was adapted to provide optical turbulence forecasts.

SUMMARY: Using balloon data from the US Air Force Research Laboratory and optical data provided by the US Air Force Starfire Optical range, atmospheric optical turbulence algorithms were developed, implemented and run on a 24-hour basis for 18 months. 0Z and 12 forecasts were summarized on an Internet web page for use by program directors. Comparisons between the model and observed results are conducted in real time.

PUBLICATIONS:

Walters, D.L. and Miller, D.K., "Classified Presentation," National Government-industry Conference, Washington, D.C., September 2002.

Walters, D.L. and Miller, D.K., "Classified Presentation," National Working Group, Albuquerque, NM, 8 August 2002.

KEYWORDS: Optical Turbulence, Mesoscale Models, Turbulence Parameterization

MESOSCALE MODELING OF ATMOSPHERIC OPTICAL TURBULENCE

Donald L. Walters, Professor

Department of Physics

Douglas Miller, Research Assistant Professor

Department of Meteorology

Sponsor: U. S. Air Force Research Laboratory

OBJECTIVE: To refine, adapt and verify the mesoscale optical turbulence forecast algorithms using COAMPS and MM5 for the Joint Technology Office.

SUMMARY: The U.S. Air Force Research Laboratory has conducted two micro thermal balloon launch campaigns at Vandenberg Air Force Base, one in October 2001, and the second in February-March 2002 with 23 and 26 balloons launched respectively. This investigation used these micro thermal balloon launches to validate two optical turbulence algorithms that have been added to the US Navy COAMPS and National Center for Atmospheric Research MM5 mesoscale models. The results have shown that a modification to the K_h and K_m parameters added to produce a reasonable background turbulent kinetic energy level accentuates the turbulence under stronger wind shear and causes the model to drift away from the observations. Deleting this modification eliminates one of the two turbulence algorithms, but improves the agreement for 12-24 hour forecasts. A second result involves the effect of the initial data assimilation on the optical turbulence predictions. For some days the agreement between the model and the observations is poor. This has been traced to the input data assimilation, which ignores the Vandenberg rawinsonde launch data in favor the input model fields.

PRESENTATIONS:

Miller, D.K. and Walters, D.L., "Diagnosis and Numerical Simulation of Turbulence in the Vicinity of Coastal Topography," *Proceedings of the 10th Conference on Mountain Meteorology and MAP Meeting*, Seattle, WA, 16-21 June 2002.

Walters, D.L., "Atmospheric Propagation," *Directed Energy Weapons Conference Short Course on Atmospheric Propagation*, Monterey, CA, 12 November 2002.

THESIS DIRECTED:

Parker, S., "Atmospheric Turbulence Comparison Using MM5 and COAMPS Mesoscale Models," Master's Thesis, Naval Postgraduate School, June 2002.

KEYWORDS: Optical Turbulence, Mesoscale Models, Turbulence Parameterization

**DEPARTMENT OF
PHYSICS**

**2002
Faculty Publications
and Presentations**

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JOURNAL PAPERS

Blau, J., Campbell, T., Colson, W.B., Ng, I., Ossenfort, W., Benson, S.V., et al., "Simulations of the 100kW TJNAF FEL Using a Short Rayleigh Length," *Nuclear Instruments and Methods in Physics Research*, A483, p. 142, 2002.

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Smith, K.B. and Nickila, J.D., "Environmental Influences on the Frequency Dependence of Effective Bottom Attenuation," *Journal of the Acoustical Society of America*, Vol. 112, pp. 2310, 2002.

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Celik, M., Kenter, Y., Cooper, A. and Pieper, R., "Aliasing Effects in Thermal Images of Four-bar Patterns Above and Below the Nyquist Limit," *Proceedings of the 35th Annual Asilomar Conference on Signals, Systems and Computers, Pacific Grove, CA, 4-7 November 2001*, February 2002.

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Walker, Philip and Blomshield, Fred, "Optical Characteristics of Desert Dust," *Proceedings of SPIE*, Vol. 4718, Orlando, FL, April 2002.

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Carter, B., Shifflet, D., Arnold, T., Aronson, W., Benford, J. and Umstattd, R., "Domestic Water System Vulnerability to HPM Scenarios and Tests," Fifth Annual Directed Energy Symposium, Monterey, CA, 12-15 November 2002.

Colson, W.B., "Free Electron Lasers," Fifth Annual Directed Energy Symposium, Naval Postgraduate School, November 2002.

Larrazza, A., "The Crookes Radiometer: How a Toy Pushed the Frontiers of Physics," Natural Science Seminar, Central Washington University, 4 October 2002.

Olsen, R.C., Ganer, J. and Van Dyke, E., "Terrain Classification in Urban Wetlands with High-spatial Resolution Multi-spectral Imagery," SPIE International Symposium on Remote Sensing, Agia Pelagia, Greece, 22-26 September 2003.

Ossenfort, W., Campbell, T., Bouras, V., Kalfoutzos, A., Blau, J., Crooker, P.P., et al., "Simulations of the Proposed 100 kW Jefferson Laboratory Free Electron Laser," Directed Energy Professional Society Symposium, Monterey, CA, November 2002.

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Walters, D.L. and Miller, D.K., "Classified Presentation," National Government-industry Conference, Washington, D.C., September 2002.

Walters, D.L. and Miller, D.K., "Classified Presentation," National Working Group, Albuquerque, NM, 8 August 2002.

Walters, D.L. and Miller, D.K., "Optical Turbulence Modeling," U.S. Air Force Airborne Laser Program Office Workshop on Atmospheric Turbulence Modeling, Albuquerque, NM, 10 April 2002.

OTHER

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**SPACE SYSTEMS
ACADEMIC GROUP**

**RUDOLF PANHOLZER
CHAIR**

SPACE SYSTEMS

OVERVIEW:

The Space Systems Academic Group (SSAG) along with eight academic departments is an integral part of the Graduate School of Engineering and Applied Sciences. As an interdisciplinary association of professors it provides direction and guidance for two curricula: Space Systems Engineering and Space Systems Operations.

Officer students in the Space Systems curricula fulfill degree requirements for a Master of Science in the department of their choice or in a specialized Engineering Science. A space-oriented thesis is mandatory as well as course work to fulfill the requirements of a space billet. Officer graduates are prepared to manage the technical aspects of a space system life cycle including design, development, installation, and maintenance of spacecraft, space payloads, supporting ground stations, terminals, and C3 connectivity.

The SSAG serves as the focal point for all space-related research performed at NPS. A major goal is to couple NPS space research efforts with the graduate education of military officers. This is typically accomplished through space-related thesis research in several areas and includes small satellite projects created specifically as an educational tool for officer students. The SSAG oversees classified and unclassified student involvement in research activities and helps facilitate their placement in follow-on tours.

CURRICULA SERVED:

- Space Systems Operations
- Space Systems Engineering

DEGREES GRANTED:

- Master of Science in Space Systems Operations
- Master of Science in Astronautical Engineering
- Master of Science in Electrical Engineering
- Master of Science in Mechanical Engineering
- Master of Science in Applied Physics

RESEARCH THRUSTS:

- Military Applications for Space
- Space Reconnaissance and Remote Sensing
- Radiation Hardened Electronics for Space
- Design, Construction and Launching of Small Satellites
- Classified (SCI level) Research
- Satellite Communications Systems
- Military Space Systems and Architectures

RESEARCH CHAIRS:

- Navy Space Technology Program Chair
- Navy Tactical Exploration of National Capabilities (TENCAP) Space Chair
- Space Systems Academic Chair
- NASA Michael J. Smith Space Systems Chair
- National Reconnaissance Office Chair
- Lockheed Martin Space and Missile Operations Chair

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RESEARCH CENTERS:

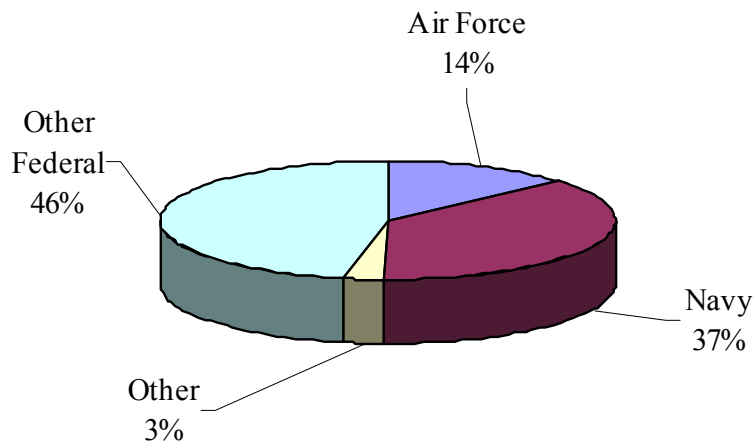
- Spacecraft Research and Design Center
- Center for Reconnaissance Research
- Center for Radiation Hardened Electronics
- Center for Cryptologic Research

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

SPONSORED RESEARCH PROGRAMS (Research and Academic)-FY2002:

The Naval Postgraduate School's sponsored program exceeded \$61 million in FY2002. Sponsored programs included both research and educational activities funded from an external source. A profile of the sponsored program for the Space Systems Academic Group is provided below:



Size of Program: **\$865K**

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SPACE SYSTEMS

ADVANCED MULTI-JUNCTION SOLAR CELLS MEASUREMENT SYSTEM FOR NPSAT1 SATELLITE

Rudolf Panholzer, Professor
Space Systems Academic Group
Sponsor: Space Missile Systems Command

OBJECTIVE: The objective of this proposal is to fund officer student design and development of a measurement system for advanced multi-junction solar cells to be used on the NPSAT1 micro-satellite.

KEYWORDS: Spacecraft Electrical Power, Multi-junction Solar Cells, Small Satellites

FERROELECTRICITY RESEARCH NEWSLETTER

Rudolf Panholzer, Professor
Space Systems Academic Group
Sponsor: Office of Naval Research

OBJECTIVE: This is a proposal to provide two year funding for a quarterly research newsletter designated to supply information on national and international symposia, conferences, workshops, and meetings which deal with topics of interest to scientists, engineers, and students in the field of integrated ferroelectrics research.

KEYWORDS: Integrated Ferroelectrics

LITHIUM-ION POLYMER BATTERY TECHNOLOGY DEVELOPMENT FOR NPSAT1 SATELLITE

Rudolf Panholzer, Professor
Space Systems Academic Group
Sponsor: National Reconnaissance Office

OBJECTIVE: The objective of this proposal is to fund the development of the NPSAT1 Micro-satellite which is part of the small satellite design program under the NPS Space Systems Academic Group.

KEYWORDS: Lithium-Ion Polymer Battery, Space Systems Engineering, Microsat, Command and Data Handling, Ionospheric Tomography

NAVAL SPACE SYSTEMS ACADEMIC CHAIR

Rudolf Panholzer, Professor
Space Systems Academic Group
Sponsor: Naval Space Command

OBJECTIVE: Incumbents of the Naval Space Systems Academic Chair will engage in instruction and research and act as a consultant in the area of specialization to students and faculty of the Naval Postgraduate School.

KEYWORDS: Space Systems

SPACE SYSTEMS

NPS NSAT1 SATELLITE INSTRUCTIONAL SUPPORT

Rudolf Panholzer, Professor
Space Systems Academic Group
Sponsor: National Reconnaissance Office

OBJECTIVE: The objective of this proposal is to fund instructional thesis research in low-profile antenna design and attitude control design for the NPSAT1 micro-satellite and its development, which is part of the small satellite design program under the NPS Space Systems Academic Group.

KEYWORDS: Spacecraft Antenna, Space Systems Engineering, Microsat

SPACE SYSTEMS OPERATIONS STUDENT THESIS RESEARCH/EXPERIENCE TOUR

Rudolf Panholzer, Professor
Space Systems Academic Group
Sponsor: Naval Space Command

OBJECTIVE: The objective of this proposal is to fund Space Systems Academic Group (SSAG) Space Systems Operations student thesis research related travel and experience tour travel.

KEYWORDS: Space Systems Operations

SPACE SYSTEMS STUDENTS THESIS RESEARCH PROJECTS, DIRECTED STUDIES AND SPACE ENGINEERING EXPERIENCE TOUR

Rudolf Panholzer, Professor
Space Systems Academic Group
Sponsor: National Reconnaissance Office

OBJECTIVE: The objective of this proposal is to fund Space Systems Academic Group (SSAG) Space Systems Engineering curriculum support and space engineering experience tours.

KEYWORDS: Space Systems Engineering, Microsat, Command/Data Handling, Satellite Digital Communications

AEROASSISTED MANEUVERS AND MISSION DESIGN

Alan Ross, Tactical Exploitation of National Capabilities Chair Professor
Space Systems Academic Group
Sponsor: National Aeronautics and Space Administration-Joint Propulsion Laboratory

KEYWORDS: Aeroassist, Mission Design, Inner Planets, Outer Planets

MILITARY APPLICATION OF SPACE RESEARCH PROJECT - BASIC FUNDING FOR 2002-2003

Alan Ross, Tactical Exploitation of National Capabilities Chair Professor
Charles M. Racoosin, Naval Space Command Academic Chair Professor
Space Systems Academic Group
Sponsor: Naval Engineering Logistics Office

FIRST PRINCIPLES PREDICTION OF X-RAY IMPULSE

Donald v. Z. Wadsworth, Senior Lecturer
Space Systems Academic Group

Sponsor: Strategic Systems Programs Office

OBJECTIVE: Develop a first-principles physics model for predicting the impulse induced on selected surfaces by an X-ray burst in space. Validate the theoretical model by comparing predictions with available underground test data and other experimental data.

SUMMARY: This research project (currently in its third year) supports the Trident Stockpile-to-Target Stewardship program. Multi-year objectives are: (i) collect and archive key data (reports and interviews) relevant to predicting vulnerability of an RB aeroshell to an x-ray burst in space, (ii) compare the capability of existing physics-based models (finite-element hydrocodes and radiation deposition codes) to predict blow-off impulse and damage to various RB composite materials, (iii) modify a selected code to improve fidelity, (iv) validate the modified code against existing UGT data.

This is a collaborative effort involving faculty in the NPS Space Systems Academic Group and the departments of Physics, Mechanical Engineering, and Electrical and Computer Engineering. Two Navy master's degree candidates have performed thesis research in support of this effort. Significant consulting support is being provided by the DoE National Laboratories, as well as DTRA, and DoD contractors.

Available radiation deposition and hydrodynamics codes (XRAY and CTH) were adapted to simulate the radiation/matter interaction and the subsequent material response. The radiation absorption model used a blackbody source to compute the net energy deposition in graphite material. The calculated energy deposition was used in the hydrodynamic code to predict the shock impulse at the radiated surface. Very good agreement was obtained between the numerical impulse predictions and a well-known one-dimensional analytical impulse model (MBBAY). The predictions also compared very favorably with UGT data. It is concluded that the numerical model, with certain physics-based improvements, could serve as an accurate tool for prediction of the shock impulse response of future materials and x-ray sources.

THESIS DIRECTED:

Juster, J.J., "Impulse Generation by Radiation Absorption in Graphite: Numerical Modeling and Comparison to Analytical Predictions," Master's Thesis, Naval Postgraduate School.

KEYWORDS: X-ray, Lasers, Weapons Effects

**SPACE SYSTEMS
ACADEMIC GROUP**

**2002
Faculty Publications
and Presentations**

SPACE SYSTEMS

There are no publications included in the Space Systems Academic Group section. Publications for professors associated with Space Systems are listed in each professor's home department.

**GRADUATE SCHOOL OF
BUSINESS AND PUBLIC POLICY**

**DOUGLAS A. BROOK
DEAN**

GRADUATE SCHOOL OF BUSINESS AND PUBLIC POLICY

MISSION:

The mission of the Graduate School of Business and Public Policy is:

- To Improve the managerial capabilities and leadership qualities of US and international officers and government civilians through graduate education, research, and professional service.
- To develop students' abilities to analyze, think critically, and take intelligent action so they can more effectively carry out their professional responsibilities, and lead their organizations in complex, and sometimes life-threatening, environment.
- To conduct research that supports military decision-making, problem solving, and policy setting, improves administrative processes and organizational effectiveness, contributes knowledge to academic disciplines, and advances the mission of graduate education.
- To provide professional expertise that supports the development of the Naval Postgraduate School, the Departments of Navy and Defense, and other branches of Government, as well as our professional and academic organizations.

RESEARCH MISSION:

Faculty research is an important component of the Graduate School of Business and Public Policy's mission. As such, the school strives to "conduct research that supports military decision making, problem solving, and policy setting, improves administrative processes and organizational effectiveness, contributes knowledge to academic disciplines, and advances the mission of graduate education."

The research program is integrated to the greatest possible extent with the educational process. Students are encouraged to participate in faculty projects, and faculty research results are typically incorporated in classroom instruction.

CURRICULA SERVED:

The Graduate School of Business and Public Policy has primary responsibility for five graduate degrees. The largest degree program is a group of curricula in the Defense-focused Master of Business Administration, with the following curricular concentration areas:

- Acquisition Management
- Logistics Management
- Financial Management
- Information Management
- Defense Management

Another resident program is the Master of Science in Management, with a concentration in manpower analysis.

Distance learning graduate programs offered by the Graduate School of Business and Public Policy include: 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 US Naval Academy), which awards a Master of Science in Human Resources Management.

The school's graduates programs achieved the distinction of being one of only two graduate management programs in the country earning dual accreditation by AACSB-the Association to Advance Collegiate Schools of Business and NASPAA-the National Association of Schools of Public Affairs and Administration.

The faculty of the Graduate School of Business and Public Policy are drawn from a wide variety of academic disciplines in business and public sector management. The diverse, multidisciplinary character of the faculty is reflected in the breadth and depth of issues addressed by faculty research, which has historically been concentrated in areas of interest to the Departments of Defense and Navy. Therefore, faculty research directly enriches the instructional materials used in the curricula in the school. The topics and issues can be grouped into five broad areas:

- Acquisition and Contract Management,
- Logistics and Transportation Management,
- Financial Management,
- Manpower Systems Analysis,
- Organization, systems and Management.

RESEARCH THRUSTS:

The primary goal of the school's research program is to provide the Navy and DoD with the capability of managing defense organizations and programs efficiently and effectively. Therefore, the objective of the school's research effort is to apply existing knowledge base in support of resource utilization decisions, to develop new concepts or theory if no such knowledge base exist to support the policy/decision making process, to enhance the relevance of the school's instructional programs, and to involve the students through their thesis or application project work in enhancing their decision making capability.

While concepts and knowledge base are generally divided into different functional areas or disciplines, actual resource utilization decisions or policies often require multi-disciplinary efforts. Therefore, in addition to pursuing functional area research in those disciplines with a critical mass of faculty, the thrust of the school's research program is to conduct cooperative interdisciplinary research in areas where the school is in a strong position to become a leading force in research. It also places the school in a strong position to assist defense policymakers, since it allows for a coordinated, broad-based program under "one roof"-where researchers from diverse fields can share information and findings in a unified and truly systematic fashion.

FACULTY:

The research thrusts and faculty in each of the functional areas in the Graduate School of Business and Public Policy are discussed in greater detail in the following sections.

Acquisition and Contract Management. Defense acquisition represents a process of critical importance to the military, not only to reduce taxpayer costs, but to ensure the quality and performance of today's increasingly sophisticated weapon systems. Nevertheless, negligible academic research has been applied to systematically investigate, understand, and model the acquisition process; and current innovations in this domain—such as process reengineering and acquisition reform—are uncoordinated, ad-hoc, and performed largely on a trial-and-error basis. This is the case because many acquisition policymakers and executives have little or no benefit of sound theories to rely upon.

The acquisition group's primary objective is outlined as a multidisciplinary research program, designed to address this dearth of acquisition theory. Generally, research objectives are directed at the following:

- basic theory-building research into critical questions;
- fundamental dimensionality and key attributes associated with defense acquisition; and
- exploring the integrated reengineering and reform of acquisition processes through the development of empirical models, prototyping of advanced technologies, and rigorous analysis of process innovations and regulatory reform.

This research represents seminal scholarly work in the area of defense acquisition and draws from expertise in accounting, contracting, economics, information systems, law, organizational design, public policy, and other academic disciplines.

Logistics and Transportation Management. The primary mission of the Logistics and Transportation Management group is to educate military officers and DoD civilians in state-of-the-art concepts of logistics and transportation management. Emphasis is placed on understanding both military and non-military applications, so that students will be prepared to perform effectively in a military environment and interact efficiently with civilian contractors and suppliers. The general research perspective of the group is focused

on improving DoD logistics and transportation performance as well as management effectiveness. Major research thrusts in this area include:

- DoD inventory policy;
- inventory and cycle time reduction;
- defense transportation and distribution systems;
- modeling and simulation for logistics decision support;
- reduction of manpower in aircraft and ship maintenance;
- aircraft Component Improvement Program (CIP); and
- sea-based logistics for the Navy and the Marine Corps.

Professor Kevin Gue's projects deal with throughput and storage system models for crossdocks and transshipment points, with particular application to sea base design in Sea Based Logistics. Professor Keebom Kang focused on using modeling and simulation method to address transportation and inventory issues. His current project addresses sea-based combat logistics of LHD amphibious attack ships. Senior Lecturer Don Eaton (RADM, USN, Ret.) has been active in investigating the issues and concerns of aging aircraft and tactics of remediation and amelioration.

Financial Management. Research in the area of financial management has become increasingly important since the end of the Cold War, as defense organizations “downsize” and policymakers exercise renewed efforts to gain maximum utility of shrinking resources at minimum cost. The Financial Management (FM) group has identified four major functional areas as targets of opportunity for future research. These are:

- financial resource policy formulation, analysis and management;
- enterprise resource planning systems;
- financial matters of personnel entrusted with sensitive information;
- cost analysis,

The first of these functional areas—financial resource policy formulation, analysis, and management—covers a range of sub-areas: national defense and national security resource policy and management; resource planning, programming, budgeting, and policy under the Planning, Programming, Budgeting System; and relationships between financial management, contracting, acquisition, and other policy fields. Professors Larry Jones, Jerry McCaffery, and Richard Doyle have the expertise in this area.

Resource planning systems cover the development of systems, such activity-based management systems (ABM) and enterprise resource planning systems (ERP) capable of generating timely and reliable information for operational decisions. Professor Ken Euske continues to be involved in DoN's ERP efforts. Professor Joseph San Miguel was supported by the Financial Executive Research Foundation to study the strategic impact of ERP systems.

Recent events of high profile security breach have heightened interest in the financial matter of those entrusted with sensitive information. Since 1998, Professor San Miguel has provided financial expertise to the National Security Agency, U.S. Customs, and the Central Intelligence Agency on the design and evaluation of employee financial disclosures for identifying unexplained affluence and financial stress. His current project applied financial analysis techniques to live data obtained from federal employees in positions of national security in attempt to highlight abnormality.

The research area of cost analysis covers the following: weapon systems and software cost estimation; resource requirement analysis; the cost of new technologies; and cost analysis of major system modifications. Presently, Professor Bill Gates is the most active in this area.

Manpower Systems Analysis. The focus of research in the Manpower Systems Analysis (MSA) group is on *human* resources. Defense manpower policymakers have been faced with many challenges since the end of the Cold War. Key among these challenges were a reduction of the active-duty force by over 30 percent, budget reductions in recruiting and advertising, a steady operational tempo and deployment schedule with fewer people, new missions, declining levels of public and congressional support for the military, increasing pressure to change the “culture” of military service, renewed efforts toward population representation of women and racial/ethnic minorities throughout the force, a seemingly immovable, high rate of first-term attrition among new recruits, declining levels of personnel retention in certain critical areas, a number of high-profile “scandals,” and others. As the active-duty force was reduced and missions changed, it soon became clear that a smaller military had to be even more skilled and adaptable than the one that witnessed the end of compulsory service and performed so successfully throughout the early 1980s

GRADUATE SCHOOL OF BUSINESS AND PUBLIC POLICY

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:

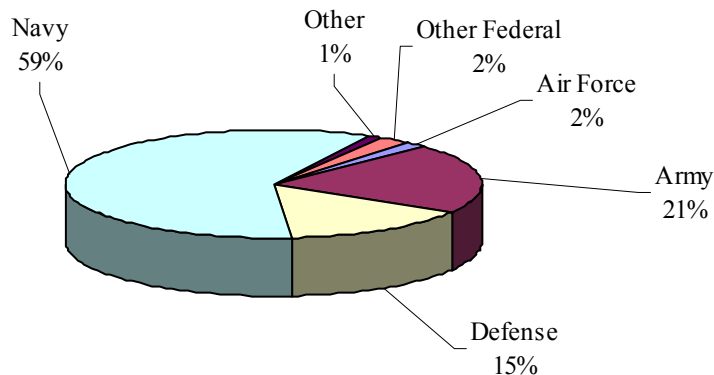
- manpower supply and force requirements;
- improvements in selection and classification of enlisted personnel;
- innovations in recruiting and the application of new technologies;
- improvements in selection of officers and pre-commissioning programs;
- effectiveness of equal opportunity and diversity management programs;
- training effectiveness and efficiency;
- personnel retention in critical fields;
- reduction of first-term attrition rates among enlisted personnel;
- force management and planning, including Reserve components;
- force structure and cost analysis;
- career-force modeling;
- officer promotion and performance; and
- civil-military relations and the All-Volunteer Force.

Professors Mark Eitelberg, Armando Estrada, Janice Laurence, Stephen Mehay, George Thomas, and Senior Lecturer Alice Crawford are involved in this area.

Organization, Systems and Management. Faculty in this functional area pursue basic and applied research on key management issues at a variety of organizational levels. Individual faculty members are acknowledged experts who publish leading-edge research on a variety of issues. Top management issues include strategic planning, change management, stakeholder analysis, organizational design and the development of culture. Human resource management issues include the design of strategic reward systems, managing gender and diversity issues, managing stress, forming career identities, and alternative strategies to training and education (including distance learning). There is a strong expertise in leadership issues, change management, intrinsic motivation, motivational strategies, empowerment, coaching, communications strategies, conflict management, and constructive uses of power.

SPONSORED RESEARCH PROGRAMS (Research and Academic)-FY2002:

The Naval Postgraduate School's sponsored program exceeded \$61 million in FY2002. Sponsored programs include both research and educational activities funded from an external source. A profile of the sponsored program for the Graduate School of Business and Public Policy is provided below.



Size of Program: \$4,129K

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SYSTEM DYNAMICS DECISION SUPPORT TOOL FOR OBESITY TREATMENT PROGRAM

Tarek K. Abdel-Hamid, Professor
Graduate School of Business and Public Policy
Sponsor: Un-sponsored

OBJECTIVE: Develop a comprehensive System Dynamics computer model for learning and as a decision support tool for assessing treatment options and predicting treatment outcomes.

SUMMARY: Overweight and obesity are among the most important health challenges in the U.S. It is an issue that has great relevance to DoD because of its implications for health, physical fitness, and cost.

In this research effort, the growing obesity problem is addressed from a decision-theoretic perspective. In managing their health (and their bodies), people are viewed as decision makers who are managing a truly complex and dynamic system – the human body.

A comprehensive System Dynamics computer model is being developed that integrates nutrition, metabolism, hormonal regulation, body composition, and physical activity. These processes are typically fragmented between many different disciplines and conceptual frameworks. This work, thus, seeks to bring these ideas together highlighting the interdependence of these various aspects of the complex system that is the human body. The model serves two purposes: 1) As a simulation-based micro world for learning; and 2) As a decision support tool for assessing treatment options and predicting treatment outcomes.

KEYWORDS: Obesity Treatment, System Dynamic Modeling

COMMANDER 3D FLEET APPRECIATIVE INQUIRY SUMMIT

Frank J. Barrett, Associate Professor
Graduate School of Business and Public Policy
Sponsor: Personnel Security and Research Command

OBJECTIVE: To conduct a positive change effort using AI, support the emergence of pilot programs and provide continued resources to deliver cascading AI summits.

KEYWORDS: Appreciative Inquiry, Summit, Large Group Intervention, Executive Steering

INFORMATION PROFESSIONAL (IP) COMMUNITY ESC AND SUMMIT

Frank J. Barrett, Associate Professor
Graduate School of Business and Public Policy
Sponsor: Chief of Naval Operations

OBJECTIVE: To conduct a positive change effort using AI, support the emergence of pilot programs and provide continued resources to deliver cascading AI summits.

KEYWORDS: Appreciative Inquiry, Summit, Large Group Intervention, Executive Steering Committee

SERVICE SCHOOL COMMAND ESC AND SUMMIT

Frank J. Barrett, Associate Professor
Graduate School of Business and Public Policy
Sponsor: Service School Command

OBJECTIVE: To conduct a positive change effort using AI, support the set-up of an executive steering committee on the way to developing an AI Summit.

KEYWORDS: Appreciative Inquiry, Summit, Large Group Intervention, Executive Steering Committee

ESTABLISHMENT OF ACQUISITION CHAIR

Douglas A. Brook, Dean
David V. Lamm, Associate Professor
Graduate School of Business and Public Policy
Sponsor: Naval Sea Systems Command

OBJECTIVE: Create a new chair in the School of Business and Public Policy in support of the acquisition curricula/AP community/DoD acquisition.

KEYWORDS: Aquisition

SAFE SCHOOLS PROJECT

Alice Crawford, Senior Lecturer
Kenneth J. Euske, Professor
Mary Malina, Assistant Professor
Stephen L. Mehay, Professor
Graduate School of Business and Public Policy
Sponsor: Salinas Union High School

OBJECTIVE: The objective is to help improve the learning experience of Salinas middle and high school students.

SUMMARY: The Salinas Safe Schools/Healthy Students project is a partnership to improve school safety as well as reduce violence in the city of Salinas. The partnership includes the U.S. Departments of Education, Health and Human Services, and Justice. The agencies have united to provide grants to assist students, schools and communities. The aim is to promote healthy childhood development and to prevent violence and alcohol/drug abuse with enhanced educational, mental health, social service, law enforcement and juvenile justice system services.

KEYWORDS: Education, Human Capital

**ECONOMIC AND RETURN-ON-INVESTMENT ANALYSIS FOR ADVANCED TECHNOLOGY
ORDINANCE SURVEILLANCE**

Kenneth Doerr, Associate Professor
William R. Gates, Associate Professor
John Mutty, Senior Lecturer
Graduate School of Business and Public Policy
Sponsor: Naval Surface Warfare Center, Indian Head

OBJECTIVE: Perform an independent economic and Return-On-Investment (ROI) analysis for the Advanced Technology Ordinance Surveillance (ATOS) Advanced Concept Technology Demonstration (ACTD). An independent ATOS economic and ROI analysis will help validate whether the benefits of ATOS exceed their costs, and help justify program funding.

SUMMARY: Advanced Technology Ordinance Surveillance (ATOS) is an Advanced Concept Technology Demonstration (ACTD) involving a system of electronic tags with sensors affixed to ordnance items that automatically collects and reports inventory and environmental data on individual items throughout their lifecycle. ATOS will improve inventory accountability, reduce manpower requirements, reduce overall inventory investment and enhance safe shelf life and service-life predictions.

This analysis compares the ATOS investment costs to the expected ATOS benefits to estimate an ATOS ROI. Investment costs include developing hardware/software components, manufacturing test quantities, demonstrating military utility, modifying and maintaining hardware/software as necessary, and operational production, implementation and operation. Benefits involve inventory accuracy, reduced opportunity cost of the inventory investment (holding cost), improved service-life prediction and shelf life safety, and the

associated manpower savings. The economic and ROI analysis uses simulation models to explicitly incorporate uncertainty, and provides the capability to perform sensitivity analysis on investment costs and other key components. The analysis develops the appropriate cost models, and analyzes the model results. A multi-attribute decision model is also used to evaluate non-monetary benefits of ATOS technology. A working cost model will be delivered, along with the project report, to allow the sponsor to explore further sensitivities as necessary.

TECHNICAL REPORT:

Doerr, K., Gates, W. and Mutty, J., "Economic Analysis, Return-on-Investment, Cost-Benefit Analysis, Advanced Technology Ordinance Surveillance (ATOS), Advanced Concept Technology Demonstration (ACTD)," Naval Postgraduate School Technical Report, 2003, (forthcoming).

OTHER:

Maj Eric Garretty, USMC, developed an initial economic and ROI analysis model as well as a preliminary Ordnance Management Survey as part of the ATOS analysis in a directed readings class, Fall AY2003.

KEYWORDS: Economic Analysis, Return-on-Investment, Cost-benefit Analysis, Advanced Technology Ordinance Surveillance (ATOS), Advanced Concept Technology Demonstration (ACTD)

**INTELLIGENT AGENTS AND WEB-BASED MARKETS FOR DETAILING NAVAL
PERSONNEL**

William R. Gates, Associate Professor

Mark E. Nissen, Associate Professor

Graduate School of Business and Public Policy

Sponsor: Naval Personnel Research Studies and Technology (PERS 1)

OBJECTIVE: Analyze the technological and operational feasibility of establishing a web-based market, using intelligent agents, to match naval enlisted personnel to specific navy billets.

SUMMARY: This multi-year research analyzes the technological and operational feasibility of establishing a web-based market, using intelligent agents, to match naval enlisted personnel to specific navy billets. This system will be part of a general DoN Sailor Career Management System that manages cradle to grave career paths to facilitate both recruiting and retention by enhancing the quality of life within DoN.

This is the third year of research on this project. During FY02, development of the proof-of-concept Intelligent Personnel Mall continued. Research on two-sided matching algorithms also continued. In particular, exploratory experiments to assess the performance of five alternative employment market designs, including the Personnel Mall, two-sided matching, optimization, and humans both unaided and using decision support software (Logical Decisions for Windows) continued. Using a quasi-price measure examining social welfare to assess market-design alternatives, novel insight into the balance required between technologically enabled efficiency and economically principled effectiveness of markets was developed. These experiments addressed labor market economics in an analytically difficult, public-sector context. Results point to a Pareto superior increase in total welfare through market design, which can dramatically increase employee morale and retention, and increase overall labor market efficiency.

PUBLICATIONS:

Gates, W.R. and Nissen, M.E., "Agent- and Web-based Employment Market Spaces in the U.S. Department of Defense," *Electronic Government - Design, Applications and Management*, Hershey, PA: Idea Group Publishing, Åke Grönlund (Ed.), 2002.

Gates, W.R. and Nissen, M.E., "Experimental Analysis of e-Employment Market Design," *Journal of Organizational Computing and Electronic Commerce*, 2003, (forthcoming).

PRESENTATIONS:

Butler, V. and Molina, V., "Command and Sailor Preferences in a Two-Sided Matching Distribution Process," presentation to William Navas, Jr., Assistant Secretary of the Navy (Manpower and Reserve Affairs), Naval Postgraduate School, 25 January 2002.

Butler, V., Molina, V., Nissen, M. and Gates, W., "Characterizing Sailor and Command Enlisted Assignment Preferences," Navy Manpower Research and Analysis Conference, Center for Naval Analysis, Alexandria, VA, 14-15 February 2002.

Koh, G., "A Redesign of the U.S. Navy's Enlisted Assignment Process," presentation to William Navas, Jr., Assistant Secretary of the Navy (Manpower and Reserve Affairs), Naval Postgraduate School, 25 January 2002.

Koh, G., Nissen, M. and Gates, W., "A Redesign of the U.S. Navy's Enlisted Assignment Process," Navy Manpower Research and Analysis Conference, Center for Naval Analysis, Alexandria, VA, 14-15 February 2002.

Gates, W.R. and Nissen, M.E., "The Navy Enlisted Detailing Process: An Empirical Analysis," Western Economics Association International Meetings, Seattle, WA, 29 June-3 July 2002.

Gates, W.R. and Nissen, M.E., "The Navy Enlisted Detailing Process: An Empirical Analysis," presentation to Admiral Deutsch, J6, Naval Postgraduate School, 17 January 2003.

Gates, W.R. and Nissen, M.E., "The Navy Enlisted Detailing Process: An Empirical Analysis," presentation to Admiral Shuford, N4, Naval Postgraduate School, 17 February 2003.

Gates, W.R. and Nissen, M.E., "The Navy Enlisted Detailing Process: An Empirical Analysis," Western Economics Association International Meetings, Denver, CO, 11-15 July 2003.

Gates, W.R., Nissen, M.E., Ho, J. and Low, E.H., "Two-Sided Matching for the U.S. Navy's Enlisted Detailing Process: A Comparison of Deferred Acceptance Versus Linear Programming Via Simulation," Navy Manpower Research and Analysis Conference, Center for Naval Analysis, Alexandria, VA, 31 March-1 April 2003.

Gates, W.R., Nissen, M.E., Ho, J., Low, E.H., Park, D.H. and Ramirez, M., "The Navy's Enlisted Detailing Process: An Empirical Analysis," presentation to the NPS GSBPP Board of Advisors, Naval Postgraduate School, 17 December 2002.

TECHNICAL REPORT:

Gates, W.R. and Nissen, M.E., "Two-Sided Matching Agents for Electronic Employment Market Design: Social Welfare Implications," Naval Postgraduate School Technical Report, NPS-GSBPP-02-005, December 2002.

THESES DIRECTED:

Butler, V. and Molina, V., "Characterizing Sailor and Command Enlisted Assignment Preferences," Master's Thesis, Naval Postgraduate School, March 2002.

Fectau, L., "2002 - Analysis of the Marine Corps Enlisted Assignment Process," Master's Thesis, Naval Postgraduate School, June 2002.

Ho, J.H. and Low, E.H., "Two-Sided Matching for USN's Enlisted Distribution and Assignment Process: A Revised Simulation Study," Master's Thesis, Naval Postgraduate School, December 2002.

Koh, G., "A Redesign of the U.S. Navy's Enlisted Assignment Process," Master's Thesis, Naval Postgraduate School, March 2002.

KEYWORDS: Intelligent Agents, Web-based Markets, Two-sided Matching Games

OPTIMAL SLOTING OF FORWARD PICK AREAS FOR THE DEFENSE DISTRIBUTION CENTER

**Kevin R. Gue, Associate Professor
Graduate School of Business and Public Policy
Sponsor: Office of Naval Research**

OBJECTIVE: To develop slotting tools to help the Defense Logistics Agency (DLA) choose the right products in the right amounts to be stored in the forward pick areas of the Defense Distribution Centers.

SUMMARY: This project seeks to apply existing theoretical models for assigning products to pick locations within a warehouse in order to reduce total labor costs. The theoretical models seek to assign products to a fast pick area—one for which pick costs and retrieval time are lowest—in such quantities that the area is most economically used. This is a constrained, non-linear resource allocation problem that yields itself to an elegant heuristic for solution. The project is using those models on data from the Defense Distribution Depots in Tracy, CA (DDJC) and in Susquehanna, PA (DDSP).

KEYWORDS: Logistics, Warehousing, Distribution, Optimization, Order Picking

SEA BASED WAREHOUSING

**Kevin R. Gue, Assistant Professor
Graduate School of Business and Public Policy
Sponsor: Office of Naval Research**

OBJECTIVE: To develop throughput and storage system models for cross docks and transshipment points, with particular application to sea base design in Sea Based Logistics.

SUMMARY: Throughput models for unit-load cross docking systems were developed, including a new type of queue called a *staging queue*. Analytical results were obtained with a continuous-time Markov chain model of the system, and built simulation models for more complex systems. Uses of the model in in-stream off-load operations and for the future sea based warehouse platform were proposed.

CONFERENCE PAPERS:

Bartholdi, III, J.J., Gue, K.R. and Kang, K., "Staging Freight in a Cross Dock," *Proceedings of the International Conference of Industrial Engineering and Production Management*, Quebec City, Canada, May 2001.

Gue, K.R. and Kang, K., "Staging Queues in Material Handling and Transportation Systems," *Proceedings of the 2001 Winter Simulation Conference*, Washington, D.C., December 2001.

KEYWORDS: Distribution, Logistics, Warehousing, Cross Docking, Simulation

GRADUATE SCHOOL OF BUSINESS AND PUBLIC POLICY

ANALYSIS OF BUDGET REDUCTION, COST-AVOIDANCE AND FINANCIAL MANAGEMENT INITIATIVES IN COMNAVAIRPAC

Lawrence R. Jones, Professor

Jerry L. McCaffery, Professor

Graduate School of Business and Public Policy

Sponsors: Office of the Comptroller, COMNAVAIRPAC

OBJECTIVE: To provide assistance to the Office of the Comptroller, AIRPAC in analysis of initiatives for improving command management and management control, cost-reduction and cost avoidance in the Flight Hour Program (FHP) and in accommodating budget reduction.

SUMMARY: The project provided analytical assistance to the Office of the Comptroller, AIRPAC in responding to the necessity for reviewing and assessing options for improving command management and management control, achieving cost-reduction and avoidance in the Flight Hour Program (FHP) and accommodating budget redirection in the period FY 2002 and beyond.

PUBLICATIONS:

Jones, L.R., "Best Practices e Controllo di Gestione nell'Esperienza del Governo Statunitense," *Il Controllo di Gestione nella Amministrazioni Centrali*, pp. 18-21, Rome: Rubbettino, R. Mussari (Ed.), 2002.

Jones, L.R., "The New Public Management: Book Review Essay," *Journal of Comparative Policy Analysis*, 4/1, 2002.

Jones, L.R., "The New Public Management: Improving Research and Policy Dialogue," *International Public Management Review*, 3/2, 2002.

Jones, L.R., "Symposium on Performance Budgeting: What Have We Learned?" *International Public Management Review*, 3/2, 2002.

Jones, L.R., "Symposium on Public Management Reform and E-Government," *International Public Management Journal*, 5/1, 2002.

Jones, L.R., "An Update on Budget Reform in the U.S.," *International Public Management Newsletter No. 2*, 7 February 2002.

Jones, L.R. and McCaffery, J., "Budget Process Reform," *Public Finance and Management*, 10/2 2002.

Jones, L.R. and McCaffery, J., "Budgeting and Financial Management in the Federal Government," *Armed Forces Comptroller*, 47/3 2002.

Jones, L.R. and McCaffery, J., "Tracing the Development of Financial Management Change: Practice and Theory," *Financial Management Theory in the Public Sector*, Westport, CT: Greenwood Press, A. Kahn and H.B. Hildreth (Eds.), 2002.

Jones, L.R., McCaffery, J. and Thompson, F., "Budget Execution and Management Control," *Encyclopedia of Public Administration and Public Policy*, New York: Marcel Dekker, J. Rabin (Ed.), 2002.

Jones, L.R. and Thompson, F., "Performance Budgeting and Accounting in the Public Sector," *Budget Theory*, New York: State University of New York Press, A. Kahn (Ed.), 2002.

THESES DIRECTED:

Anderson, W., "Funding the Theater Special Operations Commands: An Assessment of Alternatives," Master's Thesis, Naval Postgraduate School, December 2002.

Oxendine, E. and Hoffman, D.M., "Enterprise Resource Planning (ERP): A Case Study of Space and Naval Warfare Systems Center San Diego's Project Cabrillo," Master's Thesis, Naval Postgraduate School, September 2002.

Thompson, C.E., "The Submarine High Data Rate Antennae Acquisition Program: Methods to Improve the Difference Between Estimated and Actual Cost," Master's Thesis, Naval Postgraduate School, December 2002.

Turner, J.S., "The Pearl Harbor Fleet Maintenance Pilot Program: Conversion From the Navy Working Capital Fund to Appropriated Funding," Master's Thesis, Naval Postgraduate School, June 2002.

KEYWORDS: Resource Management, Financial Management, Public Budgeting, Defense Budgeting, Defense Management Reform, Public Sector Management Reform

SIMULATION MODELING ANALYSIS OF SEA PORTS OF DEBARKATION (SPODS)

Keebom Kang, Associate Professor

Graduate School of Business and Public Policy

Sponsor: U.S. Transportation Command

OBJECTIVE: Strategic sealift plays a vital role in the U. S. military's concept of battlespace sustainment and projecting maritime power. In this research, modeling and simulation methodology is applied to study strategic sealift and port congestion at Seaports of Debarkation (SPODs) to help decision makers to reduce delays in moving materiel rapidly to war fighters.

SUMMARY: A simulation model has been successfully developed that is flexible, adaptable, and methodical. Real data was included, making the model more valid. The use of real distance, real ports, real cargo amounts, and shipping speeds add to the significance of this model. This model can be applicable for decision-making process at the Military Sealift Command (MSC) or at TRANSCOM. This model can be modified to an airlift model for the Air Mobility Command (AMC). This simulation model will allow USCINCTRANS to electronically exercise planned movements and deployments of materiel and equipment necessary to meet military objectives overseas, prior to actually having to execute their mission. The goal was established of making the model flexible, adaptable, and methodical. To maximize flexibility, the model was based on information read from text files. These text files can easily be customized to perform what-if simulations with varied numbers of ships, cargo capacities, ship speeds, cargo quantities, and distributions between the ports of embarkation. The model logic is adaptable to major changes due the unique pattern chosen to follow. Ports may be added and deleted with little or no manual input from the user.

PUBLICATION:

Goldsman, D., Petnet, S. and Kang, K., "Simulation of Transportation Logistics," *Proceedings of the 2002 Winter Simulation Conference*, pp. 901-904, IEEE, E. Yücesan, C.-H. Chen, J. L. Snowdon and J. M. Charnes (Eds.), 2002.

PRESENTATION:

Kang, K., "Simulation of Transportation Logistics," Winter Simulation Conference, San Diego, CA, 8-11 December 2002.

KEYWORDS: Readiness, Transportation, and Logistics

COMPREHENSIVE STUDY OF JUNIOR ROTC
Janice H. Laurence, Research Associate Professor
Graduate School of Business and Public Policy
Sponsor: Office of the Assistant Secretary of Defense

OBJECTIVE: Assess budget planning, curriculum, and operation of JROTC across services.

KEYWORDS: JROTC, Curriculum, Budget, Youth Development Program

DESCRIPTION AND ASSESSMENT OF PERSONNEL SECURITY PROCESS AND PROCEDURES FOR MILITARY PERSONNEL
Janice H. Laurence, Research Associate Professor
Graduate School of Business and Public Policy
Sponsor: Personnel Security and Research Command

OBJECTIVE: Describe personnel security screening from the point of accession through job assignment and implications for readiness.

KEYWORDS: Personnel Security, Readiness, Needs, Occupational Assignment

EVALUATION OF EFFICIENT OFFICER COMMISSIONING SOURCE MIXES
Janice H. Laurence, Research Associate Professor
Graduate School of Business and Public Policy
Sponsor: Office of the Secretary of Defense

OBJECTIVE: Assess alternative officer commissioning sources and source mixes.

KEYWORDS: Officer Commissioning Source, Academy, ROTC, OCS

RESEARCH DESIGN AND METHODOLOGICAL SUPPORT
Janice H. Laurence, Research Associate Professor
Stephen L. Mehay, Professor
Graduate School of Business and Public Policy
Sponsor: Central Intelligence Agency

OBJECTIVE: To provide advice and guidance with regard to research design and analysis for approved and ongoing studies supported by the defense personnel security and interagency intelligence community (e.g., CIA, NSA, DIA). Devise appropriate study methodology and conduct research needs analysis in the area of personnel security. Conduct a content analysis of existing interview data.

KEYWORDS: Personnel Security, Research Design, Qualitative Methods, Quantitative Methods

BUILDING CAUSAL PERFORMANCE MODELS FROM QUALITATIVE DATA

Mary Malina, Assistant Professor
Graduate School of Business and Public Policy
Margaret Abernethy, University of Melbourne
Malcolm Horne, Monash University
Anne Lillis, University of Melbourne
Frank Selto, University of Colorado at Boulder
Sponsor: Un-sponsored

OBJECTIVE: The objective is to demonstrate that it is: (1) feasible to tap the causal knowledge of individual experts in the field and (2) advantageous to triangulate various methods of qualitative data analysis.

SUMMARY: This paper reports the results of a field study to build a causal performance model (CPM), which is the conceptual foundation of a performance management model (PMM). The study uses three qualitative methods to identify the performance drivers and causal structure of the CPM from interviews with a major hospital's administrators, physicians, and nurses. This is a particularly critical first step to building valid performance management models.

KEYWORDS: Causal Model, Qualitative Method, Expert Knowledge, Validation

CORPORATE EQUALITY INDEX: A STOCK MARKET REACTION STUDY

Mary Malina, Assistant Professor
Graduate School of Business and Public Policy
Derek Johnston-Wilson, Colorado State University
Sponsor: Un-sponsored

OBJECTIVE: The objective is to determine if the stock market reacted to the announcement of the Corporate Equality Index ratings in August, 2002.

SUMMARY: The stock market price of a company's stock is a measure of the future value of the company. Stock price incorporates any information that may shed light on the company's future profits. Specifically for this study, the information is the Corporate Equality Index. The Corporate Equality Index is compiled and released by the Human Rights Campaign. The Index rates large corporations on policies that affect diversity issues for employees, consumers and investors. The index is a tool that can help fair-minded Americans decide what products to buy, where to work and how to invest.

KEYWORDS: Event Study, Corporate Responsibility, Diversity

MANAGEMENT CONTROL AND PERFORMANCE MEASUREMENT: AN EMPIRICAL TEST OF CAUSAL RELATIONS

Mary Malina, Assistant Professor
Graduate School of Business and Public Policy
Frank Selto, Professor
University of Colorado at Boulder
Sponsor: Un-sponsored

OBJECTIVE: The objective is to test for internal causality among measures in a Fortune 500 company's performance measurement model.

SUMMARY: This research paper describes the efforts of a large U.S. manufacturing company to improve profitability by creating a performance measurement model that reflects managers' understanding of causal relations among key strategic and operational activities and desired financial outcomes. Research question

address how the performance measurement model measures were chosen and whether the performance measurement model exhibits internal causality.

KEYWORDS: Performance Measurement, Strategy, Causality

DEVELOPMENT OF ASPEN DATA BASE

Stephen L. Mehay, Professor

Graduate School of Business and Public Policy

Sponsor: Naval Personnel Research, Studies and Technology

OBJECTIVE: A biographical inventory, ASPEN, has been administered to over 8,000 Navy recruits prior to entry into Navy basic training. While responses have been automated, auditing, editing, and collating processes continue to be needed to improve the quality and breadth of information available for analysis.

SUMMARY: The objective of this project is to provide programming and analytical support to develop an accurate and complete ASPEN database to be delivered to NPRST. The data file will contain demographic, aptitude, and other descriptive information for each recruit tested, as well as behavioral criterion information for validation studies. Empirical data tabulations will be provided on the relationships between item responses and attrition from basic training.

KEYWORDS: Attrition, Recruiting

GENERAL EDUCATIONAL DEVELOPMENT (GED) SCREENING PILOT STUDY - PART II

Stephen L. Mehay, Professor

Graduate School of Business and Public Policy

Sponsor: Chief of Naval Operations

OBJECTIVE: The purpose of this study is to identify and evaluate procedures for the increased recruitment and improved selection of GED certificate holders to meet Navy procurement goals. If successful, the Navy could broaden its recruitment base and reduce first-term attrition.

SUMMARY: The effort will develop and pre-test a biographical questionnaire and evaluate its productivity in obtaining relevant behavioral information. The study will prepare guidelines for the administration of the questionnaire at the MEPS and prepare the data for subsequent statistical analysis.

KEYWORDS: GED, Recruitment, Selection, Attrition

SUPPORT TO MSA CURRICULUM FROM CHIEF OF NAVAL PERSONNEL

Stephen L. Mehay, Professor

Graduate School of Business and Public Policy

Sponsor: Chief of Naval Personnel (N-13)

OBJECTIVE: The purpose of this funding is to support research efforts by students and faculty in the MSA Curriculum that support the Chief of Naval Personnel.

SUMMARY: The funds supported a number of research efforts related to Navy manpower and personnel issues. Projects included the following:

- A Cost Analysis of Officer Commissioning Programs
- An Analysis of Rate of Return on Navy's Investment in Graduate Education Programs
- Trends and Analysis of Technical Skills in the URL Junior Officer Corps
- Cost-Effectiveness Analysis of Officer Commissioning Programs
- Construction of Navy Officer Cohort Files

PUBLICATION:

Mehay, S., "A Survey of Navy Retention and Compensation Models," Technical Report prepared for Navy Personnel Research, Studies and Technology Center, Millington, TN, July 2001.

PRESENTATIONS:

Bowman, W. and Mehay, S., "An Analysis of Return on Investment in Navy's Graduate Education Programs," Annual Navy Workforce Conference, Center for Naval Analyses, Alexandria, VA, February 2002.

Bowman, W. and Mehay, S., "Marital Status and Job Performance: Evidence from Personnel Data," Annual Meetings of the Western Economic Association, Seattle, WA, July 2002.

THESES DIRECTED:

Bernard, J., "An Analysis of Alternate Accession Sources for Naval Officers," Master's Thesis, Naval Postgraduate School, March 2002.

Clemens, G., "Factors Affecting Retention Plans of U.S. Navy Officers," Master's Thesis, Naval Postgraduate School, March 2002.

Fagan, B., "Analysis of Determinants of Training Performance, Retention, and Promotion of Naval Flight Officers," Master's Thesis, Naval Postgraduate School, June 2002.

Mook, R. and High, R., "An Exploratory Analysis of First-Term Reenlistment Modeling using the Per SMART Data Warehouse," Master's Thesis, Naval Postgraduate School, March 2002.

Ryu, S. and Kol, M., "An Analysis of the Relationship between Marital Status and On-the-Job Productivity," Master's Thesis, Naval Postgraduate School, March 2002.

KEYWORDS: Retention, Officer Performance, Promotion, Graduate Education

**INTELLIGENT AGENTS AND WEB-BASED MARKETS FOR DETAILING NAVAL
PERSONNEL**

Mark E. Nissen, Associate Professor

William R. Gates, Associate Professor

Graduate School of Business and Public Policy

Sponsor: Navy Personnel Research Studies and Technology

OBJECTIVE: Analyze the technological and operational feasibility of establishing a web-based market, using intelligent agents, to match Naval enlisted personnel to specific Navy billets.

KEYWORDS: Intelligent Agents, Web-based Markets, Two-sided Matching Games

KNOWLEDGE-FLOW THEORY FOR VERY-LARGE ENTERPRISES

Mark E. Nissen, Associate Professor

Graduate School of Business and Public Policy

Sponsor: Office of Naval Research

**APPLICATION OF INFORMATION TECHNOLOGY TO PEACE OPERATIONS AND
COMPLEX EMERGENCIES**

**Nancy Roberts, Professor
Graduate School of Business and Public Policy and
School of International Graduate Studies
Sponsor: Un-sponsored**

OBJECTIVE: To apply information technology to complex, joint and combined operations in all stages of peace operations, including complex emergencies.

SUMMARY: Great strides have been made in information technology. Yet its application lags in settings that require the coordination and collaboration of joint and combined forces, especially in crisis countries that do not have the infrastructure to support the new technology. In addition, military, NGOs (non governmental) and UN organizations each have their own systems that do not interface with one another. Communication and collaboration are very difficult when computer systems and software are not compatible among the parties.

This line of research asks: How can information technology improve the communication, coordination and collaboration among military, NGO, and UN organizations during complex emergencies and peace operations? Specifically, how can the Internet be used to link the players and reduce the communication barriers across all sectors?

PUBLICATIONS:

Perry, M.W., Roberts, N.C. and Bordetsky, A., "Networks for Peace Operations: Knowledge Portals for Communication, Coordination, and Collaboration," Networks for Nation Building: Inter-organizational Coordination in Peacekeeping and Development, Academy of Management Symposium, 12 August 2002.

Roberts, N.C., "The Dark Side of Networks," Academy of Management National Meeting, 14 August 2002.

THESES DIRECTED:

Adonis, M. and Bridges, D.M., "Wireless Technology During Complex Humanitarian Emergencies and Peace Operations," Master's Thesis, Naval Postgraduate School, March 2003.

Ford, T.D., Hogan, J.L. and Perry, M.W., "Communication During Complex Humanitarian Emergencies: Using Technology to Bridge the Gap," Master's Thesis, Naval Postgraduate School, September 2002.

Harrell, A., "Wireless Technology via Satellite Communications for Peacekeeping Operations," Master's Thesis, Naval Postgraduate School, September 2001.

Hoffler, R.E., "International Training for Peace Support Operations: Models, Assessments, and Implications," Master's Thesis, Naval Postgraduate School, March 2002.

Spivey, M.A., "Web-based Collaboration Technology for Peace Operations," Master's Thesis, Naval Postgraduate School, March 2002.

KEYWORDS: Internet, Peace Operations, Complex Emergencies, Information Technology

**FINANCIAL REPORTING AND ANALYSIS RESEARCH FOR THE DEPARTMENT OF
DEFENSE PERSONNEL SECURITY RESEARCH CENTER**

**Joseph G. San Miguel, Professor
Graduate School of Business and Public Policy
Sponsor: Personnel Security Research Center**

OBJECTIVE: The objective of the research during the fourth year of this program was to assist the security agencies in applying financial analysis techniques to live data obtained from federal employees in positions of national security. Prior work recommended new tools for uncovering unexplained affluence or financial distress. The results have financial implications for security policies and programs of the Defense Security Service, the National Security Agency, the Central Intelligence Agency, and the U.S. Customs.

SUMMARY: Although National Security has always been a major concern of US federal officials, the September 11 attack has added more importance to this major area. Numerous initiatives are underway to evaluate the quality of financial and non-financial information for purposes of deterring or detecting security threats. Prior investigation and research has established that financial incentives and payments are generally the primary motives for acts of spying by U.S. citizens. The well-known spy cases involving Aldrich Ames and John Walker are examples. This project considers the use of the financial information for use as predictors of potential security risks and the need for security investigations. Financial information includes unexplained increases or decreases in an individual's net worth. The various sources of net worth such as earned income, inheritance, or sale of personal assets as well as the uses of net worth for investments and asset acquisitions, are variables that must be considered. Due to the sensitivity of the subject, the reports prepared for the sponsor and the other federal agencies are CLASSIFIED.

KEYWORDS: National Security, Financial Analysis, Cost Analysis, Cost Estimation

THE IMPACT OF INFORMATION TECHNOLOGY INVESTMENTS

**Joseph G. San Miguel, Professor
Department of Systems Management
Sponsor: Financial Executive Research Foundation**

OBJECTIVE: In recent years, business enterprises have made significant investments in information technology called customer relationship management to improve their strategic positioning, responsiveness to the customer, and market direction. This follows huge investments in enterprise resource planning systems that provided weak results. This research examines companies that have implemented new information technology to better understand the roles and responsibilities of financial managers and the resulting improvements in strategic information and performance measurement systems.

SUMMARY: For survival and growth in the global marketplace a firm must effectively allocate its strategic resources, which include human, physical, and financial assets, across business operations and processes. Its strategy must be supported by management systems that assist the planning and control of operations and processes. Today information technology supports these information systems. In recent years enterprise resource planning (ERP) systems have been used as a means to comprehensively link firm-wide operations and processes. The majority of the thousand largest firms in the U.S. have either implemented or in the process of implementing enterprise resource planning systems. Because of the millions of investment dollars involved, executive management is keenly aware of ERP and its promised benefits. Today, ERP vendors and IT consultants are also targeting middle-level firms with annual sales less than \$1 billion. The question is how effective are these significant investments in assisting executive management in achieving corporate objectives.

PUBLICATION:

San Miguel, J.G. and Shank, J.K., "ERP as a Strategic Management Tool: Six Evolutionary Stages," *Competitive Financial Operations, the CFO Project*, Vol. 1, pp. 130-134, 2002.

CASE STUDIES:

San Miguel, J.G., "Dallas Consulting Group," *Cases and Readings in Cost Management*, Irwin/McGraw-Hill, E.J. Blocher, et al., 2002.

San Miguel, J.G., "Emerson Electric Company," *Cases and Readings in Cost Management*, Irwin/McGraw-Hill, E.J. Blocher, et al., 2002.

KEYWORDS: Customer Relation Management, ERP

NAVY SENIOR EXECUTIVE MANAGING DIVERSITY SEMINAR

George W. Thomas, Professor
Graduate School of Business and Public Policy
Sponsor: Chief of Naval Operations (N09BX)

OBJECTIVE: Two-fold: development managing diversity seminar for new Admirals and USN Senior Executives; and conduct seminar.

KEYWORDS: Executive Education, Managing Diversity

EFFICIENT ESTIMATION OF POPULATION PROPORTIONS

R.A. Weitzman, Associate Professor
Graduate School of Business and Public Policy
Sponsor: Unfunded

OBJECTIVE: This research aims at estimating population proportions from small samples or sub-samples, such as might result from breaking down a moderately large sample by demographic variables.

SUMMARY: This research began in the early 1970's as a project supported by the Navy Personnel Research and Development Center (NPRDC). The project was originally called "pattern analysis" and produced a number of FORTRAN computer programs and NPS technical reports. The most recent product is a work submitted for publication this year and cited below. This work provides an efficient method of estimating population proportions from small samples. The method is Bayesian and involves both point and interval estimation, different from both conventional and empirical Bayesian methods. In an example of the savings afforded by the method, a margin of error (.04) requiring a sample of 702 conventionally is obtainable by this method from a sample of only 285.

PUBLICATION:

Weitzman, R.A., "Population-sample Regression in the Estimation of Population Proportions," *Journal of the American Statistical Association*, 2002, (submitted).

KEYWORDS: Survey Research, Estimation of Proportions, Measurement Theory

MULTIPLE-CHOICE TESTS IN CLASSICAL AND MODERN TEST THEORY

**R.A. Weitzman, Associate Professor
Graduate School of Business and Public Policy
Sponsor: Unfunded**

OBJECTIVE: Instead of considering guessing and unreliability in responding to multiple-choice items as nuisances to be ignored or to be estimated away, this research has aimed at taking advantage of these challenges in attempts to solve some of the persistent problems of both classical and modern test theory.

SUMMARY: This project began in about 1967. The first product developed in 1968 and published in a technical report that year was a formula for estimating the reliability of a multiple-choice test. This work ultimately appeared in a journal article in 1984. Two subsequent works have led to the development of methods of incorporating guessing in modern test theory without losing important advantages of classical test theory. One of these works was published in 1996 and is cited below. The other was first submitted for publication in 1997 and is also cited. The manuscript looks at modern test theory from the viewpoint of classical test theory via the concept of item reliability. While citing the resemblance between the Rasch model and classical test theory, this publication concentrates on the discriminability parameter as a measure of item reliability and shows how the Rasch model with this parameter held constant can describe test data as well as it appears to do.

PUBLICATIONS:

Weitzman, R.A., "Modern Test Theory: A View from Classical Test Theory," *Psychological Review*, 2002, (submitted).

KEYWORDS: Multiple-choice Testing, Classical Test Theory, Regression Analysis, Least-squares Estimation, Item Response Theory, Rasch Model, Financial Analysis, Cost Analysis, Cost Estimation, Strategy

PART AND PARTIAL CORRELATIONS IN STANDARDIZED TESTING

**R.A. Weitzman, Associate Professor
Graduate School of Business and Public Policy
Sponsor: Unfunded**

OBJECTIVE: Continuing a career-long interest in part and partial correlations and regression analysis, this research has aimed at developing and applying part and partial correlations in the context of test validity and test fairness in personnel selection.

SUMMARY: This research produced a well-received publication in the mid-eighties indicating through part-correlation analysis that the test validities of standardized tests used for college admissions might actually be considerably higher than the data appeared to show. The current research focuses on a flaw in that earlier work: The usual part-correlation formula does not apply when the control variable is categorical, rather than quantitative. The current research develops the correct formula and examines the effect of the correction on the results obtained previously.

PUBLICATION:

Weitzman, R.A., "Part-correlation with a Categorical Variable: Application to the Predictive Validities of the SAT and the High School Record," *Journal of Educational Measurement*, 2002, (submitted).

KEYWORDS: Part Correlation, Categorical Variables, Scholastic Aptitude Test

QUANTILE LOGISTIC MODELS
R.A. Weitzman, Associate Professor
Graduate School of Business and Public Policy
Sponsor: Unfunded

OBJECTIVE: To use item data in quantiles of total test scores for estimating the parameters of logistic item response models.

SUMMARY: Noting that users of item response models often evaluate model fit by comparing observed and theoretical test response curves on quantile data, this research developed methods to estimate logistic model parameters by optimizing the fit of the two curves. In so doing, the research showed that such fitting and estimation can work only for single-parameter models like the Rasch model. The research will show how the methods can be applied to a "two-parameter" Rasch Model. The methods are especially useful for small groups of examinees. The research illustrated the methods by application to empirical Navy data.

OTHER:

Weitzman, R.A., "Quantile Logistic Models," 2003, (submitted).

KEYWORDS: Item Response Models, Logistic Models, Rasch Model

SEQUENTIAL TESTING FOR SELECTION
R.A. Weitzman, Associate Professor
Graduate School of Business and Public Policy
Sponsor: Unfunded

OBJECTIVE: This research aims at developing sequential item-sampling methods for selecting a person for school or work with pre-established error probabilities of acceptance or rejection. These methods involve the use of the sequential probability ratio test (SPRT).

SUMMARY: Previous research required the use of large samples. The latest research makes use of the Rasch model to reduce considerably the size of the samples required, while applying a modified version of the SPRT. This research is in progress.

OTHER:

Weitzman, R.A., "Sequential Testing for Selection: Small-sample Procedure via the Rasch Model," in progress.

KEYWORDS: Sequential Probability Ratio Test, SPRT, Sequential Testing for Selection, Rasch Model

**GRADUATE SCHOOL OF BUSINESS
AND PUBLIC POLICY**

**2002 Faculty Publications
and Presentations**

JOURNAL ARTICLES

Abdel-Hamid, T., "Modeling the Dynamics of Human Energy Regulation and its Implications for Obesity Treatment," *System Dynamics Review*, Vol. 18, pp. 431-471, 2002.

Bowman, W. and Mehay, S., "College Quality and Employee Job Performance: Evidence from Naval Officers," *Industrial and Labor Relations Review*, Vol. 55, No. 4, pp. 700-714, July 2002.

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Coombs, J.L. and Yoder, E.C., "Humanitarian Organizations in Uzbekistan," *Army AL&T*, pp. 38-40, September-October 2002.

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INSTITUTES AND CENTERS

**Institute for Information Superiority and Innovation
(I2SI)**

**Wayne E. Meyer Institute of Systems Engineering
(MISE)**

**The Modeling, Virtual Environments and Simulation
(MOVES) Institute**

**Center for Interdisciplinary Remotely Piloted Aircraft
Studies (CIRPAS)**

**INSTITUTE FOR INFORMATION
SUPERIORITY AND INNOVATION
(I2SI)**

**CYNTHIA E. IRVINE
DIRECTOR**

INSTITUTE FOR INFORMATION SUPERIORITY AND INNOVATION

OVERVIEW:

The Institute for Information Superiority and Innovation was established to be the center for innovative research and education in enabling information technologies, operations, and strategies, with focus on their development and application for national security. The Institute provides a venue for interdisciplinary research in a wide variety of areas related to the capture, processing, display and storage of information in a warfighting environment. Research and educational activities within the Institute are intended to support both immediate and long-term objectives for the effective use of computers and networks within the military.

CURRICULA SERVED:

The Institute for Information Superiority and Innovation does not manage its own curriculum. Instead, students from any curriculum at the Naval Postgraduate School can participate in the Institute's wide range of research and educational programs.

RESEARCH THRUSTS:

- Signals Intelligence
- Electronic Communications Systems
- Electronic Warfare
- Information Warfare
- Information Operations
- Computer and Network Security
- Threat and Risk Analysis and Countermeasures
- System Certification and Accreditation
- Motivations and Operations of Information Threats

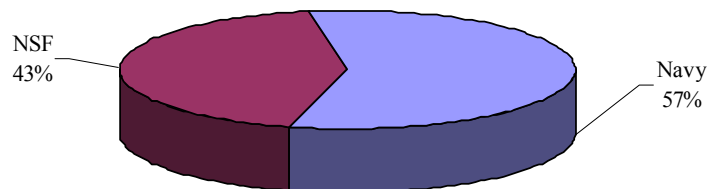
For faculty members investigating these areas, see the research summaries for each faculty member's home department.

RESEARCH CENTERS:

Cryptologic Research Center (CRC)
Center for Information Security (INFOSEC) Studies and Research (CISR)
Center for the Study of Terrorism and Irregular Warfare

SPONSORED RESEARCH PROGRAMS (Research and Academic)-FY2002:

The Naval Postgraduate School's sponsored program exceeded \$61 million in FY2002. Sponsored programs included both research and educational activities funded from an external source. A profile of the sponsored program for the Institute for Information Superiority and Innovation (I2SI) is provided below:



Size of Program: \$726K

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RESEARCH SUMMARY CDTEMS SUPPORT FOR I2S1

Cynthia E. Irvine, Associate Professor

Department of Computer Science

Sponsor: Naval Postgraduate School, Office of Naval Research

OBJECTIVE: The objectives of the effort included basic support of the Institute in the areas of administrative and technical support, the Institute Summer Research Forum, and a small amount of space refurbishment. The bulk of the Center for Defense Technology and Education (CDTEMS) support was allocated to the Center for the Study of Mobile Devices and Communications.

SUMMARY: Institute Summer Research Symposium

In July 2002 the Institute held its first Summer Research Symposium. The agenda included 20 presentations by Institute faculty and students as well as tours of several laboratories.

Center for the Study of Wireless Devices and Communications

In 2002 the Institute formed a new affiliated research center, the Center for the Study of Wireless Devices and Communications (CSMDC). The original center proposal included 29 Naval Postgraduate School faculty members from departments including: Electrical and Computer Engineering, Computer Science, Information Sciences, and Defense Analysis.

The goal of the Center is to focus research attention on the emerging fields of ubiquitous devices that communicate by some form of wireless network and the applications that run on them.

The research agenda of the CSMDC includes the following broad areas for networks incorporating untethered devices: network security, network management, productivity, grids, location-based computing, context-aware computing, mobile devices as transforming technology for 21st century computing, electronic signatures, wireless propagation, wireless signals intelligence, electromagnetic interference and compatibility, and a heterogeneous wireless testbed. The objective will to explore this technology in the context of application to Navy needs.

A project initiated with CDTEMS support by the CSMDC during FY02 was the Nemesis project.

Nemesis

The purpose of the Nemesis project was to create a fully re-configurable mobile computer network attack/defense and exploitation lab and research platform to ensure NPS's roles as a dominant resource for years to come in the wireless Information Assurance space. Nemesis's initial configuration was as a mobile 802.11 wireless computer network vulnerability lab and research facility. It will be one of the Naval Postgraduate School's premier technology innovations in support of Homeland Security and the Global War on Terrorism. The Nemesis deployment platform will be re-configurable to allow for research and development of solutions for vulnerability assessment for several other emerging wireless communications mediums such as cellular phone communications, fixed broadband wireless data, and other radio frequencies (RF).

Work is underway to create a Computer Network Vulnerability Assessment Training portal via a secure website on the SIPRNET for USPACOM and other major DoD organizations.

This is an interdisciplinary project involving six students from several NPS curricula. A website for the Nemesis project is located at: <http://intranet.nps.navy.mil/nemesis/>.

In addition to participation in the Institute Summer Research Symposium and involving students in the project's research objectives, progress in other areas of the project was achieved:

- A. An exhaustive Requirements equipment suite analysis was conducted and all equipment has been identified.
- B. A Draft Nemesis Concept of Operations has been completed and is attached.
- C. A Vehicle Cost-Benefit Analysis has been completed.

Basic Support

Web sites both for general Institute information as well as for the Institute Summer Research Symposium were developed. Also staff created art work in support of space planning and business needs.

Staff conducted the planning required to work with NPS public works and others to specify and equip the temporary space for the Institute. This included architectural layout, as well as specification of work, meeting, and laboratory areas.

Staff provided financial management.

Cebrowski Institute for Information Innovation and Superiority Web Resources

Web site: <http://ci.nps.navy.mil/>
Affiliated Research Centers: <http://ci.nps.navy.mil/research.html>
Sponsors: <http://ci.nps.navy.mil/sponsors.html>
Organization: <http://ci.nps.navy.mil/organization.html>
Advisory Council: <http://ci.nps.navy.mil/council.html>
Faculty: <http://ci.nps.navy.mil/faculty.html>
Projects: <http://ci.nps.navy.mil/projects.html>
Education: <http://ci.nps.navy.mil/education.html>
Location: <http://ci.nps.navy.mil/location.html>

PUBLICATIONS:

See publications from affiliated research centers. A website supported the Summer Research Symposium and a CD of the presentations was provided to all participants.

THESES DIRECTED:

See theses of affiliated research centers.

KEYWORDS: Wireless Systems, Mobile Devices, Information Assurance, Communications Systems, Strategic Analysis

RESEARCH SUMMARY NPS CISR SCHOLARSHIP FOR SERVICE

**Cynthia E. Irvine, Associate Professor
Department of Computer Science
Sponsor: National Science Foundation**

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

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

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

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

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

THESES DIRECTED:

Theses are in progress. A number of the theses will be tied to other research projects. The first students will graduate in June 2003.

KEYWORDS: Computer Security, Information Assurance, Critical Infrastructure Protection

**INSTITUTE FOR INFORMATION
SUPERIORITY AND INNOVATION
(I2SI)**

**2002
Faculty Publications
and Presentations**

INSTITUTE FOR INFORMATION SUPERIORITY AND INNOVATION

All faculty affiliated with the Cebrowski Institute have home departments. See the research summaries for each faculty member's home department for Institute member's presentations and publications.

**WAYNE E. MEYER
INSTITUTE OF
SYSTEMS ENGINEERING
(MISE)**

**PHIL E. DEPOY
DIRECTOR**

WAYNE E. MEYER INSTITUTE OF SYSTEMS ENGINEERING

OVERVIEW:

The Wayne E. Meyer Institute of Systems Engineering was first established as the Institute of Defense Systems Engineering and Analysis in 2001. In May 2002, the Institute was renamed the “Wayne E. Meyer Institute of Systems Engineering” after RADM Wayne E. Meyer, USN (Ret.) who was the founding Program Manager of the Aegis combat system, the first large Navy acquisition program in which a total systems approach was used in the system development and design.

The mission of the Institute is to provide an interdisciplinary education and research center, matrixed across the four academic schools at the Naval Postgraduate School. Faculty and students are drawn from various schools and departments to form interdisciplinary research teams, and courses from various departments are combined to offer interdisciplinary curricula in systems engineering.

Research projects recently completed or currently being conducted in the Meyer Institute include analysis support for Fleet Battle Experiment-Juliet, systems engineering support for the Joint Fires Network (JFN), analysis of the Joint Force Maritime Component Commander’s Maritime Planning Process, and experimentation with Force Protection concepts.

CURRICULA SERVED:

- Total Ship Systems Engineering (TSSE)
- Systems Engineering and Analysis (SEA)
- Master of Science in Systems Engineering (MSSE)
- Product Development for the 21st Century-Systems Engineering Management (PD-SEM)
- Undersea Warfare (USW)

RESEARCH THRUSTS:

- Mine Warfare
- Anti-Terrorism/Force Protection
- Data Collection and Analysis for Fleet Battle Experiments
- Joint Warfare
- Concept and Process Modeling
- Evolutionary Computing
- Unconventional Weapons of Mass Destruction
- Sparse Optical Array Radar
- Dealing with Islamic Terrorists

RESEARCH CHAIRS:

- Expeditionary Warfare
- Undersea Warfare
- Mine Warfare
- Northrop Grumman Systems Engineering
- Northrop Grumman Professor of Systems Integration

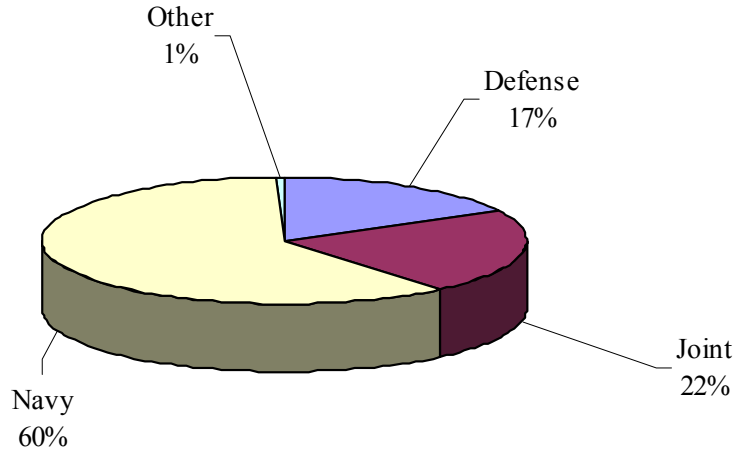
RESEARCH FACILITIES:

- Three Integrated Student Design Labs

WAYNE E. MEYER INSTITUTE OF SYSTEMS ENGINEERING

SPONSORED RESEARCH PROGRAMS (Research and Academic)-FY2002:

A profile of the sponsored program for the Wayne E. Meyer Institute Systems Engineering (MISE) is provided below:



Size of Program: \$4,243K

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NAVY'S MINE IMPACT BURIAL PREDICT MODEL

Peter C. Chu, Professor

Wayne E. Meyer Institute of Systems Engineering

Sponsor: Naval Oceanographic Office

OBJECTIVE: The ultimate goals were to substantially improve, quantitatively, the U.S. Navy's mine burial predictive capabilities and to provide a complete data set of mine movement in water phase and mine impact burial for model evaluation. The goals included the development of a new mine impact burial model for improving Naval technical decision aids and involvement of NPS students' (U.S. Naval officers) thesis study for enhancing their combat effectiveness.

SUMMARY: Work completed:

A synchronized data set of ocean environment (including waves, currents, and bottom shear strength) and mine burial depth was established on the base of the Mine Impact Burial Experiment (MIBEX).

A Mine Drop Experiment (MIDEX) was conducted in June 2001 at the NPS swimming pool with 1/20 scale model mines. Around 500 mine drops were completed with different mine parameters and drop conditions. Upon completion of the drop phase, the video from each camera was converted to digital format, and a dataset for mine movement in the water column was established.

A Mine test experiment at Carderock was completed.

The hydrodynamic system depicting the movement of a rigid body (such as a mine) in the water column has been established on the base of balance of momentum and moment of momentum.

A Workshop was conducted on the Office of Naval Research (ONR) Expert System Program on Mine Impact Burial Prediction at NPS on January 10, 2001. The MIBEX dataset was transferred to the ONR Expert System group.

The dynamic system (nine nonlinear equations) for the mine movement has potential impact on the nonlinear dynamics. The hydrodynamics of mine impact in water column can be applied to a general scientific problem of the fluid-rigid body interaction including stability and chaotic motion.

The datasets obtained from three consecutive experiments, MIBEX, MIDEX, and mine testing at Carderock, will impact the scientific and Naval mine warfare communities on the mine movement in the water column.

DATA AND ANALYSIS SUPPORT FOR FLEET BATTLE EXPERIMENT-JULIET

Shelley P. Gallup, Research Associate Professor

Wayne E. Meyer Institute of Systems Engineering

Sponsor: Maritime Battle Center, Navy Warfare Development Command, Naval War College

OBJECTIVE: The Wayne E. Meyer Institute of Systems Engineering (MISE), provided data-capture and analysis planning, execution and reporting, for Fleet battle Experiment-Juliet.

SUMMARY: The Naval Warfare Development Command (NWDC), in cooperation with the numbered fleets, plans and executes Fleet Battle Experiments (FBEs) through the Maritime Battle Center (MBC). The Wayne E. Meyer Institute of Systems Engineering (MISE) of the Naval Postgraduate School (NPS) developed plans for data collection and analysis design in experiment planning, then conducted data collection during execution and post experiment analysis.

MISE provided support for this program in the following elements:

- Physical Experiment Planning
- Analysis Planning
- Fleet Coordination for Analysis
- Data Capture Planning
- Data Capture
- Analysis
- Quantitative MOEs
- Knowledge Management
- Reporting

- Workshop Planning and Execution
- Modeling and Simulation
- NPS Systems

KEYWORDS: Experimentation, Operations Analysis, Knowledge Management, Concept Based Analysis, Network Centric Warfare, Time Critical Strike, Maritime Access, Ballistic Missile Defense

**CENTER FOR DEFENSE TECHNOLOGY AND EDUCATION FOR THE MILITARY SERVICES
(CDTEMS)**

William G. Kemple, Associate Professor
Susan G. Hutchins, Research Assistant Professor
Wayne E. Meyer Institute of Systems Engineering
Sponsor: U.S. Joint Forces Command

OBJECTIVE: To conduct investigations and participate in activities that support joint experimentation and enhance joint capabilities.

SUMMARY: The project team fielded a group of thirteen observer/analysts for Global 2000. The Naval Postgraduate School (NPS) team provided daily and post-game input to the J9 team and administered two surveys. In conjunction with Navy Warfare Development Command (NWDC), a concept for the ETO-to-Actions LOE was developed and conducted. The NPS team served as the lead for training and analysis. The project continued with the follow-on workshop on synchronization and effects assessment.

Planning for the final phases of the Peer-to-Peer (P2P) Wireless LOE was completed. New applications were developed to enable players with commercial-off-the-shelf (COTS) PDAs (iPaq) to automatically report their location and to display the locations of all such equipped players on an electronic map.

The NPS team initiated the generation of a web-based 3D representation of the LOE area and events, which can be viewed in collaborative, networked environments. Under other funding, this technology is also being applied to support after-action review in Force Protection LOEs and may be a subject of a future LOE for evaluation of web-based 3D visualization for collaborative mission planning. Agent-based applications were also developed to allow monitoring and repair of the wireless network.

KEYWORDS: Joint Warfare, Joint Experimentation, Knowledge Experimentation, Experimentation Courseware, Concept Modeling, Simulation, Information Warfare and Operations

TEST OF DESIGN OF SPARSE OPTICAL ARRAY

Michael E. Melich, Research Professor
Rodney Johnson, Visiting Professor
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Naval Research Laboratory

OBJECTIVE: To determine the applicability of evolutionary computing techniques to the design of a partially filled optical aperture intended to be used for imaging.

SUMMARY: “Evolutionary Computation” refers to a family of related approaches to complex computational problems that are finding a wide range of applications to design, optimization, classification, search, and adaptive control. These methods are based on ideas from biology: Darwinian natural selection and survival of the fittest. The context of this project is a larger study of the application of evolutionary and other methods to force structure planning, including the use of evolutionary computation for the conceptual design of weapon system components. In previous work, the investigators had successfully applied evolutionary computation to a problem in phased-array radar antenna design.

The proposed work is a preliminary exploration of the use of evolutionary computation in the design of sparse optical arrays for imaging, e.g. in satellite applications. The work comprises three tasks of which the first is to set up the geometries and representations for the optical aperture, design algorithms, and specify “fitness functions.” The “fitness function” is the figure of merit to be optimized by a design. Informally,

the criterion for an optical array is that a quantity known as the optical transfer function should provide “good coverage” in the domain of spatial frequencies. In the absence of an accepted explicit analytical definition of “good coverage,” it was decided to accommodate the use of several plausible “fitness functions” to permit comparison of the designs resulting from each. The second and third tasks are: (2) run the algorithm to generate candidate designs and prepare an annotated briefing of the results, and (3) present results to designated representatives of the sponsor.

KEYWORDS: Evolutionary Computing, Optical Aperture Design

UNCONVENTIONAL WEAPONS OF MASS DESTRUCTION

Michael E. Melich, Research Professor

Robert C. Harney, Senior Lecturer

Wayne E. Meyer Institute of Systems Engineering

Sponsor: Office of the Secretary of Defense

OBJECTIVE: To develop physically observable indicators and relative priorities of economically and technically feasible, and socially attractive, unconventional weapons of mass destruction (UWMD) systems or operations listed in Robert Harney’s book on UWMD. This work will reflect the competitive interaction of potential UWMD actors and the U.S. and its allies.

SUMMARY: For the past six years the Naval Postgraduate School (NPS) has conducted studies of economically, technically, and operationally feasible threats to the United States for the period 2000-2021, under the sponsorship of the Chief of Naval Operations (CNO) Executive Panel, the Office of Naval Research, and in collaboration with the CNO Strategic Studies Group. These studies have included iterative consideration of the actions of the competitors. The primary focus has been on military threats, but an integral part of the effort has been considerations of competitors with limited resources but potentially very lethal weapons. Robert Harney, a major participant in these NPS studies, has written a book entitled “Unconventional Weapons of Mass Destruction and Terrorism” (UWMD)[Harney2001]. He distinguishes UWMD as follows:

Conventional weapons of mass destruction (WMD) threats are those agents and modes of attack which have either seen significant past use by terrorist organizations or which are derived from military weapons or which have been frequently identified as serious threats. In the course of unrelated research and study into conventional WMD and into unconventional warfare, the author identified a number of threats which did not fit any definition of conventional WMD, yet possessed lethality comparable to military weapons and were readily available to terrorists. With few exceptions these unconventional threats were not being addressed by those groups attempting to curb terrorist use of WMD.

The book tabulates specific examples of 21 classes of UWMD and characterizes 15 potential users of these weapons in trying to establish the probability that they could pose a threat to the U.S.A. and her allies. In light of the terrorist attacks on the World Trade Center in New York and the Pentagon in Washington, D.C., there has been a heightened need to understand significant threats to the existence of the U.S.A. This study expanded upon Professor Harney’s work with an eye to clarifying how these threats may manifest themselves, particularly in the face of the changing attention that the U.S.A. pays to implementing countermeasures. Such clarification would permit improved targeting of intelligence collection efforts and identify countermeasures.

The study was organized and staffed to answer the following questions for each UWMD technology in Harney’s book:

- How close to weaponization is it?
- What would it take to make the weapon fully operational ... in terms of developing both technology and operational concepts?
- What are the resource allocation implications of pursuing the option?
- Who are the potential users and customers? How well does the option fit their objectives, culture and modes of operation?
- What are the observable events associated with pursuing the option?

- What exploitable vulnerabilities can be expected in (a) the development process and (b) the fully operational weapon?

KEYWORDS: Strategic Planning, Weapons of Mass Destruction, Technological Forecasting

A STRATEGY FOR DEALING WITH ISLAMIC TERRORISTS

Patrick Parker, Project Manager

Wayne E. Meyer Institute of Systems Engineering

Sponsor: Office of the Secretary of Defense

OBJECTIVE: The issues of dealing with terrorism in a world where Weapons of Mass Destruction (WMD) are becoming increasingly accessible pose a profound intellectual challenge. One approach to this challenge is to form teams of knowledgeable and experienced people working independently to develop strategic approaches to the threat to U.S. national security posed by well-armed and funded militant terrorists. The Naval Postgraduate School (NPS) formed such a team focusing on terrorism originating in or supported by the Islamic world. Attention was paid to insuring that the analyses and processes developed are applicable to a wide range of terrorist threats.

SUMMARY: Rapidly increasing access to nuclear weapons (and other WMD) combined with the rise of well-funded and supported Islamic terrorist groups has changed the defense paradigm and calls for a fundamental rethinking of our strategy, much as the advent of nuclear weapons and the rise of the Soviet threat did at an earlier time.

Today, the falling cost and growing accessibility of things that can do great harm are making it increasingly possible for small groups to inflict great damage. While terrorism is an age-old phenomenon, until now truly nation-threatening capabilities have required a national effort. It is difficult to kill a nation; witness the recoveries of Germany, Japan, and Russia after WW II. While this nation could survive a number of devastating terrorist attacks, even those involving WMD, profound social effects that would change the society and many of its underlying values would probably result. The meaning of victory or the nature of a successful endgame is unclear. Indeed, a successful one may not exist and will be difficult to define.

While focusing on terror, this project was mindful of the fact that rapid economic growth may well result in the emergence of nations with the resources to compete effectively with us in more traditional ways. Emphasis on terrorism should not ignore this, or the possibility that such nations may use covert, deniable support of terrorists to weaken us.

Independent teams working on the formulation of national strategy can assist top management in sharpening issues, directing research into areas that will make a difference in policy, and choosing successful courses of action in the face of uncertainty and imperfect information.

Protection of U.S. interests against terrorist threats is a complex undertaking because of the variety of threats, the interaction between countermeasures and the development of new threats, and the great variety of means used, both violent and non-violent.

The project characterized the enemy in the war on terror and used scenarios to identify issues and formulate strategies for dealing with a variety of possible circumstances.

KEYWORDS: Terrorism, Islamic Fundamentalism

DIRECTIONAL TRANSDUCER MEASUREMENT FACILITY

Joseph Rice, Engineering Acoustic Chair

Department of Physics

Sponsor: Space and Naval Warfare Command - San Diego

OBJECTIVE: Implement a high fidelity measurement capability in conjunction with the anechoic tanks in Spanagel Hall. Purpose of the facility is testing and calibrating experimental telesonar transducers operating in the 8-100 kHz band. This work is done in conjunction with the Navy SBIR Topic N99-011

performers, Office of Naval Research (ONR) 321SS project personnel. This work is performed as an activity of the NPS Undersea Warfare Center and involved thesis research.

KEYWORDS: Acoustics, Transducer, Telesonar, Modem, Directivity

NPS MINE AND UNDERSEA WARFARE PROGRAM

C. Scandrett, Professor
Department of Applied Mathematics
Sponsor: Naval Sea Systems Command

OBJECTIVE: The Chair of Mine Warfare was established in 1996 with a MOU between the Director, Expeditionary Warfare on the staff of the Chief of Naval Operations (CNO), the Program Executive Office for Mine Warfare, and the Naval Postgraduate School (NPS).

The Chair program is intended to enhance the academic and research content in several curricula with mine warfare related material 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 present Director, NPS Undersea Warfare Research Center.

The position operates on a continuing basis to support mine warfare acquisition and life cycle management.

ANTI-TERRORISM INFORMATION SYSTEM

Gordon E. Schacher, Professor
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Naval Criminal Investigative Service

OBJECTIVE: To complete the design and initial testing of the TATIPS information network for utilization by the Naval Criminal Investigative Service (NCIS) and Multi-Threat Alert Center (MTAC), to develop requirement for AT/FP Navy information systems designers, and report on the Area Security Command and Control System (ASOCC) test.

SUMMARY: The Naval Postgraduate School and NCIS worked together to design a web-based Anti-terrorism information system. The system is to be used by the Multi-Threat Alert Center, a new NCIS organization. The work of this project completed the design and performed initial testing of the network, developed requirements and reported in the testing.

FORCE PROTECTION EXPERIMENTATION, NON-LETHAL WEAPONS TESTING

Gordon E. Schacher, Professor
Wayne E. Meyer Institute of Systems Engineering
Sponsor: Chief of Naval Operations (N77)

OBJECTIVE: The Wayne E. Meyer Institute of Systems Engineering (MISE) conducted a series of Force Protection Limited Objective Experiments. This work added the use of Non-Lethal Weapons for the application of Continuum of Force to these experiments.

SUMMARY: The MISE at the Naval Postgraduate School and Third Fleet conducted a series of Force Protection (FP) Limited Objective Experiments (LOEs) for CINCPACFLT.

Rigorous testing of Non-Lethal Weapons (NLW) for protection of facilities and ships was added to the previous FP LOEs. This research focused on development of processes for the use of NLW and systems requirements, not on test and evaluation of specific systems.

The experimentation was done using operating forces, within an FP scenario set up specifically for this program. A scenario contains three parts:

- pre-planning, where a basic plan is set up prior to an incident such as a port visit,
- dynamic planning, where situation changes are followed prior to a terrorist incident, and

- response, where an attack occurs that requires assessing multi-source tactical information and application of a Continuum of Force.

This project dealt with the response phase of the experiments.

These experiments have two main purposes:

1. Develop and test FP information systems and processes. Their purpose is to enable dynamic planning that involves the strategic down through the tactical level.
2. Act as a test-bed for FP systems. This test-bed will provide the physical structure for testing during an operation, the scenario that supports the test goals, and insure that both support systems testing goals.

Continuum of Force (COF): This work focused on NLW within the context of COF application. To apply the COF concept, the following tasks were done synergistically:

evaluated the details of the current threat,
developed exclusion zones,
provided sensing within those zones,
had NLWs available to probe intent within the zones (and other means),
had NLWs available to enforce the zones.

Planning and executing this process must be done as a whole, not as independent parts. An LOE will focus on the information, processes, and systems needed to execute each of these tasks.

The end result of the project was requirements, CONOPS, and TTPs for COF.

The following work was done in partnership with N757.

1. Developed the specific scenarios for NLW testing for each LOE.
2. Determined the specific NLW system to be used.
3. Determined the sensors that will be used in conjunction with the NLW.
4. Extended data collection to cover NLW play.
5. Analyzed the NLW portion of the LOEs to determine system requirements and TTPs.
6. Provided a section in LOE final reports on NLW requirements and process.
7. Provided a person to be a direct liaison with the NLW program office for planning and support.

KEYWORDS: Experimentation, Non-lethal Weapons, Force Protection, Homeland Defense, Operations Analysis, Network Centric Warfare

FORCE PROTECTION LIMITED OBJECTIVE EXPERIMENT

Gordon E. Schacher, Professor

Shelley P. Gallup, Research Associate Professor

Wayne E. Meyer Institute of Systems Engineering

Sponsor: Office of Naval Research

OBJECTIVE: Plan, execute, and report findings from a series of Limited Objective Experiments (LOEs) directly related to the critical operational issue of Force Protection (FP).

SUMMARY: Force Protection (FP) is an identified Future Navy Capability (FNC), related specifically to the Navy's perceived future access mission. Recent events have underscored the need to understand and implement appropriate capabilities in FP. The LOEs are directed at understanding the means to utilize and enhance organic ship capabilities in a range of conditions, using information technologies.

The proposed Dynamic Port Assessment (DPA) provides timely and useful information directly to a Navy ship prior to visiting a specific port. Improved situational awareness capabilities combined with the DPA must be coordinated with defense in depth, other USN ships in port, innovation in the use of shipboard weapons capabilities, and host nations. This LOE series resulted in the development and identification of processes and technologies that permit a coordinated and dynamic capability in FP. The FP LOEs addressed the urgent operational requirements for Commander in Chief Pacific Fleet, developed a "Community of Interest" and process to respond to emergent operational needs of Fleet Commanders, and designed a "road ahead" for experimentation to address future FP scenarios.

KEYWORDS: Force Protection, Network Centric Warfare, Knowledge Management

NFN FLEET IMPLEMENTATION, SYSTEMS AND PROCESS ANALYSIS

Gordon E. Schacher, Professor

William G. Kemple, Associate Professor

Wayne E. Meyer Institute of Systems Engineering

Sponsor: PMA 454

OBJECTIVE: The Wayne E. Meyer Institute of Systems Engineering (MISE) planned, managed, and participated in a series of studies directly related to the modeling, analysis, and fielding of the Navy Fires Network (NFN) system. In the first year of the program, FY02, MISE coordinated with the program office and Third Fleet to develop a set of project objectives and design the study plan to meet those objectives. A broad range of objectives was addressed, from system interoperability and performance to TTPs and training. Project results are applicable to NFN inclusion in all Fleets.

SUMMARY: The Naval Fires Network (NFN) is a prototype system that is being tested by 3rd Fleet for incorporation as the principal delivery means for fire control solutions. Its implementation has been supported by Limited Objective Experiments (LOEs) and Fleet Battle Experiment-India (FBE-I) results. Those experiments provided preliminary information for this project. Relevant lessons learned have been generated and Time Critical Strike CONOPS examined through this integration of TES-N with the Navy's current exploitation, targeting, and communications systems.

This project will consist of a number of information capture venues, workshops, games, simulation, and field experiments. These will be designed to meet a set of NFN program office and Fleet needs. A broad range of objectives will be addressed, from system performance and interoperability to TTPs and training.

The MISE provided data capture and analysis for the FBE series. Information that was obtained during those experiments provided some preliminary information for this project

NFN is currently being installed on Third Fleet ships. Thus, the proposed investigations will occur concurrent with demonstration, rapid fielding, and implementation of the system on carriers, flagships, combatants, and submarines.

This project gathered information and data through experiments. Experiment was meant in the broad sense, including workshops, games, simulation, system level laboratory experiments, and operational field experiments. Central foci of the experiments were:

- Operational Requirements
- Information Content Requirements
- Information Distribution Requirements
- Command Relationships and Decision Processes
- Human Situation Awareness
- Decision Support Systems

Considerable emphasis was placed on understanding and quantifying benefits that NFN brings to the Navy Fires (TCT/TST) process. This was done by comparing current system and process capabilities with those provided by NFN. Included were any new processes that would be put in place in order to implement NFN.

Implementing NFN installation and use on ships required a wide range of actions. The following is a list of considerations, in broad categories, which must be addressed. Those covered in this project are indicated.

Hardware Installation	
System Architecture Design	
Process Architecture Design	(Covered)
Configuration Requirements	(Covered)
System Utilization Processes	(Covered)
Hardware System T&E	
Process T&E	(Covered)
Human Factors	(Covered)
Training Requirements	(Covered)
CONOPS and TTPs	(Covered)

The NFN implementation program has a broad range. The main activities for this initiation year of this multi-year project were to determine which of those needs were addressed and to develop a comprehensive project plan.

Task 1. Identify NFN project stakeholders (within OPNAV, SYSCOMS, Fleets). Determine from those stakeholders their objectives for this project.

Task 2. Develop a preliminary NFN study plan to meet stakeholder objectives. This plan is to include needed experimentation events, participating organizations, and required outputs.

Task 3. Work with PMA 454 to finalize the study plan.

Task 4. Identify those areas within the study plan that are appropriate for IDSEA participation or management. Prepare an FY03 proposal to support those activities and forward to PMA 454.

A secondary FY02 task is to examine FBE and LOE experimentation to date and determine what available information can be used for this project.

Task 5. Examine experimentation information previously produced by IDSEA, and information from FBE-J and MC02, to determine if results are present which can be used for this project. Archive this information to be used for this project. Reporting on such results is not expected to occur until FY03.

KEYWORDS: Naval Fires Network (NFN), TES-N, AFATADS, JSIPS, PTW+, EPPIC, Network Centric Warfare, Knowledge Management, Systems Engineering, Systems Acquisition

**WAYNE E. MEYER
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**2002
Faculty Publications
and Presentations**

PUBLICATIONS

Chu, P.C., Lan, J. and Strauhs, H., "2000: A Numerical Simulation of the Japan/East Sea (JES) Seasonal Circulation," *Estuarine and Coastal Modeling*, American Society of Civil Engineering, Vol. 6, pp. 94-113, 2002.

CONFERENCE PAPERS

Diedrich, F.J., Hocevar, S.P., Entin, E.E., Hutchins, S.G., Kemple, W.G. and Kleinman, D.L., "Adaptive Architectures for Command and Control: Toward an Empirical Evaluation of Organizational Congruence and Adaptation," *Proceedings of the 2002 Command and Control Research and Technology Symposium*, Naval Postgraduate School, June 2002.

Diedrich, F.J., Hocevar, S.P., Hutchins, S.G., Kemple, W.G., Kleinman, D.L. and Entin, E.E., "Divisional Versus Functional Organizations: Analysis of a Concept Experiment," *Proceedings of the Command and Control Research and Technology Symposium*, Naval Postgraduate School, 11-13 June 2002, (submitted).

Hutchins, S.G., Kemple, W.G., Adamo, R. and Boger, D., "Knowledge Management and Collaboration in an Effects-based Operations Environment," *Proceedings of the 2002 Command and Control Research and Technology Symposium*, Naval Postgraduate School, 11-13 June 2002.

Hutchins, S.G., Kemple, W.G., Adamo, R., Boger, D. and Nelson, B., "Comparison of Two Collaboration Tool Suites Developed to Support Joint Command and Control Planning and Decisionmaking," *Proceedings of the Command and Control Research and Technology Symposium*, Naval Postgraduate School, 11-13 June 2002.

Hutchins, S.G., Kemple, W.G., Adamo, R., Boger, D., Nelson, B.W. and Penta, H.L., "Collaboration Tool Suites Developed to Support Joint Command and Control Planning and Decisionmaking," *Proceedings of the 2002 Command and Control Research and Technology Symposium*, Naval Postgraduate School, 11-13 June 2002.

Hutchins, S.G., Kemple, W.G. and Boger, D., "Knowledge Management and Collaboration in an Effects-based Operations Environment," *Proceedings of the 7th International Command and Control Research and Technology Symposium*, Quebec, Canada, 16-20 June 2002, (accepted).

Kemple, W.G., Hutchins, S.G., Adamo, R. and Boger, D., "Effects-based Planning: An Empirical Examination of the Process," *Proceedings of the 2002 Command and Control Research and Technology Symposium*, Naval Postgraduate School, 11-13 June 2002.

Kemple, W.G., Hutchins, S.G., Adamo, R., Boger, D. and Crowson, J.J., "Effects-based Planning and Assessment: An Empirical Examination of the Process," *Proceedings of the Command and Control Research and Technology Symposium*, Naval Postgraduate School, 11-13 June 2002.

Thate, T., "'Focused Logistics' to Support 'Rapid Decisive Operations,'" *10th Annual Warehouse of the Future (WoF2002)*, Orlando, FL, 24-26 June 2002.

Thate, T., "Identifying Collaborative Tools for Combined Joint Task Force 'Focused Logistics' to Support 'Rapid Decisive Operations,'" *Fourth International Conference on Electronic Commerce Research (ICECR-4)*, Dallas, TX, 8-11 November 2001.

CONFERENCE PRESENTATIONS

Bordetsky, A., Cook, G.R., Kemple, W.G. and Thate, T., "A Limited Objective Experiment on Wireless Peer-to-Peer Collaborative Networking," 7th ICCTRS, Quebec, Canada, September 2002.

Bordetsky, A., Cook, G.R. and Thate, T., "Experimental Study of Operating Wireless Peer-to-Peer Collaborative Networks: Lessons Learned at GIGA CODE Lab," Cebrowski Institute Symposium, Naval Postgraduate School, 30 July 2002.

Bordetsky, A., Cook, G.R. and Thate, T., "Managing Wireless Peer-to-Peer Collaborative Networks," 10th International Conference in Telecommunication Systems Modeling and Analysis, Naval Postgraduate School, October 2002.

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

**MICHAEL ZYDA
DIRECTOR**

MODELING, VIRTUAL ENVIRONMENTS AND SIMULATION

OVERVIEW:

Our mission is research, application and education in the grand challenges of Modeling, Virtual Environments and Simulation (MOVES).

The MOVES Institute operates independently and in collaboration with various U.S. Navy and defense modeling and simulation centers to:

- Carry out basic and applied research
- Analyze continuing Modeling, Virtual Environments and Simulation programs
- Create advanced prototypes
- Develop real technologies and applications for the defense community

CURRICULUM SERVED:

- Modeling, Virtual Environments and Simulation

DEGREE GRANTED:

- Master of Science in Modeling, Virtual Environments and Simulation

FACULTY EXPERTISE:

- Virtual Environments:
Professor Michael Zyda, Military Instructor CDR Russell Shilling, Lecturer Perry McDowell, Senior Lecturer John Falby, Associate Professor Rudolph Darken, Professor Peter Chu, Research Assistant Professor Michael Capps, and Associate Professor Donald Brutzman
- Modeling Simulation:
Research Associate Professor Wolfgang Baer, Research Associate Curtis Blais, Professor Gordon Bradley, Distinguished Professor Donald Gaver, Research Professor John Hiles, Professor Patricia Jacobs, Associate Professor Thomas Lucas, Associate Professor Neil Rowe, Professor James Taylor, and Associate Professor Xiaoping Yun
- Human Factors:
Research Assistant Barry Peterson, Professor Robert McGhee, Lecturer Eric Bachmann, Associate Professor Rudolph Darken
- Security:
Associate Professor Cynthia Irvine
- Communications/Networks:
Assistant Professor Geoffrey Xie and Professor Nancy Roberts

RESEARCH THRUSTS:

3D VISUAL SIMULATION

- **3D Visual Simulation** - Virtual naval gunfire support. Immersive ship walkthroughs - damage control virtual environments. Littoral zone warfare. Building and Urban Walkthroughs - urban warfare, hostage extraction, operations other than war. Ocean environment tactical visualization. C4I/IW information visualization. Game-engine utilization and handheld visual simulation delivery systems. Synthetic ocean environment simulations.
- **XML/X3D** - Use of Extensible Markup Language (XML) for deploying 3D M&S products over DoD messaging systems, creating interoperable behavior streams, gaining database schema interoperability, and defining ontologies for software agent interactions compatible with deployed C4I and combat control systems.

NETWORKED VIRTUAL ENVIRONMENTS

- **Multicast and Area of Interest Managers** - Software architectures for facilitating the development of large-scale, media-rich, interactive, networked VEs.
- **High Bandwidth Networks** - Experimentation and utilization of next-generation Internet technologies for large-scale, networked virtual environments, and collaborative M&S development and application.
- **Wireless** - Handheld delivery systems.
- **Latency-reduction** - Techniques for predictive modeling in distributed simulations.
- **VE Architectures for Interoperability** - Network software architectures for scalability, composability and dynamic extensibility.
- **Standards for Interoperability** – High Level Architecture; Next Generation RTI; Web-based interoperability. Standards for streamed interactive 3D as an automatically created component for joint message systems. Guiding M&S standards interoperability efforts with the Web3D Consortium, World Wide Web Consortium and MPEG4 Streaming Group.

COMPUTER-GENERATED AUTONOMY

- **Agent-based Simulation** - Computer-generated characters that accurately portray the actions and responses of individual participants in a simulation. Adaptability - computer generated characters that can modify their behavior automatically. Learning - computer generated characters that can modify their behavior over time. Organizational modeling.
- **Story Line Engines** - Content production and simulation prototyping. Technologies for autonomous, real-time story direction and interaction.
- **Human Representations and Models** - Authentic avatars that look, move, and speak like humans.
- **Modeling Human and Organizational Behavior** - Integrative architectures for modeling of individuals, including neural networks; rule-based systems, attention and multitasking phenomena, memory and learning, human decision-making, situation awareness, planning, behavior moderators, modeling of behavior of organizational units, modeling of military operations, and modeling of information warfare.

HUMAN-COMPUTER INTERACTION

- **Training in the Virtual Environment** - Fidelity requirements for wayfinding in the virtual environment. Developing virtual environments for training. Evaluating virtual environments for their utility in training.
- **Intelligent Tutoring Systems** - Developing experts via the use of computer-based virtual environments.
- **Human Factors in Virtual Environments** - Multimodal interfaces, task analysis, spatial orientation and navigation, performance evaluation, interaction techniques, interaction devices, virtual ergonomics, cybersickness, usability engineering, training transfer, human perception.

TECHNOLOGIES FOR IMMERSION

- **Image Generation** - Real-time, computer graphic generation of complex imagery, HDTV, DVD, next generation delivery systems, novel display technologies, handheld and body-worn devices.
- **Tracking** - Technologies for keeping track of human participants in virtual environments.
- **Locomotion** - Technologies that allow participants to walk through virtual environments while experiencing hills, bumps, obstructions, etc.
- **Full Sensory Interfaces** - Technologies for providing a wide range of sensory stimuli: visual, auditory, olfactory, and haptic.
- **Novel Sound Systems** – The generation and delivery for both interactive and recorded media. Spatial sound. Immersive sound and psychoacoustics.

MODELING, VIRTUAL ENVIRONMENTS AND SIMULATION

DEFENSE AND ENTERTAINMENT COLLABORATION

- **Technology Transition** - Adapt technologies and capabilities from the entertainment industry.
- **Game-Based Learning** - Distance learning via the use of game technology and development.
- **Internet and Game Delivery Systems** - SimNavy, Army Game Project, SimClinic, SimSecurity.

NEXT GENERATION MODELING

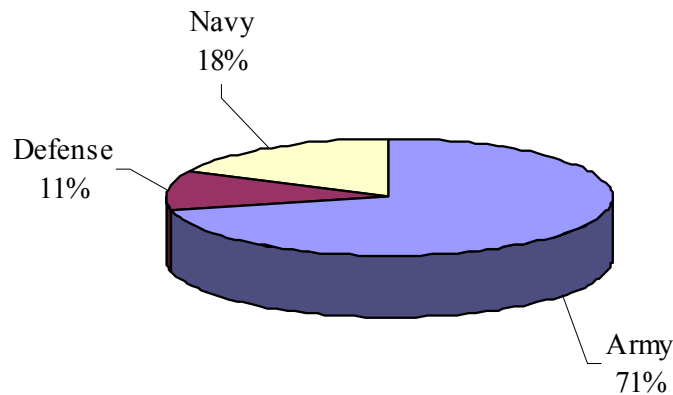
- **Modeling and Simulation** - Dynamic and state space modeling for information warfare and information operations. High-resolution combat models. High-level aggregate models. Network centric warfare. Agent-based simulation. Physically-based modeling to insure physical realism underlies the VR. Theater, tactical and campaign level modeling. Sensor modeling. Architectures for future combat modeling systems.
- **Navy Cyberspace** - Full end-to-end simulation of the ocean environment including subsurface surface, air and space. Oceanographic data sets and models. Tactical databases. Interoperability with live ship tracking message systems. Reusable, in the small or in the large, by fleet assets. Underwater robots. Interoperability with global command and control systems.
- **Current Programs in Combat Modeling** – JSIMS Maritime Battlespace, Naval Simulation System, JSIMS, JWARS, JMASS, OneSAF, HLA, Computer-Generated Forces.

TECHNOLOGY TRANSITION

- Technology transition is part of the MOVES Institute. CRADAs with industry are encouraged as well as the licensing of institute generated intellectual property.

SPONSORED RESEARCH PROGRAMS (Research and Academic)-FY2002:

The Naval Postgraduate School's sponsored program exceeded \$61 million in FY2002. 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: \$7,845K

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MODELING AND SIMULATION TECHNICAL SUPPORT

Curtis L. Blais, Research Associate

Modeling, Virtual Environments and Simulation Institute

Sponsor: Space and Naval Warfare Command -San Diego

OBJECTIVE: The Naval Postgraduate School provides technical consultation for specification and design of Marine Corps specific capabilities in the next-generation command staff training system, the Joint Simulation System (JSIMS). JSIMS will be used by the U.S. Marine Corps in joint exercises.

KEYWORDS: Modeling and Simulation, Amphibious Operations, JSIMS

EXTENSIBLE MODELING AND SIMULATION (XMSF): ESTABLISH REQUIREMENTS, DEVELOP EXEMPLARS

Donald Brutzman, Associate Professor

Michael Zyda, Professor and Director

Modeling, Virtual Environments and Simulation Institute

Sponsor: Defense Modeling and Simulation Office

OBJECTIVE: The objective of this project was to conduct a series of workshops to explore technical opportunities and strategic priorities related to the use of Extensible Modeling and Simulation Framework (XMSF) as a framework that can be applied to simulation of operational tactical systems. The Naval Postgraduate School conducted this research in partnership with George Mason University and Science Applications International Corporation.

SUMMARY: This work involved scoping a DoD-scale strategy for the web-compatible XMSF framework, enumerating a family of technical components, languages and specifications in a white paper. The white paper served as entry point for a workshop of invited expert researchers to identify available technical opportunities and refine framework requirements. Workshops resulted in specific recommendations for a leadership symposium in Washington, DC to solicit feedback from the Defense Modeling and Simulation Office (DMSO), service M&S management offices, uniformed operational representatives and the Office of the Secretary of Defense. A suite of exemplar applications was demonstrated in December 2002 in Orlando, Florida, at the Interservice/Industry Training, Simulation and Education Conference (I/ITSEC).

KEYWORDS: Extensible Modeling and Simulation Framework, XMSF

GENERIC HUB: XML-BASED INFORMATION INTERCHANGE FOR DEFENSE MESSAGING, SHIPBOARD/THEATRE COMMAND AND CONTROL, DISTRIBUTED 3D BATTLESPACE VISUALIZATION

Donald Brutzman, Associate Professor

Modeling, Virtual Environments and Simulation Institute

Sponsor: Naval Undersea Warfare Center Newport Division

OBJECTIVE: The Naval Postgraduate School (NPS) has long been a leader in exploring new technologies for large-scale virtual environments and DoD distributed simulation. Recent results in Extensible (X3D) graphics and Web3D GEOVRML has enabled wide-scale distribution of georeferenced 3D scenes. NPS and the DIS-JAVA-VRML working group have produced georeferenced tactical 3D simulations using distributed interactive simulations (DIS) networking. NPS work has further shown that XML-based military operations orders can be adapted to automatically generate matching 3D virtual environments.

MODELING, VIRTUAL ENVIRONMENTS AND SIMULATION

NPSNET-V - SEMANTIC INTEROPERABILITY FOR LARGE-SCALE NETWORKED VIRTUAL ENVIRONMENTS

Donald Brutzman, Associate Professor
Don McGregor, Computer Specialist
Michael Zyda, Professor and Director
Michael Capps, Research Assistant Professor
Modeling, Virtual Environments and Simulation Institute
Sponsor: Chief of Naval Operations (N6M)

RENDERING DYNAMIC STRUCTURES USING WEB-CAPABLE 3D MODELS FOR MILITARY SIMULATIONS

Donald Brutzman, Associate Professor
Modeling, Virtual Environments and Simulation Institute
Sponsor: U.S. Army TRADOC Analysis Command

STREAMING 3D GRAPHIC USING VRTP FOR DISTRIBUTED SIMULATION

Donald Brutzman, Associate Professor
Modeling, Virtual Environments and Simulation Institute
Sponsor: Defense Threat Reduction Agency

OBJECTIVE: The Naval Postgraduate School (NPS) and the George Mason University (GMU) C3I Center Networking and Simulation Laboratory have been leaders in exploring new technologies for DoD distributed simulation. Both groups have worked in the areas of virtual environments, network protocol support and multi-platform software tools based on web browsers and Java.

NAVAL SURFACE SUPPORT FOR JOINT LAND WARRIOR

Alexander J. Callahan, Jr., Research Assistant Professor
Department of Information Science
Curtis L. Blais, Research Associate
Modeling, Virtual Environments and Simulations Institute
Sponsor: Naval Surface Warfare Center, Crane Division

OBJECTIVE: This study provided an analysis of the methodology to evaluate the effective use of Naval surface gunfire support of the Joint Land Warrior in expeditionary maneuver warfare. The scope included the use of modeling and simulation techniques recently developed for the Naval Simulation System (NSS) and other appropriate analytic systems.

ADAPTIVE MONITORING AND VALIDATION OF AGENT-BASED SYSTEMS

Michael Capps, Research Assistant Professor
John Hiles, Research Professor
Modeling, Virtual Environments and Simulation Institute
Sponsor: Chief of Naval Operations (N6M)

SYNTHETIC OCEAN FOR MODELING, VIRTUAL ENVIRONMENTS, AND SIMULATION (MOVES) USING THE ARCVIEW GEOGRAPHIC INFORMATION SYSTEM (GIS)

Peter C. Chu, Professor
Modeling, Virtual Environments and Simulation Institute
Sponsor: Chief of Naval Operations (N6M)

MODELING, VIRTUAL ENVIRONMENTS AND SIMULATION

ATC PROCEDURES FOR SIMULTANEOUS NON-INTERFERING FLIGHT WITHIN THE NATIONAL AIRSPACE SYSTEM

Rudolph P. Darken, Associate Professor

CDR Joseph Sullivan, USN

Department of Computer Science

Modeling, Virtual Environments and Simulation Institute

Sponsor: Federal Aviation Administration

OBJECTIVE: The objective for this program was to study air traffic patterns in order to compare rotary wing navigation using feature navigation vice GPS or instrument navigation. If it could be shown that GPS navigation improved the variance on flight, the FAA would have an opportunity to condense traffic patterns by moving flight paths closer together in space and time. This study provided simulation capabilities. Other partners first executed a detailed experiment gathering GPS data and data on eye movement (scan patterns) of pilots on a complex navigation route. This study then replicated the experiment in a virtual environment to determine the closeness in performance. If it did, then simulation could be used to experiment with a variety of new traffic patterns that would be impossible to study in the air.

SUMMARY: The kick-off to this program began very late in FY02. Databases were built for the experiment. Construction of the cockpit assembly began, utilizing much of the same equipment used in another program.

THESIS DIRECTED:

Thien, R., "Realistic Airspace Simulation Through the Use of Visual and Aural Cues," Master's Thesis, Naval Postgraduate School, June 2002.

KEYWORDS: Training, Virtual Environment, Simulation

EXPLANATIONS USED IN TUTORING

Rudolph P. Darken, Associate Professor

Department of Computer Science

Modeling, Virtual Environments and Simulation Institute

Sponsor: Defense Advanced Research Projects Agency

OBJECTIVE: This project was about bringing aspects of real human to human interaction typical in military training, into virtual environments (VE). The vision was to provide a mentor/apprentice relationship in VE training similar to that in real military training. Through an idea called "experiential replay," episodes were captured in simulation and could later be replayed for a novice trainee.

SUMMARY: This project began with an idea concerning why virtual tutoring tends to be less than personal. Virtual tutoring is limited to very simple direction or adjustments to performance or behavior with very little, if any, insight into why the behaviour might be occurring. This is very counter to how real training occurs, especially in the military. There is typically a relationship where the trainee is coached, not through declarative knowledge but rather through specific learning examples – call them "war stories" – where the specifics of a given situation are to be generalized and then applied to a new situation. This study captured episodes in simulation and then made them available to trainees in a learning environment as replays of that situation where the trainee learned from the specifics and then reapplied the learning point to a new situation.

THESIS DIRECTED:

Desypris, G., "Enhancement of Learning Process in Web-based Courses Using Combined Media Components," Master's Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: Training, Virtual Environment, Simulation

MV-22 CREW TRAINING FOR DEPLOYED EXPEDITIONARY FORCES: MARINE CORPS AIR TO GROUND OPERATIONS

Rudolph P. Darken, Associate Professor

CDR Joseph Sullivan, USN

Department of Computer Science

Modeling, Virtual Environments and Simulation Institute

Sponsor: Office of Naval Research

OBJECTIVE: The purpose of the Virtual Technologies and Environments (VIRTE) program was to develop deployable trainers for Navy and Marine Corps expeditionary warfare. The Naval Postgraduate School (NPS) portion of the program is helicopters, but NPS work has not been platform specific so that results may be applied to any rotary or tiltrotor aircraft. The objective was to first identify training opportunities and then prototype a training system that could subsequently be evaluated for training transfer and therefore, value to the fleet.

SUMMARY: The VIRTE program is a multi-year program built in three phases. This study represented the first phase having to do with vehicle simulation. This project's achievements this year included:

Completion of the VEHELO prototype that utilized Chromakey technology to augment the actual cockpit controls with a virtual environment. Video signals from a helmet-mounted camera were mixed with the virtual environment generated on an image generator to form an aggregate image that "passes through" all video except what the pilot would see through the glass. This was replaced with simulation.

An experiment was completed showing that the VEHELO apparatus can be used effectively in simulation allowing the pilot to accurately navigate overland in a complex environment. While this was not a training transfer study, the experiment did show that performance was similar to real world performance.

An experiment was completed studying the effect of low level surface detail on the ability of an experienced helicopter pilot to hold a hover. This is a primary reason many simulations fail for helicopters.

As a further part of work for the Office of Naval Research (ONR), this project looked ahead to the second and third demonstration which address close quarters battle and combined arms respectively. This work included the following:

Completion of a cognitive task analysis of close quarters battle (CQB). This was very detailed and is being used by other participants in the program who are less knowledgeable in CQB, in order to assure that they are training the correct aspects of the task.

Completion of a simple prototype trainer for CQB based on a home grown game engine. An instrumented weapon, head-tracker, and head mounted display was used in implementation. The study's objective was to show how small the trainer could be made and still have it be a practical training tool of use to the fleet.

PUBLICATION:

Cockayne, W. and Darken, R.P., "The Application of Human Ability Requirements to Virtual Environment Interface Design and Evaluation," *Handbook of Task Analysis for Human-Computer Interaction*, D. Diaper and N. Stanton, N. (Eds.), 2003.

THESES DIRECTED:

Arisut, O., "Effects of Navigation Aids on Human Error in a Complex Navigation Task," Master's Thesis, Naval Postgraduate School, March 2002.

Aronson, A., "A Cognitive Task Analysis for Close Quarters Battle," Master's Thesis, Naval Postgraduate School, September 2002.

List, R., "A Rendering System Independent High Level Architecture Implementation for Networked Virtual Environments," Master's Thesis, Naval Postgraduate School, September 2002.

Peitso, L., "Visual Field Requirements for Precision Nap-of-the-Earth Helicopter Flight," Master's Thesis, Naval Postgraduate School, September 2002.

Reece, J., "Virtual Close Quarters Battle (CQB) Graphical Decision Trainer," Master's Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: Training, Virtual Environment, Simulation

VIRTUAL AT-SEA TRAINER
Rudolph P. Darken, Associate Professor
CDR Joseph Sullivan, USN
Department of Computer Science
Modeling, Virtual Environments and Simulation Institute
Sponsor: Chief of Naval Operations (N61M)

OBJECTIVE: The Virtual At-Sea Trainer (VAST) was a quick start ONR program to show that it was possible to create a virtual range for Naval Surface Fire Support (NSFS). With actual ranges being closed, a replacement for this training will be needed. The VAST project was successful but opened a number of interesting problems when considering expanding the program to actual fleet-ready trainers. One aspect of the trainer that did not receive much attention in the initial program was the role of the Forward Observer (FO). The objective of this project was to investigate the role of the FO and to design and implement a prototype trainer interface for the FO.

SUMMARY: The project began with a full-scale cognitive task analysis to determine exactly how the job of an FO is done under a variety of conditions. The purpose here was to determine (A) what the training opportunities are, and (B) how to map a proper interface to the task such that execution in the simulator closely matches actual execution. Completing this analysis, a prototype training system was implemented and then an experiment was conducted to show that performance in the simulator approximates actual performance at the schoolhouse. The next phase will be to link this trainer to the helicopter trainer to begin to study the Forward Air Controller (FAC) role in combined arms exercises.

THESIS DIRECTED:

Brannon, D. and Villandre, M., "The Forward Observer Personal Computer Simulator (FOPCSIM)," Master's Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: Training, Virtual Environment, Simulation

ANALYTICAL DECISION-SUPPORTING RESEARCH USING SYNTHESIZED ADAPTIVE-AGENT-BASED MODELING AND MATHEMATICAL MODELING

Donald P. Gaver, Jr., Distinguished Professor
Patricia A. Jacobs, Professor
John Hiles, Research Professor
Modeling, Virtual Environments and Simulation Institute
Sponsor: Chief of Naval Operations (N6M)

OBJECTIVE: The purpose of this research was to provide analytical and information to support decision making; to provide mathematical and probabilistic/statistical input to the Adaptive Agent-Based Modeling (A-A-BM) process that will connect it efficiently, tightly and informatively to the decision-making process.

SUMMARY: This work applied mathematical methods to quantify the interactive and adaptive behavior of cooperating and opposed groups (populations) of agents that operate under realistic constraints – limited and error-susceptible sensors, and intelligence and communication system information, in part because of enemy deception (decoys). Mathematically/analytically modeling the behavior of numbers of similar agents in terms of state variables and state transitions, interacting with A-A-BM simulation experiments, shortens the time to achieve a general understanding of large system behavior. This work shall continue to

MODELING, VIRTUAL ENVIRONMENTS AND SIMULATION

apply hybrid (A-A-BM and mathematical/analytical) modeling to various generic Navy and Joint military-significant areas: logistics, maintenance and repair, combat, and acquisition issues (e.g., whether to upgrade or replace, adopt a concept of operations, how to conduct affordable entire system testing, etc.). Generic examples of areas for use of hybrid modeling are planning and executing reconnaissance/scouting operations, and, more broadly, to understand and define the value of Network-Centric Warfare and Information Operations. The project results were documented in technical reports and papers, student theses, and software for use by decision makers.

KEYWORDS: Adaptive Agent-Based Modeling, Hybrid Modeling, Mathematical Modeling

NPS-MOVES AGENT ARCHITECTURE

John Hiles, Research Professor

Rudolph P. Darken, Associate Professor

Curtis L. Blais, Research Associate

Modeling, Virtual Environments and Simulation Institute

Sponsor: Defense Advanced Research Projects Agency

OBJECTIVE: The purpose of this work was to perform research into modeling of complex and adaptive behaviors for application to military modeling and simulation (M&S) and Command and Control (C2). The work focused on evaluation of the Naval Postgraduate School (NPS) multi-agent system architecture in relation to the Defense Advanced Research Projects Agency (DARPA) control of agent-based system (CoABS) program approach. NPS provided consultation to the DARPA CoABS program on complementary areas of research and where NPS concepts enhanced previous and ongoing CoABS agent-based work.

KEYWORDS: Agents, Agent-based Simulation, Multi-agent Simulation, Agent Architecture, Computer-generated Autonomy

CENTER FOR THE STUDY OF POTENTIAL OUTCOMES

Ted Lewis, Professor

Modeling, Virtual Environments and Simulation Institute

Sponsors: Naval Postgraduate School, Office of Naval Research

DC TRAINER EXPERIMENT

Perry McDowell, Lecturer

Modeling, Virtual Environments and Simulation Institute

Sponsor: Office of Naval Research

HYBRID INERTIAL MOTION TRACKING FOR INSERTING HUMANS INTO NETWORKED SYNTHETIC ENVIRONMENTS

Robert B. McGhee, Professor

Eric Bachmann, Lecturer

Xiaoping Yun, Associate Professor

Modeling, Virtual Environments and Simulation Institute

Sponsor: Chief of Naval Operations (N6M)

OBJECTIVE: The purpose of this research was to produce a fully wireless body tracking system that allows tracking of the posture and location of human subjects over a wide area for the purpose of inserting them into networked virtual environments. The major focus in the near term included improvements to the MARG sensor design, further refinement of the quaternion filter algorithm, elimination of all encumbering wires within the system and the creation of realistic avatars that can be efficiently rendered as well as sized for particular individuals.

SUMMARY: Currently, each magnetic/angular rate/gravity (MARG) sensor outputs nine analog signals representing nine axis measurements. These outputs are connected by a cable to an A/D converter board residing in a desktop PC. As a result, the user of the MARG sensors is tethered. This research involved a two-phased effort to untether the user and eliminate all wires on the body of the user. In the first phase, a preliminary prototype was implemented using a ViA II wearable PC equipped with a Cisco Aironet 350 wireless LAN adaptor and a 12-bit A/D converter. Preliminary results indicated that the average bandwidth of the wireless LAN is sufficient for the application, but the network latency causes jittering movements of the avatar implemented on the desktop PC. Further investigation was planned. The goal of the second phase was to remove the cables connecting sensors to the wearable PC, thereby making the system less cumbersome to use.

KEYWORDS: MARG, Wireless Body Tracking System

COUNTERPLANNING IN SIMULATION OF INFORMATION WARFARE

Neil C. Rowe, Professor

Modeling, Virtual Environments and Simulation Institute

Sponsor: Chief of Naval Operations (N6M)

OBJECTIVE: The purpose of this study was to develop methods for counterplanning, or planning to obstruct plans, of an enemy attacking a computer system with objective to compromise the system, disable the system, or extract secrets.

SUMMARY: This work addressed "counterplanning", or planning to inhibit, complicate, or thwart existing planning, in the domain of information warfare. Work in FY02 focused on techniques for efficient determination of counterplanning "ploys", specific atomic tactics that can be used to interfere with an existing complex multi-agent plan. This work has developed a tool MECOUNTER that builds on the existing tool MEAGENT for multi-agent simulation with hierarchical planning in worlds with significant levels of uncertainty, work that has resulted in tools usable to analysts and planners without significant expertise in discrete-event simulation or artificial intelligence. MECOUNTER can analyze an existing MEAGENT simulation for quantitative assessment of counterplanning opportunities. A key challenge was in making the analysis efficient so that every possible combination of ploy and state need not be considered, while still ensuring that the optimal ploy opportunities are not missed. For this, three key inference methods were developed that significantly prune the counterplanning analysis. Methods were tested in experiments involving many runs of carefully modified simulations, using the results to quantify the effects of various counterplanning tactics, and then produce a counterplan. This approach was exemplified for the domain of loosely coordinated hacker attacks on a computer system. This study's methods provide a way to provide intelligent software decoys for a second line of defense (after intrusion-detection systems) during information-warfare attacks.

PUBLICATIONS:

Andrade, S., Rowe, N., Gaver, D. and Jacobs, P., "Analysis of Shipboard Firefighting-team Efficiency Using Intelligent-agent Simulation," *Proceedings of the Command and Control Research and Technology Symposium*, Monterey, CA, June 2002.

Rowe, N. and Andrade, S., "Counterplanning for Multi-agent Plans Using Stochastic Means-ends Analysis," *Proceedings of the IASTED Artificial Intelligence and Applications Conference*, pp. 405-410, Malaga, Spain, September 2002.

Rowe, N., Michael, J., Auguston, M. and Riehle, R., "Software Decoys for Software Counterintelligence," *Inewsletter*, Vol. 5, No. 1, pp. 10-12, Spring 2002.

THESIS DIRECTED:

Julian, D.P., "Delaying-Type Responses for Use by Software Decoys," Master's Thesis, Naval Postgraduate School, September 2002.

KEYWORDS: Planning, Counterplan, Multi-agent Systems, Computer Systems, Hackers, Security, Compromise, Attacks, Information Warfare

**AUDIO DESIGN PRINCIPLES FROM THE ENTERTAINMENT INDUSTRY AND HIGH END
AUDIO SERVERS APPLIED TO NAVY AND MARINE CORPS TRAINING**

**LCDR Russ Shilling, USN, Military Faculty
Rudolph P. Darken, Associate Professor
Modeling, Virtual Environments and Simulation Institute
Sponsor: Office of Naval Research**

OBJECTIVE: A library of professional sound effects and sound ambiances for both Demo I and Demo II was compiled. The goal was to enhance the training effectiveness and sense of immersion and realism of the simulation. Pertinent sound effects that are not available in professional sound libraries were identified and custom recordings were made as appropriate. Additionally, two audio servers, the AuSim Goldserver and the Lake Huron, were evaluated to ascertain whether they meet the needs of Demo II for producing a realistic sound environment in a multi-user system.

KEYWORDS: Training, Virtual Environments, Simulation, Spatial Audio

AUDIO TECHNOLOGY AND MANAGEMENT IN MODERN NAVY SYSTEMS

**LCDR Russ Shilling, USN, Military Faculty
Modeling, Virtual Environments and Simulation Institute
Sponsor: Office of Naval Research**

OBJECTIVE: The purpose of this research was to develop and test advanced audio technology and an interactive audio management user interface for advanced operational Navy workstations and other Navy applications.

KEYWORDS: Audio Technology, Interactive Audio Management Users Interface

**DEVELOPING AN AUDIOMETRIC MEASURE TO ASSESS LOCALIZATION
PERFORMANCE FOR VIRTUAL ENVIRONMENTS AND SPATIALIZED AUDITORY
DISPLAYS**

**LCDR Russ Shilling, USN, Military Faculty
Modeling, Virtual Environments and Simulation Institute
Sponsor: Office of Naval Research**

OBJECTIVE: The proposed project is a three year effort. During the first year, various combinations of audio equipment were evaluated to determine the appropriateness for use in spatialized audiometry tasks. In addition, appropriate psychophysical tasks were identified for use in an audiometric test of headphone localization. Perceptual comparisons were made between off-the-shelf audio equipment and specialized spatial audio equipment to determine whether off-the-shelf components were adequate for testing localization ability. Companion systems were created and data collected at Boston University with a leading expert in spatial auditory perception. The second year's effort will use what is learned during the first year to revise the individualized head related transfer functions, and assess the effectiveness of the system. The third year will complete data collection, assemble libraries of highly localizable stimuli and Head Related Transfer Functions (HRTF), and provide the software and techniques to interested researchers in the audiology and VE community.

MODELING, VIRTUAL ENVIRONMENTS AND SIMULATION

KEYWORDS: Spatialized Audiometry, Head Related Transfer Function

UPGRADING GROUND-COMBAT ATTRITION AND MOVEMENT FOR ITEM

James G. Taylor, Professor

Modeling, Virtual Environments and Simulation Institute

Sponsor: Defense Threat Reduction Agency

OBJECTIVE: This project involved close work with item developer (SAIC) to improve assessment algorithm for direct-fire ground-combat attrition in item. The new single-weapon-system-type kill rates recently developed by the proposed principal investigator were the basis for this upgrade.

KEYWORDS: Stand-alone Attrition Methodology, Lanchester Attrition-rate Coefficient, Direct-fire Ground-combat Attrition, Indirect-fire Ground-combat AT

AMERICA'S ARMY-COMBAT MEDIC

Michael Zyda, Professor and Director

John Falby, Senior Lecturer

Modeling, Virtual Environments and Simulation Institute

Sponsor: U.S. Army Forces Command

OBJECTIVE: The Naval Postgraduate School (NPS) will add a combat medic as part of team dynamics in America's Army-operations. The research goal of the project was to answer the question as to whether a part task trainer can be constructed using a commercial game engine and a commercial quality PC game, America's Army.

KEYWORDS: Modeling and Simulation, Defense/Entertainment Collab, Transformation

ARMY GAME PROJECT

Michael Zyda, Professor and Director

John Hiles, Research Professor

Michael Capps, Research Assistant Professor

John Falby, Senior Lecturer

Modeling, Virtual Environments and Simulation Institute

Sponsor: Office of the Assistant Secretary of the Army Manpower and Reserve Affairs

OBJECTIVE: The U.S. Army has a shortfall in recruiting. There is the potential for improving recruiting through the use of a web-based, instrumented, set of networked videogames or computer games (both of which are hereafter referred to as videogames). The web-based videogames will: attract people to the Army, provide high fidelity feedback about potential recruits, obtain leads for recruiting, and deliver strategic communications about the Army to the potential recruits, obtain leads for recruiting, and deliver strategic communications about the Army to the potential recruit. The Naval Postgraduate School Modeling, Virtual Environments and Simulation (MOVES) Academic Group proposed to develop instrumented, networked videogames to improve Army recruiting.

KEYWORDS: Synthetic Environments, Virtual Environments, Modeling and Simulation, Agent-based Simulation, Defense and Entertainment

THE CONTEXT MACHINE

Michael Zyda, Professor and Director
Rudolph P. Darken, Associate Professor
Michael Capps, Research Assistant Professor
John Falby, Senior Lecturer

Modeling, Virtual Environments and Simulation Institute
Sponsor: Defense Advanced Research Projects Agency

OBJECTIVE: The Defense Advanced Research Projects Agency (DARPA) augmented cognition program is studying ways in which an electronic prosthesis can be developed that augments cognitive processing. One way to think about such a machine might be that it is like the annoying help feature of Microsoft Word that tells you “I think you are trying to write a business letter. Would you like me to suggest to you how?” What we would perhaps like is something grander than help with the written page. We would like something that watches over our shoulder and provides us appropriate information (guidance, warning, help) when it senses our current context. Such a machine is called a context machine in this research. The work proposed was to develop a plan for constructing such a machine, a timeline for its construction, and an elucidation of the technologies (sensors, computing, displays) required for the construction of a portable context machine.

KEYWORDS: Computing, Agent Based Simulation, Cognition, Wireless

**INERTIAL MOTION TRACKING FOR INSERTING HUMANS INTO A NETWORKED
SYNTHETIC ENVIRONMENT**

Michael Zyda, Professor and Director
Xiaoping Yun, Associate Professor
Eric Bachmann, Lecturer

Modeling, Virtual Environments and Simulation Institute
Sponsor: USARO

THE MOVES INSTITUTE

Michael Zyda, Professor and Director
Rudolph P. Darken, Associate Professor

Modeling, Virtual Environments and Simulation Institute
Sponsor: Chief of Naval Operations (N6M)

OBJECTIVE: The Naval Postgraduate School, in conjunction with N6M, 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 that are capable of filling xx99-P/6202-P coded billets upon graduation. The degree program is roughly half computer science and half operations analysis, with the goal of producing officers with an understanding of the mathematics and technology behind modern modeling, virtual environments and simulation systems. The mission of the MOVES Institute is to be the world class institute for research, application, and education in the grand challenges of Modeling, Virtual Environments and Simulation. The goal of this proposal is to provide faculty support on mid-term and long-term issues of interest to the N6M sponsor and to couple student theses to N6 programs.

KEYWORDS: Synthetics Environments, Virtual Environments, Modeling and Simulation

VIRTUAL VAUDEVILLE

Michael Zyda, Professor and Director
Modeling, Virtual Environments and Simulation Institute
Sponsor: University of Georgia

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

**2002
Faculty Publications
and Presentations**

JOURNAL ARTICLES

Rowe, N., Michael, J., Auguston, M. and Riehle, R., "Software Decoys for Software Counterintelligence," *IAnewsletter*, Vol. 5, No. 1, pp. 10-12, Spring 2002.

CONFERENCE PAPERS

Andrade, S., Rowe, N., Gaver, D. and Jacobs, P., "Analysis of Shipboard Firefighting-team Efficiency Using Intelligent-agent Simulation," *Proceedings of the Command and Control Research and Technology Symposium*, Monterey, CA, June 2002.

Rowe, N. and Andrade, S., "Counterplanning for Multi-agent Plans Using Stochastic Means-ends Analysis," *Proceedings of the IASTED Artificial Intelligence and Applications Conference*, pp. 405-410, Malaga, Spain, September 2002.

CONTRIBUTION TO BOOKS

Cockayne, W. and Darken, R.P., "The Application of Human Ability Requirements to Virtual Environment Interface Design and Evaluation," *Handbook of Task Analysis for Human-Computer Interaction*, D. Diaper and N. Stanton (Eds.), 2003.

**CENTER FOR INTERDISCIPLINARY
REMOTELY PILOTED
AIRCRAFT STUDIES
(CIRPAS)**

**ROBERT BLUTH
DIRECTOR**

CENTER FOR INTERDISCIPLINARY REMOTELY PILOTED AIRCRAFT STUDIES

OVERVIEW:

The Center for Interdisciplinary Remotely-Piloted Aircraft Studies (CIRPAS) is a research center at the Naval Postgraduate School. The Office of Naval Research established CIRPAS in the spring of 1996. CIRPAS provides measurements from an array of airborne and ground based meteorological, aerosol and cloud particle sensors, radiation and remote sensors to the scientific community. The data are reduced at the facility and provided to the user groups as coherent data sets. The measurements are supported by a ground based calibration facility. CIRPAS conducts payload integration, reviews flight safety and provides logistical planning and support as a part of its research and test projects around the world. The center operates a variety of manned aircraft and Unmanned Aerial Vehicles. CIRPAS is also a National Research Facility of UNOLS.

The facility provides unique flight operation and scientific measurement services by:

- Providing access to manned aircraft, UAVs and support equipment, as well as to scientific instruments, to spare users the cost of ownership, guaranteeing equal access by all interested parties on a first-come, first-served basis.
- Instrumenting and operating aircraft to meet the requirements of a variety of individual research and test programs.
- Developing new instrumentation to meet increasing challenges for improvements in meteorological and oceanographic measurements.
- Calibrating, maintaining, and operating the facility's airborne instruments in accordance with individual mission specifications.
- Integrating auxiliary payloads, as required, and handling flight safety and logistics tasks, allowing the user to concentrate on his specific mission goals.

The facility has unique UAV flight services, which include:

- An available and centralized repository of diverse UAV assets to meet the needs of individual programs.
- Access to the UAVs and support equipment on a "lease" basis so the user is spared the cost of ownership.
- Turnkey UAV operations, including payload integration, flight safety and logistics support.
- Low cost services using shared assets.

CIRPAS provides cost effective flight services, which benefits a broad spectrum of research.

CIRPAS operates out of two facilities. The primary site is located near the NPS campus at the Marina Municipal Airport. This facility includes a 30,000 sq ft hangar, maintenance and administrative spaces for CIRPAS staff. These include a fully outfitted machine shop, electronics room and a calibration lab for the upkeep of scientific instrumentation. The second site is at McMillan Airfield, Camp Roberts, CA, 90 miles south of the Marina facility. The Camp Roberts site provides the Center with a base of operations for both manned and unmanned aerial vehicle (UAV) flight activities.

The California Institute of Technology supports CIRPAS as the prime contractor. It is also partners with NPS in providing the latest instrumentation for atmospheric research.

RESEARCH THRUSTS:

- Atmospheric and Oceanographic Research
- Fleet and USJFCOM Exercises
- Support for CONOPS Development
- Payload Test and Evaluation
- UAV Experimentation with Operational Forces supported by analysis provided by NPS Departments and Institutes

THE CIRPAS AIRCRAFT

UV-18A 'Twin Otter': The CIRPAS UV-18A 'Twin Otter' has two primary missions. The vehicle's large useful load makes it ideal for carrying instrumentation for atmospheric/oceanographic research. The

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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's second Pelican air vehicle is a converted Cessna O2-A. It is operated without the Predator avionics equipment and is available for use in support of a variety of generic payload demonstrations.

Characteristics of Pelican include:

- Maximum endurance of 15 hrs.
- Maximum altitude of 15kft
- Cruise speed of 90 KIAS
- Nose payload bay capacity of 330 lbs.
- Wing hardpoints and cabin space for additional payloads
- 1.2 kW of payload power
- Wing span of 42 ft.
- GTOW of 4600 lbs.

Altus ST UAV: The Altus Single Turbo (ST) UAV was developed by General Atomics ASI to support high-altitude atmospheric monitoring requirements of NASA's Environmental Research Aircraft and Sensor Technology Program. The Altus™ UAV is based on the proven Predator® and GNAT™ line of unmanned aircraft. The Department of Energy's Sandia National Labs funded the fabrication of a single-stage turbocharged Altus™ UAV to support the Atmospheric Radiation Measurement (ARM) Science Campaign. As a result of a cooperative agreement with DOE, CIRPAS provides the vehicle's services during the remainder of the year to other users.

Characteristics of Altus ST include:

- Maximum endurance of 30 hrs.
- Maximum altitude of 45kft
- Cruise speed of 70 KIAS
- Nose payload bay capacity of 330 lbs.
- 1.2 kW of payload power
- Wing span of 55 ft.
- GTOW of 2100 lbs.

Predator UAV: CIRPAS maintains and operates the US 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

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- Cruise speed of 70 KIAS
- Nose payload bay capacity of 450 lbs., wing hardpoints
- 1.8 kW of payload power
- Wing span of 48 ft.
- GTOW of 2250 lbs.

GNAT-750 UAV: The GNAT-750 UAV was developed by General Atomics ASI to support unmanned, medium altitude, endurance surveillance and other sampling requirements. The GNAT-750 is the predecessor to the Predator UAV.

Characteristics of the GNAT-750 UAV include:

- Maximum endurance of 30 hrs.
- Maximum altitude of 18kft
- Cruise speed of 70 KIAS
- Nose payload bay capacity of 125 lbs.
- 1.2 kW of payload power
- Wing span of 35 ft.
- GTOW of 1450 lbs.

Ground Control Station: The General Atomics ASI Ground Control Station (GCS) provides aircraft control functions for the CIRPAS-operated UAVs. The GCS has redundant Pilot/Payload Operating Stations and is housed in a rugged, 18-ft long wheeled container. CIRPAS currently owns two GCSs and associated Ground Data Terminals capable of operating Predator/Altus/GNAT-750/Pelican air vehicles. GCS #1 includes a UHF and dual VHF radios for communication to other aircraft, range or ATC personnel. Additional radios provide direct communication between flight crew and other personnel if requirement exists. GCS #1 also has a video closed-captioning system to overlay aircraft and target position data on imagery before transmission to user.

Atmospheric/Oceanographic Aircraft Payloads: CIRPAS can provide use of a wide variety of atmospheric and oceanographic sensors to the research community. The CIRPAS sensor suite includes off-the-shelf instrumentation as well as one-of-a-kind, custom-built packages.

CIRPAS possesses a variety of scientific instruments and instrument suits. The basic meteorological and GPS suite consists of a Rosemount temperature probe, a Edgetech chilled mirror dew point sensor, a Rosemount flow angle probe with static ports, Vaisala temperature and dew point sensors, a Novatel GPS receiver with a ground survey station for differential correction, a TANS Vector GPS attitude system, a C-Midget-II INS-GPS system, an IRGA humidity and carbon-dioxide sensor, and an Aerodyne fast absolute humidity sensor. The CIRPAS aerosol instrumentation suite consists of a TSI 3-color nephelometer, a Radiance soot photometer, a TSI Ultrafine particle counter, and a TSI condensation nuclei counter. The CIRPAS cloud and particle instrumentation suite consists of an FSSP-100, a PCASP-100X, both with upgraded electronics, a CAPS scatter and occultation probes, and DMT 2D-P and 2D-PP probes, a TSI aerodynamic particle spectrometer.

RESEARCH FACILITIES:

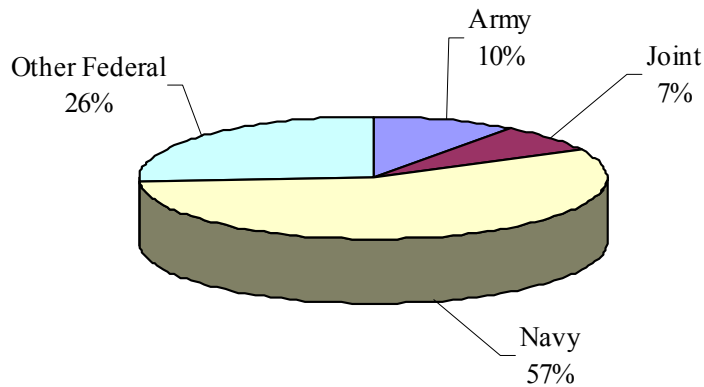
- Marina Facility
 - 30,000 sq ft maintenance hangar
 - 3000 ft runway – manned operations only
 - Naval Reserve Unit
 - Office space, flight operations
 - Maintenance facility
 - Payload development and integration
 - Logistics planning and support to research and test projects
- Camp Roberts Facility
 - Friendly airspace for testing and training (R2503)
 - Military ground maneuvers (equipment, personnel)

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- 3500 x 60 ft runway
- 2000 sq ft hangar
- Shared utilization of NRL
- Temporary office space

SPONSORED RESEARCH PROGRAMS (Research and Academic)-FY2002:

The Naval Postgraduate School's sponsored program exceeded \$61 million in FY2002. Sponsored programs included both research and educational activities funded from an external source. A profile of the sponsored program for the Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) is provided below:



Size of Program: \$3,440K

CENTER FOR INTERDISCIPLINARY REMOTELY PILOTED AIRCRAFT STUDIES

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AURA ENGINEERING FLIGHT TEST SUPPORT

Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Department of Energy

OBJECTIVE: Provide altus UAV flight support for Aura project. Funds provided by DOE primarily support CIRPAS administrative functions and CIRPAS scheduled and unscheduled maintenance.

KEYWORDS: UAV, Aura Project

CIRPAS COORDINATION F/SCIENTIFIC OUTREACH

Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: National Space and Aeronautics Administration Dryden

OBJECTIVE: Support cooperative research efforts between the National Aeronautics and Space Administration Dryden Flight Research Center (NASA Dryden) and the Naval Postgraduate School/Center for Interdisciplinary Remotely Piloted Aircraft Studies (NPS/CIRPAS). The purpose will be to utilize the technology development, flight experiments and demonstrations, and payloads development and integration for advanced Remotely Piloted Aircraft (RPA) for the development and execution of educational outreach and public awareness programs in support of communicating the knowledge of these agencies to the general public.

KEYWORDS: Pelican, Surrogate UAV, Outreach, Education

CIRPAS PREDATOR FLIGHT SUPPORT

Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Joint Forces Command

OBJECTIVE: Support Joint Forces Command, JOTBS MAE UAV test objectives with Predator MAE UAV flight operations at China Lake, CA. CIRPAS will provide flight support over a mission window from 24 July to 2 August; specific schedule per CIRPAS Asset Schedule 020325 with Predator P030 and P035 air vehicles for 40 flight hours. Predator payload will include EO/IR skyball. All flight active will be line of sight. Each sortie is approximately 10 hours per each 24-hour day. Assumes FCFs, launch and recovery activity occurs from CIRPAS GCS/GDT. Assumes level II-IV operations with EDU-2/JFCOM GDT; specific level dependent on EDU-2 status. Flight crew must be away from operations site 12 hours each 24 hours.

CIRPAS PREDATOR FLIGHT SUPPORT F/EDU-2

Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: NAVAIR

OBJECTIVE: Support NAVAIR PM-263 test objectives with Predator MAE UAV flight operations at El Mirage, California. CIRPAS will provide flight support over a two-week mission window with Predator P030 and P035 air vehicles for 20 flight and 15 ground test hours, weekdays. Predator payload will include EO/IR Skyball. All flight active will be line of sight. Each sortie is approximately two hours per each 24-hour day. Assumes FCFs, launch and recovery activity occurs from CIRPAS CGS/GDT.

KEYWORDS: Predator, MAE UAV, Millennium Challenge, JOTBS

CIRPAS PREDATOR FLIGHT SUPPORT FOR MILLENIUM CHALLENGE 02

Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Joint Forces Command

OBJECTIVE: Support Joint Forces Command, JOTB MAE UAV test objectives with Predator MAE UAV flight operations at China Lake, California. CIRPAS will provide flight support over a mission window from 24 July to 2 August; specific schedule per CIRPAS asset schedule 020325 with Predator P030 and P035 air vehicles for 40 flight hours. Predator payload will include EO/IR Skyball. All flight active will be line of sight. Each sortie is approximately 10 hours for each 24-hour day. Assumes FCFs, launch and recovery activity occurs from CIRPAS GCS/GDT. Assumes Level II-I V operations with EDU-2/JFCOM GDT; specific level dependent on EDU-2 status.

KEYWORDS: Predator, MAE UAV, Millennium Challenge, JOTBS

CIRPAS SUPPORT OF SWARM DEPLOYMENT

Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Office of Naval Research

OBJECTIVE: Swarm deployment at McMillan Airfield, Camp Roberts, California, assumes flight activity as per CIRPAS-approved test plan and no FAA CoA required.

KEYWORDS: Camp Roberts, UAV, Swarm, McMillan Airfield

HERT INTEGRATION AND FLIGHT TEST SUPPORT

Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Sandia National Lab

OBJECTIVE: CIRPAS will be responsible to payload integration flight test support during Sandia National Lab's High Explosive Ratio Telemetry (HERT) aircraft multi-path experiments. The objective is to understand wide-band RF multi-path effects on data transmission over salt water. Results of this experiment will assist in data analysis in end-event, wide-band testing for re-entry vehicle systems. CIRPAS will integrate plate-mounted payload to existing pelican frame/fairing, provide power via payload buss, and support minimal compatibility testing at Marina facility. HERT has a 3-day mission window with 10 flight hours. CIRPAS will support with Pelican vehicles number 2 from Marina and Pt. Sur, California, areas. Flight crew will be required to be away from op site 12 hours of each 24 hours. Assumes flight activity does not require FAA CoA or sanctuary waiver.

KEYWORDS: High Explosive Ratio Telemetry, RF Multi-path Transmissions

INTEGRATION OF AEROSOL AND WIND LIDAR ONTO CIRPAS' TWIN OTTER

Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: National Oceanographic and Atmospheric Administration

OBJECTIVE: Installation and flight-testing a new aerosol and wind lidar.

SUMMARY: The purpose of this research was to integrate new capability into the scientific payload of the CIRPAS Twin Otter aircraft and transition the operational and maintenance know-how over to CIRPAS to be able to successfully operate and maintain the instrument in the future. This new capability is a lidar system designed and constructed for CIRPAS under SBIR funding from the Navy. A similar instrument is

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to be launched into space for observations of the earth from an orbiting satellite. The importance of this proposal to NPOESS is that with the CIRPAS instrument already installed and operating on the aircraft, a capability will be at hand to validate measurements from the orbiting instrument by comparison with similar measurements obtained in-situ by the CIRPAS lidar.

KEYWORDS: Lidar, NPOESS, Winds, Aerosol

JCIET PELICAN FLIGHT SUPPORT
Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: USA Engineer Research Development Center

OBJECTIVE: Support JCIET with Pelican surrogate MAE UAV flight operations at Camden Ridge/Pinehill MOA, southwest Alabama. CIRPAS will conduct site survey and range brief, FRR, and all required logistics.

KEYWORDS: Pelican, Surrogate UAV, JCIET, EO/IR Payload

JTFEX02-1 UAV FLIGHT SUPPORT
Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: U.S. Joint Forces Command

OBJECTIVE: Provide MAE UAV flight support for JTFEX02-1. JTFEX02-1 has an 8-day mission window with 40 flight hours. CIRPAS will support with Predator vehicles Number 30 and 35 with EO/IR payloads and UHF radio voice relay. All flight activity will be line of sight, daytime operations. Flight crew will be required to be away from op site 12 hours of each 24 hours. More than fifty percent of the funds required to support JTFEX02-1 will be sent to a contractor. The contractor is required to provide mission and flight support for this project.

PREDATOR FLIGHT OPERATIONS FOR CVW-14
Robert T. Bluth, Research Associate and Director
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Naval Strike and Air Warfare Center

OBJECTIVE: Support CVW-14 Airwing work-ups with Predator MAE UAV flight operations at NSAWC, Fallon, Nevada. CIRPAS will provide flight support over a 2-week mission window with Predator P030 and P035 air vehicles for 40 flight hours. Predator payload will include EO/IR radio relay in one aircraft: EO/IR only in other aircraft. Each sortie is approximately eight hours per each 24-hour day. Flight crew must be away from operations site 12 hours of each 24 hours. More than fifty percent of the funds required to support the UAVSI demo will be sent to a contractor. The contractor is required to provide mission and flight support for this project.

KEYWORDS: Predator, UAV, PMA-263, AUVSI

FORMATION AND PERPETUATION OF RIFTS AND GRADIENTS IN OPTICAL AND MICROPHYSICAL PROPERTIES OF MARITIME STRATUS AND STRATOCUMULUS

Hafliði H. Jonsson, Research Assistant Professor

Center for Interdisciplinary Remotely Piloted Aircraft Studies

Sponsor: National Science Foundation

OBJECTIVE: Measurements of the physical characteristics of cloud-free areas (rifts) embedded in stratus and stratocumulus.

SUMMARY: A rift came into the range of the CIRPAS Twin Otter during the DECS experiment in 1999, and was explored in detail. Analysis of the data obtained has been performed by Neil Smith in the Meteorology Department, who completed a Master's thesis on the topic, and by a graduate student at the University of Miami, who is still working on a project. The last year's funding has been extended to obtain further measurements should an opportunity present itself during the CARMA and DECS-II experiments scheduled to take place in Marina, CA, in August-October 2002.

KEYWORDS: Stratus, Stratocumulus, Rifts, Visibility Marine Boundary Layer

NPS/CIRPAS SUPPORT OF OFFICE OF NAVAL RESEARCH AIRBORNE RESEARCH OBJECTIVES

Hafliði H. Jonsson, Research Assistant Professor

Robert T. Bluth, Research Associate and Director

Center for Interdisciplinary Remotely Piloted Aircraft Studies

Sponsor: Office of Naval Research

OBJECTIVE: NPS/CIRPAS Support of ONR funded field campaigns. The projects were carried out using the CIRPAS Twin Otter, UV-18A and various scientific instruments from CIRPAS' airborne and calibration suites. Operations were supported by CIRPAS' scientific and flight operations personnel. CIRPAS provided GPS and meteorological data to the projects, and also measurements from other facility instruments as requested for each project. CIRPAS provided a data system consisting of several computers, networked and synchronized to GPS time. The data system not only serviced the facility equipment, but also the special research instruments maintained and operated by the PIs themselves, their Co-PIs, and students.

SUMMARY: CIRPAS supported the airborne research objectives of the Office of Naval Research (ONR). Four individual research projects were supported independently using CIRPAS personnel, instrumentation, and aircraft. These projects were: 1) ACE-ASIA – a study of Asian dust transport off the continent. PI was Professor John Seinfeld of the California Institute of Technology. 2) HALO – a study of water vapor in vicinities of clouds and its effects on the earth's radiation budget. PI was Professor John Seinfeld of the California Institute of Technology. 3) CLOUD – a study of entrainment into stratus and stratocumulus clouds. PI was Professor Bruce Albrecht of the University of Miami. 4) RED – a multi-faceted study of scintillation effects on light and signal transmission in the marine boundary layer, aerosol and cloud chemistry and micro-physics, and turbulence. A science team consisting of Mr. Ken Anderson and Dr. Jeff Reid from SPAWAR, San Diego, Dr. Dean Hegg of the University of Washington, Professor Carl Friehe of the University of California, Irvine, and Dr. Haf Jonsson, NPS, directed the mission and defined individual flight objectives.

KEYWORDS: Meteorology, Aerosol, Optical Depth, Visibility

**CENTER FOR INTERDISCIPLINARY
REMOTELY PILOTED
AIRCRAFT STUDIES
(CIRPAS)**

**2002
Faculty Publications
and Presentations**

JOURNAL ARTICLES

Hegg, D.A., Covert, D.S., Crahan, K. and Jonsson, H., "The dependence of aerosol light-scattering on RH over the Pacific Ocean," *Geophysical Research Letters*, 29(8), 60-1-60-4, 2002.

Reid, J.S., Westphal, D.L., Livingston, J.M., Savoie, D.L., Maring, H.B., Jonsson, H.H., et al., "Dust vertical distribution in the Caribbean during the Puerto Rico dust experiment," *Geophysical Research Letters*, 29(7), 55-1-55-4, 2002.

**SCHOOL OF
AVIATION SAFETY**

**CAPT KENNETH P. NEUBAUER, USN
DIRECTOR**

SCHOOL OF AVIATION SAFETY

OVERVIEW:

The School of Aviation Safety's mission is to educate aviation officers at all levels to identify and eliminate hazards, to manage safety information, to investigate and report mishaps, and to develop and administer command safety programs. The School of Aviation Safety conducts safety related research and provides assistance in support of the Naval Aviation Safety Program. The combined teaching, research, and service are dedicated to enhancing combat readiness through preservation of assets, both human and material.

CURRICULA SERVED:

- Aviation Safety Officer (ASO) Course: A 21-day course designed to prepare Aviation Safety Officers to assist commanders and commanding officers in administering unit safety and mishap prevention programs.
- Aviation Safety Command (ASC) Course: A six-day course designed to indoctrinate aviation squadron commanding officers, officers screened for command, and major aviation staff officers in the policies, philosophy, and techniques of an effective command safety program.

RESEARCH THRUSTS:

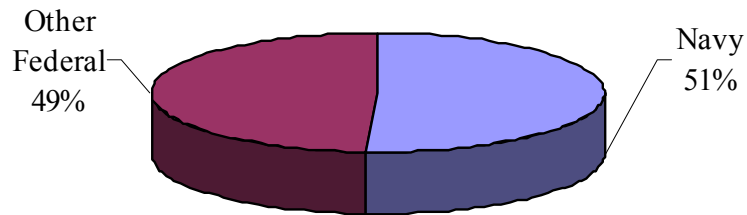
- Human Factors of Air Safety: An area of research dealing with the underlying causes of human error in aviation mishaps, including individual, team and organizational factors that may contribute to the chain of events leading to an aircraft mishap. Researchers at the School of Aviation Safety are engaged in the study of human error as an underlying cause in aviation mishaps due to aircrew, supervisory and maintenance factors. This line of research was recently expanded to include a comprehensive root cause analysis of US Navy aircraft mishaps, and to conduct extensive statistical trend analysis of the Navy's online safety climate survey database.
- Command Climate Assessment Surveys: The School of Aviation Safety has been a leader in the development and application of web-based surveys used to assess Command Climate. Two survey applications have been developed, and are in use today by U.S. Navy and U.S. Marine Corps units. The Command Safety Assessment (CSA) survey system is used to assess command climate, the perceived effectiveness of a commands safety program, and other factors related to the safety of flight operations. The Maintenance Climate Assessment Survey (MCAS) was developed to address similar command issues in the maintenance community. MCAS also measures command climate and other factors, but with respect to maintenance operations. CSA/MCAS are designed specifically for the aviation application. Additional research is being conducted to quantify results of the CSA/MCAS as a predictive tool for mishap prevention. A derivative of the on-line MCAS process focusing specifically on Naval Aviation Depot (NADEP) issues has also been developed and implemented. Recently, the School of Aviation researchers have begun to develop and apply the same command climate assessment methods to USMC Ground Forces. An advanced version of the USMC Ground Force Command Climate Survey system is currently undergoing Test and Evaluation and will become operational in FY 04.
- Afloat Safety Climate Assessment Survey: The School of Aviation Safety, a pioneer in the development and application of web-based surveys to assess organizational safety climate, expanded its aviation-oriented domain to include other naval activities. An extension of the aviation safety climate assessment process, the on-line afloat safety climate assessment survey process was tailored to afford Navy surface and subsurface commanders the ability to examine the perceived safety climates aboard their vessels. Under sponsorship of the Naval Safety Center, this program focused on key issues to better understand the influences that a Naval command may have on the chain of events leading to a mishap. The process is grounded in theory relating key attributes of organizations that were successful in reducing risks associated with hazardous operations.

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- Organizational Risk Factors: An area of research dealing with the potential influence of leadership, organizational structure, safety climate, and safety culture, on mishap causation. Researchers at the School of Aviation Safety are working in collaboration with social scientists from Haas Business School, UC Berkeley, Stanford University, Carnegie-Mellon, University of Arizona, and NASA-Ames Research Center to develop and validate Organizational Risk Models. This research is closely allied to the ongoing development and application of the U.S. Navy Surface and U.S. Marine Corps Ground Force Command Climate Assessment Surveys. The phase I organizational risk factors research effort was completed in December 2002, and included a comprehensive review of literature, and the development of a conceptual framework for measuring safety climate and safety culture. A second phase is planned for FY 04 to develop and validate web-based organizational risk assessment models and measurement methods.

SPONSORED RESEARCH PROGRAMS (Research and Academic)-FY2002:

The Naval Postgraduate School's sponsored program exceeded \$61 million in FY2002. Sponsored programs included both research and educational activities funded from an external source. A profile of the sponsored program for the School of Aviation Safety is provided below:



Size of Program: \$322K

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ANALYSIS OF AGGREGATE STATISTICAL DATA

Anthony P. Ciavarelli, Professor

Robert C. Figlock, Assistant Professor

School of Aviation Safety

Sponsor: Marine Corps Headquarters Safety Division

OBJECTIVE: Perform statistical analysis of the Command Safety Assessment and Maintenance Climate Assessment database in order to identify possible trends, and to validate climate survey instruments.

SUMMARY: An *Aviation Command Safety Assessment (CSA)* survey questionnaire was first developed and administered to Navy and Marine Corps units in August 1996. The questionnaire was designed to measure the extent to which a particular naval squadron met criteria of a so-called *High Reliability Organization*. The results of the 1996 survey were presented to the Navy's ongoing human factor's Quality Management Board (QMB) study of naval mishaps. Findings from the study were used by the US Navy to initiate a series of planned safety interventions, including a provision for continuous measurement of organizational safety effectiveness. Over the past few years, the survey questionnaire has been refined based upon statistical validation data, and an Internet-based version was developed. In addition, a comparable questionnaire survey was developed specifically for maintenance operations. This companion survey questionnaire is referred to as the Maintenance Climate Assessment Survey (MCAS). Both questionnaires (CSA/MCAS) are now available to U.S. Navy and Marine Corps units via a secure Internet Web site. The web-based surveys provide aviation commanders with a means to administer the surveys to simultaneously to both aircrews and maintainers. Following survey administration commanders receive immediate feedback concerning key issues related to command climate, safety culture, workload, resource availability, estimated success of certain safety intervention programs, and other factors related to safely managing fleet flying operations. An adapted form of this web-based organizational safety risk assessment method is currently under development for USMC ground forces. A key goal of the survey method, and Internet technology application, is to identify and correct any latent organizational conditions that may lead to increased accident risk. At this time, CSA/MCAS only provide "snapshot" statistical summaries for each squadron that has taken the survey. A squadron commander can view the results of his/her own squadron and then make statistical comparisons to other like squadrons and to fleet averages. There is presently no capability for the system to generate analyses of longitudinal "aggregate" cross-sectional statistical comparisons. Such analysis would provide useful trend information for Naval Aviation managers to better manage aviation risks.

Research tasks and analyses undertaken on this research program are focused on completing extensive analyses of the "aggregate" CSA/MCAS database as outlined below.

1. Generate descriptive statistical summaries of CSA/MCAS database, comparing results by community, aircraft type, and other specific demographic variables.
2. Create statistical summary "graphic and tabular" profiles; based on selected critical safety questionnaire items and demographics, and generate statistical profiles based upon the high-reliability organizational model or survey subscales.
3. Conduct comprehensive multivariate statistical tests to validate survey instruments. . A wide range of statistical tests is planned to establish the measurement reliability and validity of the CSA and MCAS survey instruments. Planned statistical tests include principal components Factor Analysis (exploratory and confirmatory), Analysis of Variance and Cronbach-Alpha reliability tests, Discriminate Analysis, Correlation and Multiple Regression. One very important validation strategy will be to determine whether or not survey item scores, or derived scoring metrics, can predict mishap or incident frequency. When completed, such analyses will provide evidence that measures taken during surveys can be correlated or associated with accident probability or occurrences.
4. Coordinate research activities with ongoing parallel development and validation efforts at Embry-Riddle Aeronautical University, NASA/Ames, and Stanford University Patient Safety Center to provide essential cross-validation of measurement scales, and to collaborate on lessons learned.
5. Publish periodic reports and articles for use by Department of Defense, and other government and private sectors to inform and educate aviation community and safety professionals.

PRESENTATION:

Ciavarelli, A.P., "Command Safety Assessment Summary of Selected Statistics," presented to U.S. Marine Corps Headquarters, 2002.

KEYWORDS: Organizational Climate, Survey Questionnaire, Statistics

ORGANIZATIONAL RISK MODEL DEVELOPMENT

Anthony P. Ciavarelli, Professor

School of Aviation Safety

Sponsor: National Aeronautics and Space Agency

OBJECTIVE: The objective of this study is to develop, and validate, an Organizational Risk Assessment Model for use by the National Aeronautics and Space Administration (NASA).

SUMMARY: A program of research has been initiated to develop and validate an Organizational Risk Model, for use in the NASA space exploration program. Dr. Ciavarelli is working with a research team consisting of research psychologists at the NASA-Ames Research Center, Carnegie-Mellon University, Stanford University, and the Jet Propulsion Laboratory (JPL). Dr. Ciavarelli will be drawing from his existing work related to organizational factors in aviation accidents (Ciavarelli, Figlock, Sengupta and Roberts, 2001; Ciavarelli & Figlock, 1997), the works of Roberts (1990) and Libuser (1994), Gaba, Singer, Sinaiko, and Ciavarelli, 2002). He recently completed a comprehensive review of the literature on measuring organizational climate and safety culture. A preliminary technical report was published for NASA (Ciavarelli, 2003) and will serve as a key input for construction of an organizational risk assessment model by NASA scientists. The organizational risk model will consider measures and metrics related to organizational climate and culture in assessing the potential contribution of organizational factors to a variety of risk areas, such as accident risk, mission failure, program slippage, financial loss, and other loss potentials. Dr. Ciavarelli will lead the construction of a web-based survey technology, using an adapted version of the US Marine Corps web-survey system. The web-survey technology will provide a means to rapidly construct questionnaire surveys, and to receive immediate feedback of results, and will enable normative data comparisons among survey samples and populations.

The USMC Ground Force Command Assessment system, currently under development, will serve as the methodological and software system baseline for the NASA survey system. The USMC survey system is considered as a third generation, advanced online survey technology complete with a powerful authoring capability for rapid design, development, and testing of new online survey applications.

The new survey system may be used by the NASA research team as a means for exchanging views and for reaching a decision consensus during risk model development. Later, the resulting online web-survey method may serve as one means of providing a risk-decision support system for mitigating design, development, and operational risk for the International Space Station. The Organizational Risk Model will result from a team effort that requires a final integration of related collaborative efforts at NASA, JPL, NPS and other academic institutions. Once developed and validated, the resulting Organizational Risk Model will be applicable to both civilian and military agencies. Outputs from this study are expected to greatly enhance the ongoing efforts to measure and assess operational risks in US Naval Aviation and US Marine Corps ground forces.

PUBLICATIONS:

Ciavarelli, A.P., "Assessing the Quality of Instruction: Integrating Instructional Quality and Web Usability Assessments," *Measuring Up: Assessment Issues for Teachers, Counselors, and Administrators*, ERIC Clearing House for Teaching and Research, Washington D.C., 2002, (in press).

Ciavarelli, A.P., "Human Factors Checklist: A Tool for Accident and Incident Investigation," *Flight Safety Digest*, Flight Safety Foundation, Washington D.C., February 2001.

SCHOOL OF AVIATION SAFETY

Ciavarelli, A.P., "Organizational Risk Assessment: The Role of Safety Culture," School of Aviation Safety, Naval Postgraduate School, February 2003.

Gaba, D., Singer, S., Sinaiko, A. and Ciavarelli, A.P., "Safety Culture Differences Between Hospital Personnel and Naval Aviators," *Human Factors and Ergonomics*, 2003, (in press).

PRESENTATIONS:

Ciavarelli, A.P. and Figlock, R., "Assessing Organizational Risk Using Survey Questionnaire Methods," 2001 International Symposium on Aviation Psychology, Columbus, OH, March 2001.

Ciavarelli, A.P., Figlock, R., Sengupta, K. and Roberts, K.H., "Assessing Organizational Risk Using Survey Questionnaire Methods," 11th Annual International Symposium on Aviation Psychology, Columbus, OH, 2001.

Ciavarelli, A.P., "The Human Factors of Air Safety," NASA Human Error Modeling Workshop, NASA/Ames Research Center, Moffett Field, CA, June 2000.

Ciavarelli, A.P., "Organizational Factors in Aviation Accidents," Human and Organizational Risk Management Workshop, NASA/Ames Research Center, Moffett Field, CA, April 2001.

Ciavarelli, A.P., "Organizational Factors and Flight Crew Risk Behavior," 45th Annual Meeting of the Human Factors and Ergonomics Society, Minneapolis, MN, October 2001, (invited panel member).

KEYWORDS: Organizational Behavior Models, Risk Assessment, Safety Culture, Survey Methods

ORGANIZATIONAL SAFETY RISK ASSESSMENT SYSTEM

Anthony P. Ciavarelli, Professor

School of Aviation Safety

Sponsor: U.S. Marine Corps Ground Forces Command Safety Assessment Survey

OBJECTIVE: The objective of this study is to develop, implement and test a web-based command climate assessment system for U.S. Marine Corps Ground Forces.

SUMMARY: A prototype *Aviation Command Safety Assessment* questionnaire was developed and administered to US Navy and Marine Corps units in August 1996. The questionnaire was designed to measure the extent to which a particular naval squadron met criteria of a so-called *High Reliability Organization*. Construction of the questionnaire was based primarily on the work of Karlene Roberts (1990), from the Haas Business School, UC Berkeley, and her colleague Carolyn Libuser (1994) from the University of California at Los Angeles. It was Roberts who coined the term high-reliability organization (HRO). Roberts and Libuser studied organizations in terms of their ability to effectively manage risks associated with possible accidents and material or financial losses. Results of the 1996 survey were presented to the Navy's ongoing human factor's Quality Management Board (QMB) study of naval mishaps. Findings from the study were used by the US Navy to initiate a series of planned safety interventions, including a provision for continuous measurement of organizational safety effectiveness. Over the past few years, the survey questionnaire has been refined based upon statistical validation data, and an Internet-based version was developed. The current US Naval Aviation Command Climate Survey questionnaire is now available via a secure Web site: <http://www.safetyclimatesurveys.org/index1.asp>. (Cut and past this URL to your web browser.)

The web-based survey provides aviation commanders with a means to administer the survey and to receive immediate feedback concerning key issues related to command climate, safety culture, workload, resource availability, estimated success of certain safety intervention programs, and other factors related to safely managing fleet flying operations. A key goal of the survey method, and Internet technology application, is to identify and correct any latent organizational conditions that may lead to increased accident risk. In April 2001, Dr. Ciavarelli initiated an additional application of this methodology to US

SCHOOL OF AVIATION SAFETY

Marine Corps Ground Forces, with research and development funding from the HQ USMC. The new system will be fully operational by October 2003. US Marine Corps Web site is at: <https://miras.dbidb.com/usmc/login.html> (Cut and past this URL to your web browser.)

Research plans include migration of this very successful program to the civilian sector. For example, Dr. Ciavarelli participates with a Stanford University/VA Hospital research team headed by Stanford University professor (Dr. David Gaba). The Stanford University research team uses an adapted version of the survey to examine organizational culture in medical delivery agencies. Dr. Ciavarelli has also developed an application of the web-based survey for civilian flight schools, as a consultant to Embry-Riddle Aeronautical University.

PUBLICATION:

Gaba, D., Singer, S., Sinaiko, A. and Ciavarelli, A.P., "Safety Culture Differences Between Hospital Personnel and Naval Aviators," *Human Factors and Ergonomics*, 2003, (in press).

PRESENTATIONS:

Ciavarelli, A.P., Figlock, R., Sengupta, K. and Roberts, K.H., "Assessing Organizational Risk Using Survey Questionnaire Methods," 11th Annual International Symposium on Aviation Psychology, Columbus, OH, 2001.

THESES DIRECTED:

Flowers, T.R. and Dowler, D.M., "Development of an Expert System and Software Agent for the Aviation Command Safety Assessment System," Master's Thesis, Naval Postgraduate School, March 2000.

Held, J.S. and Mingo, F.J., "Automating the Aviation Command Safety Assessment Survey as an Enterprise Information System," Master's Thesis, Naval Postgraduate School, March 1999.

Williams, T.G., "Usability of the Aviation Command Safety Assessment Web-based Questionnaire," Master's Thesis, Naval Postgraduate School, March 1999.

KEYWORDS: Organizational Effectiveness, Safety Culture, Risk Management, Survey Method

ANALYSIS OF AGGREGATE STATISTICAL DATA FROM THE COMMAND SAFETY ASSESSMENT AND MAINTENANCE CLIMATE ASSESSMENT SYSTEMS

Robert C. Figlock, Assistant Professor

Anthony P. Ciavarelli, Professor

School of Aviation Safety

Sponsor: Headquarters U.S. Marine Corps

OBJECTIVE: Perform statistical analysis of the Command Safety Assessment and Maintenance Climate Assessment database in order to identify possible trends and to validate climate survey instruments.

SUMMARY: An *Aviation Command Safety Assessment (CSA) survey* questionnaire was first developed and administered to Navy and Marine Corps units in August 1996. The questionnaire was designed to measure the extent to which a particular naval squadron met criteria of a so-called *High Reliability Organization*. The results of the 1996 survey were presented to the Navy's ongoing human factor's Quality Management Board (QMB) study of naval mishaps. Findings from the study were used by the US Navy to initiate a series of planned safety interventions, including a provision for continuous measurement of organizational safety effectiveness. Over the past few years, the survey questionnaire has been refined based upon statistical validation data, and an Internet-based version was developed. In addition, a comparable questionnaire survey was developed specifically for maintenance operations. This companion survey questionnaire is referred to as the Maintenance Climate Assessment Survey (MCAS). Both questionnaires (CSA/MCAS) are now available to US Navy and Marine Corps units via an Internet Web

site. The web-based surveys provide aviation commanders with a means to administer the surveys to simultaneously to both aircrews and maintainers. Following survey administration commanders receive immediate feedback concerning key issues related to command climate, safety culture, workload, resource availability, estimated success of certain safety intervention programs, and other factors related to safely managing fleet flying operations. An adapted form of this web-based organizational safety risk assessment method is currently under development for USMC ground forces. A key goal of the survey method and Internet technology application is to identify and correct any latent organizational conditions that may lead to increased accident risk. At this time, CSA/MCAS only provide "snapshot" statistical summaries for each squadron that has taken the survey. A squadron commander can view the results of his/her own squadron and then make statistical comparisons to other like squadrons and to fleet averages. This research project was a first step to generate analyses of longitudinal "aggregate" cross-sectional statistical comparisons. Such analysis would provide useful trend information for Naval Aviation managers to better manage aviation risks. Research tasks and analyses undertaken on this research program were focused on completing extensive analyses of the "aggregate" CSA/MCAS database and included:

1. Generating descriptive statistical summaries of CSA/MCAS database, comparing results by community, aircraft type, and other specific demographic variables.
2. Creating statistical summary "graphic and tabular" profiles; based on selected critical safety questionnaire items and demographics, and generate statistical profiles based upon the high-reliability organizational model or survey subscales.
3. Conducting comprehensive multivariate statistical tests to validate survey instruments. A wide range of statistical tests were used to establish the measurement reliability and validity of the CSA and MCAS survey instruments. Statistical tests included principal components Factor Analysis (exploratory and confirmatory), Analysis of Variance and Cronbach-Alpha reliability tests, Discriminate Analysis, Correlation and Multiple Regression. One very important validation strategy was to determine whether or not survey item scores, or derived scoring metrics, predicted mishap or incident frequency. When complete, such analyses should provide evidence that measures taken during surveys can be correlated or associated with accident probability or occurrences.
4. Coordinating research activities with ongoing parallel development and validation efforts at Embry-Riddle Aeronautical University, NASA/Ames, and Stanford University Patient Safety Center to provide essential cross-validation of measurement scales, and to collaborate on lessons learned.
5. Publishing reports and articles for use by Department of Defense, and other government and private sectors to inform and educate aviation community and safety professionals.

PRESENTATION:

Ciavarelli, A.P., "Command Safety Assessment Summary of Selected Statistics," U.S. Marine Corps HQ, 2002.

KEYWORDS: Organizational Climate, Statistics, Survey Questionnaire

HUMAN FACTORS TOOLS AND INTERVENTIONS FOR IMPROVING MAINTENANCE ERROR MANAGEMENT

Robert C. Figlock, Assistant Professor

John K. Schmidt, Assistant Professor

School of Aviation Safety

Sponsor: National Aeronautics and Space Administration Ames Research Center

OBJECTIVE: The planned effort encompasses the continued systematic implementation of the HFACS-ME based maintenance incident investigation, analysis, reporting, assessment, and intervention training, process, and tool, as well as the on-line MCAS in both operational units and rework facilities. Data derived will be used to tailor MRM training and intervention efforts. Individual pre/post training evaluations will be administered, work areas metrics will be developed to assess intervention effectiveness, and a process for estimating Return on Investment (ROI) will be developed.

SUMMARY: This project is developing a standard process to identify, assess, and control maintenance errors. It attempts to validate interventions related to specific errors. Intervention strategies developed through this task will be ear-marked for integration into standard maintenance and inspection systems for military aviation, commercial airlines, repair stations, and rotary-wing operations. This effort will lead to more effective assessment of the propensity for future errors within maintenance organizations, implementation of appropriate intervention strategies, and allocation of organizational resources toward their prevention.

KEYWORDS: Human Error, Maintenance Error, Flight Mishaps, Aviation Mishaps, Aviation Accidents, Flight Mishap Investigation, Aviation Mishap Investigation, Aviation Accident Investigation, Flight Mishap Prevention, Aviation Mishap Prevention, Aviation Accident Prevention, Design for Maintainability

MAINTENANCE ERROR RISK ASSESSMENT AND STRATEGIC INTERVENTION

Robert C. Figlock, Assistant Professor

John K. Schmidt, Assistant Professor

School of Aviation Safety

Sponsor: National Aeronautics and Space Administration Ames Research Center

OBJECTIVE: Continued development of a process to identify and manage human error and its sources in aviation maintenance related incidents. Specifically, the goal is to identify human factors issues in maintenance related mishaps, flight mishaps, flight related mishaps, aircraft ground mishaps, identified aviation hazards, and personal injuries to determine their characteristics, discern any significant patterns and trends, prioritize target areas for intervention, and design appropriate risk management intervention strategies. Results are applicable to both military and commercial aviation maintenance operations.

SUMMARY: Methods used in commercial airlines to investigate maintainer error are shown to be typically restricted to reactive analysis of error causation. These methods focus on proximate causes and immediate circumstances surrounding an adverse occurrence. The first task of this effort was the continued development, implementation, and evaluation of a Maintenance Error Information Management System (MEIMS) to catalog, classify, and analyze maintenance related incidents using the Navy's Human Factors Analysis and Classification System—Maintenance Extension (HFACS—ME) taxonomy as its framework. MEIMS provides for the examination of the latent conditions leading to errors. A second task of this project was to design a standard process to identify, measure, and assess maintenance errors. A web-based Maintenance Climate Assessment Survey (MCAS) process was developed focusing on commercial aviation maintenance activities. Both the MEIMS and MCAS systems that were developed have military aviation maintenance applicability.

CONFERENCE PAPER:

Schmidt, J., Lawson, D. and Figlock, R., "Human Factors Analysis and Classification System-Maintenance Extension (HFACS-ME) Review of Selected NTSB Maintenance Mishaps: An Update," *Proceedings of the 16th Annual Symposium on Human Factors in Maintenance and Inspection*, March 2002.

PRESENTATION:

Schmidt, J., Lawson, D. and Figlock, R., "The Human Factors and Classification System-Maintenance Extension (HFACS-ME) Review of Select NTSB Maintenance Mishaps: An Update," 16th Annual Symposium on Human Factors in Maintenance and Inspection, San Francisco, CA, 2-4 April 2002.

KEYWORDS: Human Error, Maintenance Error, Flight Mishaps, Aviation Mishaps, Aviation Accidents, Flight Mishap Investigation, Aviation Mishap Investigation, Aviation Accident Investigation, Flight Mishap Prevention, Aviation Mishap Prevention, Aviation Accident Prevention, Design for Maintainability

SCHOOL OF AVIATION SAFETY

RELIABILITY BUSINESS PROCESS REENGINEERING

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Sponsor: Naval Aviation Depot-Cherry Point

OBJECTIVE: Continue the development of a process to identify and manage human error and its sources in aviation maintenance related incidents. Specifically, the goal is to identify human factors issues in maintenance related mishaps and injuries to determine their characteristics, discern any significant patterns and trends, prioritize target areas for intervention, and design appropriate risk management intervention strategies. This project's primary focus was on Naval Aviation Depot (NADEP) issues and concerns.

SUMMARY: A three-prong strategy was implemented for this project. First, a Maintenance Error Information Management System (MEIMS) was developed to catalog, classify, and analyze maintenance related incidents using the Naval Safety Center's Human Factors Analysis and Classification System-Maintenance Extension (HFACS—ME) taxonomy as its framework. Results were used to develop tailored case studies and training materials for use in maintenance error presentations and human factors intervention workshops. The presentations/workshops were provided to NADEP Cherry Point managers. Second, a web-based Maintenance Climate Assessment Survey (MCAS) process was designed and developed focusing on depot-level maintenance activities. The on-line survey was then implemented at the NADEP (see: www.safetyclimatesurveys.org/nadep/index1.asp). Third, a web-based, depot-level, Maintenance Resource Management (MRM) module was developed to enhance NADEP maintenance personnel's safety awareness and skills. The MRM module will be part of the Navy's on-line Safe Maintenance in Aviation, Research, and Training (SMART) Center. This is an on-going research project.

KEYWORDS: Human Error, Maintenance Error, Aviation Accidents, Aviation Mishap Investigation, Aviation Accident Investigation, Aviation Mishap Prevention, Aviation Accident Prevention, Maintenance Climate Assessment

**SCHOOL OF
AVIATION SAFETY**

**2002
Faculty Publications
and Presentations**

SCHOOL OF AVIATION SAFETY

JOURNAL PAPER

Ciavarelli, A.P., "Human Factors Checklist: A Tool for Accident and Incident Investigation," *Flight Safety Digest*, Flight Safety Foundation, Washington D.C., February 2001.

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INDEX BY PRINCIPAL INVESTIGATOR

- Abdel-Hamid, Tarek K.....431
Abernethy, Margaret.....439
Adler, Richard W.....193, 196, 197
Agrawal, Brij N.....167, 168, 169
Arquilla, John.....71
Ashton, Robert W.....193
Auguston, Mikhail.....51
- Bachmann, Eric.....504, 508
Baer, Wolfgang.....79, 80
Baker, Steven F., Lt.Col., USAF.....141
Barrett, Frank J.....431
Batteen, Mary L.....319
Berzins, Valdis.....27
Blais, Curtis L.....136, 499, 500, 504
Bluth, Robert T.....521, 522, 523, 524
Boensel, Matthew G., CDR, USN.....119
Boothe, Mark A.....284, 285
Borchardt, Randy.....29, 194
Borden, Brett.....377
Bordetsky, Alexander.....80, 81, 82
Borges, Carlos F.....211, 218
Bradley, Gordon H.....119, 121, 123
Brook, Douglas A.....432
Brophy, Christopher.....169, 170, 171
Brown, Gerald G.....121, 123, 125
Brown, Michael L.....50
Brown, Ronald E.....378
Brutzman, Donald.....240, 241, 499, 500
Buddenberg, Rex A.....83
Buettner, Raymond, LCDR, USN.....83
Buss, Arnold H.....119, 126, 127
Buttrey, Samuel E.....128, 135
- Callahan, Alexander J. , Jr.,.....84, 85, 86, 500
Calvano, Charles N.....233
Canright, D.....212
Capps, Michael.....500, 507, 508
Carlyle, W. Matthew.....129
Chandrasekhara, Muguru S.....171, 172, 173
Chang, Chih-Pei.....269, 270, 271
Cheung, Kevin.....285, 290
Chiu, Ching-Sang...319, 320, 321, 339, 342, 346
Chu, Peter C.....322, 324, 326, 329, 477, 500
Ciavarelli, Anthony P.....535, 536, 537, 538
Clynch, James R.....273, 330
Collins, Curtis A.....320, 330, 331, 342, 344
Colson, W. B.....379, 380, 381, 382, 383
Conner, George W.....129
Cook, Glen L., LCDR, USN.....85
Cooper, A.W.....383
Cormican, Kelly, LCDR, USN.....27
Couch, Mark A., CDR, USN.....173
Crawford, Alice.....432
- Danielson, Donald A.....212
Darken, Rudolph P. 501, 502, 503, 504, 506, 508
Davidson, K.L.....272, 273, 274, 275, 276,
277, 278, 279
Davis, D. S.....384
Dell, Robert F.....125, 129, 130
Denardo, Bruce.....385, 386
Dinolt, George.....27
Doerr, Kenneth.....432
Dolk, Daniel R.....82, 85, 86
Driels, Morris.....233
Drusinsky, Doron.....27, 28, 51
Duren, Russell W.....174
Durkee, Philip A.....280, 281
Dutta, I.....234, 235
- Eagle, Christopher, LCDR, USN.....29, 194
Eagle, James D.....130
Elsberry, Russell L. 282, 283, 284, 285, 289, 290
Euske, Kenneth J.....432
- Fahroo, Fariba.....177, 213
Falby, John.....507, 508
Fargues, Monique P.....194, 388
Figlock, Robert C.....535, 538, 539, 540, 541
Filizetti, Julie.....129
Fouts, Douglas J.....201
Frederickson, Paul A.....272, 279
Fredricksen, H.M.....214
Frenzen, C.L.....214
Fulp, J.D.....29
- Gallup, Shelley P.....477, 482
Garwood, Roland W., Jr.....332
Gates, William R.....432, 433, 441
Gaver, Donald P.....131, 132, 133, 503
Ghoreishi, Ahmad.....9
Gopinath, Ashok.....236, 237, 238, 378
Gordis, J. H.....239
Gragg, William B.....215
Grass, Steve, MAJ, USMC.....54
Gue, Kevin R.....435
Guest, Peter.....286
Guttieri, Karen.....9
- Ha, Tri T.....194, 195
Halwachs, Thomas E.....126
Haney, Robert L.....288
Harkins, Richard.....387
Harney, Robert C.....233, 479
Harr, Patrick A.....285, 289, 290
Healey, A.J.....240, 241
Herbers, Thomas H. C.....333, 334
Hiles, John.....131, 140, 500, 503, 504, 507
Hoaglund, Jeff, Capt., USMC.....55

INDEX BY PRINCIPAL INVESTIGATOR

Hobson, Garth V.....	174	McGregor, Don.....	500
Hoivik, Thomas H., CAPT, USN (Ret.).....	134	McNelley, Terry R.....	244, 245, 246
Horne, Malcolm.....	439	Mehay, Stephen L.....	432, 438, 440
Horner, Douglas.....	86, 240	Melich, Michael E.....	478, 479
Hospodar, Ed, Capt, USA.....	387, 390	Michael, James Bret.....	49, 50, 51, 52, 53
Howard, Richard M.....	174, 274	Michael, Sherif.....	199
Hutchins, Susan G.....	87, 478	Miller, Christopher W.....	320
Irvine, Cynthia E... 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 215, 465, 466		Miller, Douglas.....	274, 294, 295, 399, 400
Jacobs, Patricia A.....	131, 132, 133, 503	Miller, Nita Lewis.....	137, 138, 139
Jayachandran, Toke.....	216	Millsaps, Knox T.....	247, 248
Jenn, David C.....	195, 196	Moran, Dan.....	10
Johnson, Rodney.....	478	Morgan, Michael A.....	199, 200
Johnston-Wilson, Derek.....	439	Muir, Thomas G.....	391, 392
Jones, Lawrence R.....	436	Murphree, Tom.....	291, 293, 299
Jonsson, Hafliði H.....	524	Mutty, John.....	432
Jordan, Mary S.....	281	Neta, B.....	218, 219
Kaminer, Isaac I.....	175, 274	Netzer, David W.....	169, 170
Kang, Keebom.....	425, 437	Nissen, Mark E.....	433, 441
Kang, Wei.....	217, 218	Nuss, Wendell A.....	294, 295, 344
Karunasiri, Gamani.....	388	Olsen, Richard Christopher.....	392, 393, 394
Kemple, William G.....	88, 92, 478, 483	Olwell, David H.....	145
Kendall, Anthony.....	96	Owen, Guillermo.....	220
Kolar, Ramesh.....	175	Pace, Phillip E.....	49, 200, 201
Koyak, Robert A.....	135	Paduan, Jeffrey D.....	274, 340, 341, 342, 343, 344, 348
Kruer, William L.....	389	Panholzer, Rudolf.....	413, 414
Kwon, Young W.....	242, 243, 254	Papoulias, Fotis A.....	233, 239, 249, 250
Lamm, David V.....	432	Parker, Andrew.....	193, 196, 197, 202
Larraza, Andres.....	389, 390	Parker, Patrick.....	480
Laurence, Janice H.....	438	Pilnick, Steven E.....	132
Lavoy, Peter R.....	9, 10	Platzer, Max F.....	176, 177
Lebaric, Jovan E.....	196, 197	Poulain, Pierre-Marie.....	344
Lewis, Ted.....	41, 504	Purdue, Peter.....	140
Lillis, Anne.....	439	Racoosin, Charles M.....	414
Loomis, Herschel H., Jr.....	197, 198	Ramp, Steven R.....	342, 344, 345, 346, 348
Looney, Robert E.....	10	Rasmussen, Craig.....	215
Lucas, Thomas W.....	136, 142	Reniers, A.....	354
Luqi.....	42, 44, 47, 48	Rhoades, Mark, CDR, USN.....	176
Maier, William B.....	389, 390	Rice, Joseph.....	480
Malina, Mary.....	432, 439	Riehle, Richard.....	54
Margulis, LCDR, USN.....	49	Roberts, Nancy.....	442
Maruyama, Xavier K.....	391	Rosenfeld, Leslie.....	342, 348, 349
Maslowski, Wieslaw.....	335, 336, 337, 338, 350, 351	Rosenthal, Richard E.....	141, 142
McCaffery, Jerry L.....	436	Ross, Alan.....	414
McCarthy, John.....	291	Ross, Michael.....	177
McClellan, Julie L.....	339, 340, 350	Rothstein, Hy S.....	51
McCormick, Gordon.....	220	Rowe, Anton.....	125
McDowell, Perry.....	504	Rowe, Neil C.....	51, 54, 505
McEachen, John.....	198	Salmeron, Javier.....	125, 141, 142
McGhee, Robert B.....	504	San Miguel, Joseph G.....	443
		Sanchez, Paul J.....	119

INDEX BY PRINCIPAL INVESTIGATOR

Sanchez, Susan	142	Van Hise, John W., Jr.	197
Sarpkaya, T.	251, 252, 253	Volpano, Dennis	56
Scandrett, C.	220, 221, 222, 481		
Schacher, Gordon E.	481, 482, 483	Wadsworth, Donald v. Z.	415
Schleher, D. C.	97, 98	Walker, Philip L.	398
Schmidt, John K.	539, 540, 541	Walters, Donald L.	399, 400
Schneidewind, Norman	99, 101	Wang, Qing.	296, 297, 298
Schrady, David A.	144	Wash, Carlyle H.	299, 300
Selto, Frank	439	Washburn, Alan R.	125, 145
Semtner, Albert J.	339, 350	Weatherford, Todd.	202
Shilling, Russ, LCDR, USN	506	Weekley, J.D.	241
Shin, Young S.	254, 255	Weitzman, R.A.	444, 445, 446
Shing, Man-Tak.	28, 49, 55	Whitaker, Lyn R.	146
Shreeve, Raymond P.	178	Williams, Laura M.	141, 146
Smith, Kevin B.	394, 395	Williams, Roger Terry	269, 300, 301
Stanton, Timothy P.	351, 352, 353, 354	Wilson, Lonnie	202, 203
Steckler, Brian D.	102	Wingfield, Thomas C.	51
Sullivan, Joseph, CDR, USN	501, 502, 503	Wirtz, James	10, 11, 12
		Wood, E. Roberts	178, 179
Taylor, James G.	145, 507	Wood, R. Kevin.	121, 123, 142, 146, 147
Therrien, Charles W.	201		
Thomas, George W.	444	Xie, Geoffrey	49, 56, 57
Thome, Geoffrey D.	104		
Thornton, Edward B.	353, 354	Yost, David S.	12, 13
Tokmakian, Robin	339, 350, 355	Young, P.E., CAPT, USN	57
Tsyarkin, Mikhail	11	Yun, Xiaoping	203, 204, 504, 508
Tucker, David.	71, 72		
Tummala, Murali	49, 202	Ziomek, Lawrence J.	204
		Zolla, George	82
Umstatt, Ryan J.	396, 397	Zyda, Michael.	499, 500, 507, 508