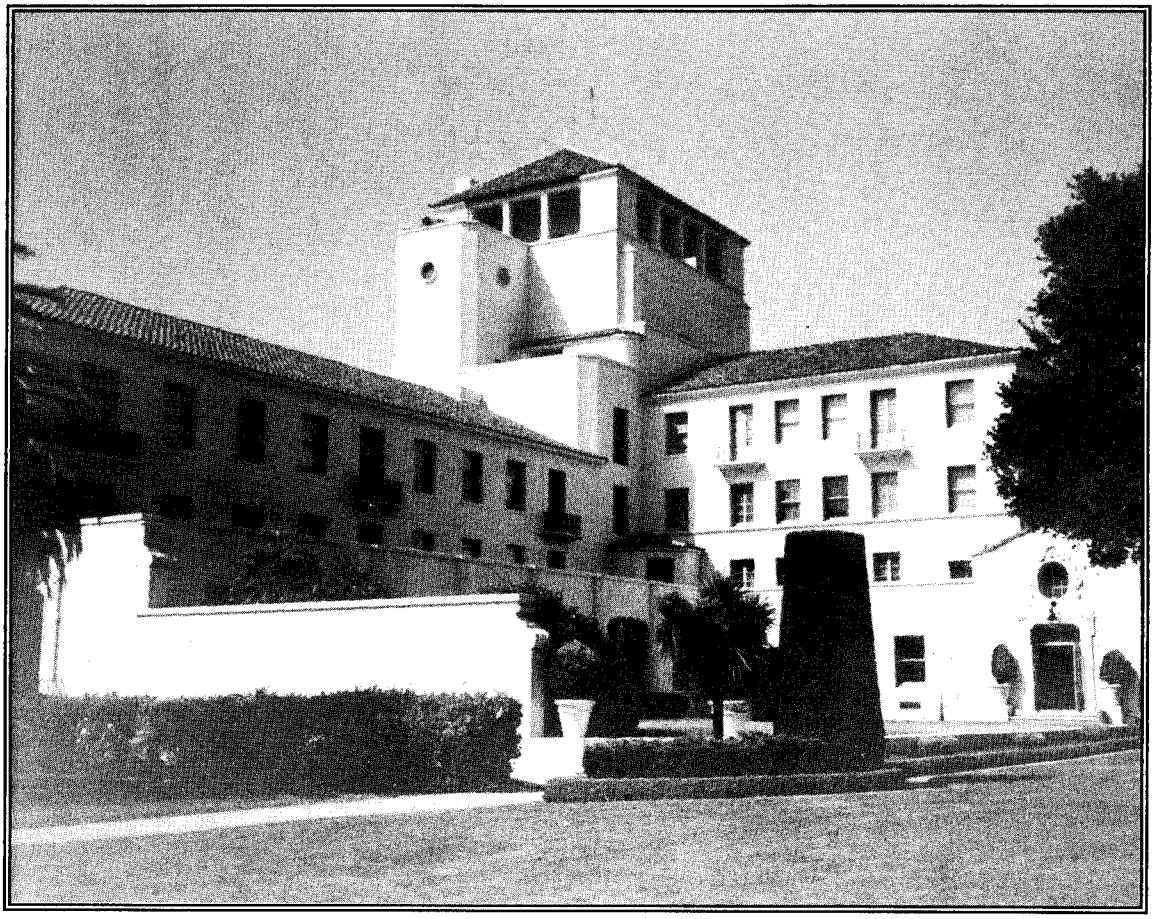
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This report contains 359 summaries of research projects which were carried out under funding of the Naval Postgraduate School Research Program. A list of recent publications is also included which consists of conference presentations and publications, books, contributions to books, published journal papers, and technical reports. The research was conducted in the areas of Aeronautics and Astronautics, Computer Science, Electrical and Computer Engineering, Mathematics, Mechanical Engineering, Meteorology, National Security Affairs, Oceanography, Operations Research, Physics, and Systems Management. This also includes research by the Command, Control and Communications (C3) Academic Group, Electronic Warfare Academic Group, Space Systems Academic Group, and the Undersea Warfare Academic Group.

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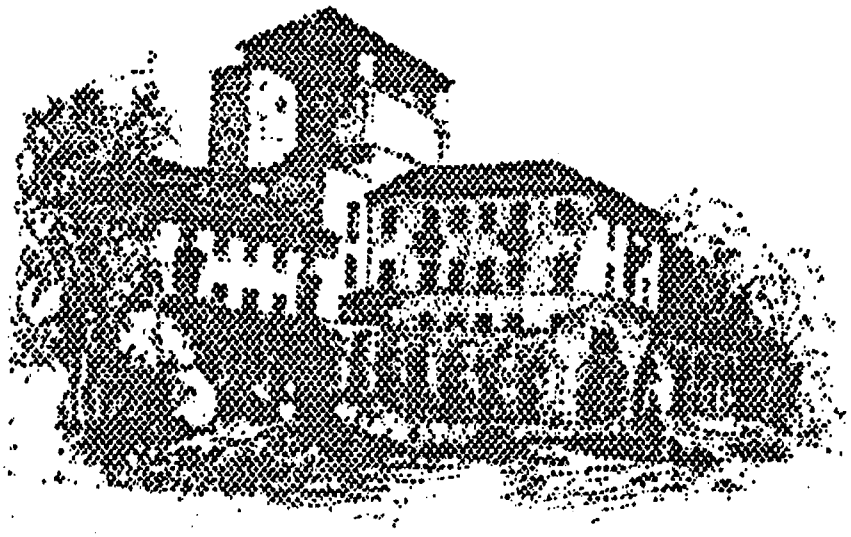
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PREFACE

The Naval Postgraduate School Research Program follows from the School's mission"... to increase the combat effectiveness of the armed forces of the United States by providing quality education ...". Quality education requires that the School foster a program of research to sustain academic excellence. The NPS Research Program is guided by the Research Office in accordance with the Research Office mission statement:

- To develop an overall research investment strategy that ensures a high quality, creative learning experience for NPS graduate students

- To encourage pursuit of new discoveries and applications which enhance the long term effectiveness of the armed forces

- To stimulate interactions between NPS faculty and a wide variety of potential research sponsors

- To publicize (both internally and externally) significant achievements of the NPS research program

The overall program consists of two parts, the Direct Funded Research Program and the Reimbursable Research Program. The Direct Funded Research Program provides internal funding for (1) the Research Initiation Program for new faculty, (2) Navy relevant, meritorious research, (3) interdisciplinary research, (4) unique facilities of institutional importance, and (5) postdoctoral programs. The Reimbursable Research Program consists of those projects which have been funded by outside agencies on the basis of proposals submitted by NPS faculty. In all cases we expect that research pursued at NPS should provide creative, relevant thesis opportunities for our students. The two programs are complementary and ensure that the overall research program is flexible, responsive, balanced and supportive of the School's curricula.

In 1994, the faculty executed 127 research work-years. Of this total, 75% were reimbursable and 25% were direct funded. The work was 64% Navy and 36% non-Navy. The funding received for reimbursable research totaled approximately $26M, including carryover from FY93, and was almost equally divided between Navy and non-Navy sponsors. The research work resulted in 819 theses, 209 journal papers, 203 published conference papers, 396 conference presentations, 65 technical reports, 56 books and chapters, and 4 patents. In addition, NPS faculty received various national and international awards in recognition of their research accomplishments.

Research at NPS is carried out by faculty in the School's eleven Academic Departments and four Academic Groups. In the pages that follow, Research Summaries are provided for projects conducted by the faculty during fiscal year 1994 and Publication Listings by the faculty during calendar year 1994. They are grouped by Department and Academic Group with an overview provided by the Department or Group Chair. A List of Publications for each Academic Department is also included. Questions about particular projects may be directed to the principal investigator or to the Research Office. General questions about the NPS Research Program should be directed to the Research Office at (408) 656-2098 (voice), (408) 656-2038 (FAX) or research@nps.navy.mil (internet).

A companion volume, "Compilation of Abstracts of Theses Submitted by Candidates for Degrees" contains abstracts of approximately 800 unclassified theses completed by NPS graduate students, and is also published yearly.

August 1995

Paul J. Marto
Dean of Research

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Department of Aeronautics and Astronautics

The research program in the Department of Aeronautics and Astronautics is the product of the activities of the Department's five technical groups, namely, Aerodynamics, Structures, Propulsion, Flight Mechanics and Controls, and System Design (both air and spacecraft). Within and across these technical disciplines, the research effort is focused on topics of critical importance to Navy and other military weapons systems. With very few exceptions, one of which is a project undertaken by Professor Howard for Naval Air Systems Command (to conduct a computer analysis and produce a training video showing the potential hazards of formation flying from aerodynamic interference effects), the Department's research activities are concentrated in the following areas:

F18, X31, High-Alpha Aerodynamics and Enhanced Aircraft Maneuver-Ability Studies

Initiated concurrently with the Navy's X31 research aircraft project, a collaborative effort by Professors Platzer, Chandrasekhara, Tuncer and Hebbar is underway to investigate the flow behavior around current and proposed fighter configurations during high angle of attack maneuvers and to identify promising methods for the generation and exploitation of dynamic lift. The effort involves both experimental and advanced computational (CFD) tasks conducted at NPS and at NASA Ames Research Center through the auspices of the NPS-Ames Joint Institute. Low speed wind and water tunnel studies have been carried out at NPS with an X-31A-like fighter model (with and without oscillating canards), double delta and YF-17 aircraft models. The latter study complimented full-scale F/A-18 tests in the Ames 80x120 ft. wind tunnel. Experiments to establish compressibility effects of dynamic stall are conducted at Ames. Also at Ames, exploratory experiments have been carried out to develop practical adaptive-geometry techniques for controlling unsteady separated flows. Methods to predict the complex flow structures and resulting unsteady forces and moments are under development using both Navier-Stokes and Viscous-Inviscid Inter-action approaches. The flow physics of multi-element airfoils in unsteady motion are also being examined for possible applications in air vehicles. In a separate effort carried out at NPS by Professor Howard, a wind tunnel investigation of wing-and-strake blowing to control vortices produced by advanced maneuverable fighter configurations at high angles of attack, has been undertaken. This follows a previous study of canard-vortex/wing vortex interactions to explain the underlying mechanism for achieving enhanced lift.

High-Angle-Of-Attack Missile Aerodynamics and Hypersonics

In support of the Naval Air Warfare Center, Weapons Division, Professors Platzer and Tuncer are developing Navier-Stokes solutions for turbulent flow over missile configurations in steady and unsteady high angle of attack flight at subsonic, transonic, and supersonic Mach numbers. Professor Newberry has been looking at a low-speed aerodynamic analysis of a hypersonic (waverider) configured model for the NASA Ames research center.

Multi-Disciplinary Design Optimization

Professor Platzer entered into a Cooperative Research & Development Agreement (CRADA) with the McDonnell-Douglas Aircraft Corporation to contribute to the development of advanced multidisciplinary analysis and design optimization methods for subsonic transport aircraft.

Studies of Short Take-Off and Vertical Landing Aircraft

Professors Hebbar and Platzer performed experiments to determine the ground interference effects on short take-off and vertical landing (VSTOL) in hover. These studies are supported by the NASA Ames Research Center.

Topics Related to Advanced Rotorcraft

A program led by Professor Wood has five areas. First, research is being conducted in the unsteady aerodynamics related to higher harmonic control (HHC). HHC is an active control system concept which promises reduced helicopter vibrations, lower rotor noise levels and improve helicopter performance. Recent NPS research based on he results from the 1984 NASA/Army/McDonnell Douglas OH-6A HHC flight test program show that a reduction in rotor power results due to the unsteady wake shed by the rotor with HHC turned on. Second, research is being conducted on the no tail rotor (NOTAR) concept which uses circulation control aerodynamics (Coanda) effect to counter the torque from the helicopter's main rotor. This research is being carried out using: (1) a 1/4 scale remotely piloted helicopter with a NOTAR tailboom; (2) the NPS water tunnel; and (3) the NPS wind tunnel Third, real-time flight simulation is being carried out for both helicopters and UAV's using *FLIGHTLAB*, which is a unique computer software program developed by Advanced Rotorcraft Technology that permits detailed modelling of aircraft to a level never before considered possible including many higher order and non-linear effects. Fourth, NPS is receiving two full scale OH-6A helicopters from the Army in September. The helicopters are being delivered in flying status. One of the helicopters will be removed from flying status and undergo structural dynamics research in the new ME Dynamics Laboratory. Goals for this research include: (1) Using ground vibration test data, devise methods for improving finite element models; (2) Extend the predictive capability of finite element models up through the 25-30 Hz range; and (3) Improve the predictive capability of current comprehensive codes for analysis of coupled rotor-airframe vibrations. The second helicopter will be maintained on flight status and used for research on helicopter noise and vibrations. Fifth, NPS is initiating work in the Physics Department directed at understanding and controlling blade-vortex-interaction (BVI) noise. In the tests to be performed, a rotor blade will be suspended in an anechoic chamber and BVI noise will be synthesized on its surface. In a separate study, aimed at the "dynamic stall" problem, Professors Chandrasekhara and Platzer are conducting unique experiments to examine the effects of compressibility on the dynamic stall of oscillating airfoils and to eventually control the stall of the retreating blade by means of periodically deforming the blade leading edge.

Unmanned Air Vehicle (UAV) Technology

In support of the DoD's role in the development of UAV's, Professor Howard has developed a UAV laboratory at NPS which now contains various vehicles for flight or wind tunnel tests. The broad goal is to develop technologies and techniques applicable to UAV's, including Maritime, Close-Range, and Vertical Takeoff and Landing (VTOL) types. The design, construction and testing of a full-scale VTOL UAV has been initiated. Current focus, jointly with Professor Kaminer, is on flight controls and stability augmentation for this unique vehicle configuration. The "Archytas" is a tailsitter design with ducted-fan propulsion that must transition to horizontal flight. A multi-input, multi-output controller has been designed and tested and hover tests are imminent. Professors Howard, Kaminer and Netzer are also investigating a lethal UAV concept.

Improving Air Vehicle Controls & Military Applications of Neural Networks

Tracking controllers for advanced air vehicles need to be robust. Professor Kaminer has begun a study of the application of H_2 and a synthesis of H_2 and H_∞ techniques to the design of such controllers. The development of a methodology to properly implement gain-scheduled controllers in the air vehicle system is identified as a primary goal. A second effort is to investigate the application of the sensor and actuator failure detection and isolation (FDI) techniques developed for automobiles to air vehicle systems. Also, the development of a differential GPS/INS navigation system for automatic aircraft landing is being initiated, and real-time hardware-in-the-loop simulation with 3D animation is planned. Following work on the X29 controller, Professor Collins has extended his work on neural networks to two important Navy problems. In the first, neural networks are being developed to identify transient sonar signals. In the second, neural network technology is being applied to

ionospheric modeling and to PMA operator training. Professor Kaminer has been looking into applications of H-Infinity and other synthesis methods to the design of robust tracking controllers.

Failure and Life Prediction for Advanced Composite and Aging Aluminum Vehicle Structures

Increased use of composites structures in all weapons platforms requires that there be developed reliable predictive methods for failure and probable structural life. Professor Wu has undertaken this fundamental problem using an analytical approach which separates fiber, matrix and interface mechanisms, and uses carefully controlled experiments to establish necessary statistical strength and life data. A unique new laboratory for composites has been established at NPS and the first successful research results have now been reported.

Advanced Aircraft Engine and Missile Propulsion Studies

Currently in its second phase, the goals of the third phase of the (tri-service, government/industry) Integrated High Performance Turbine Engine Technology (IHPTET) Program can only be reached by achieving very significant performance and weight advances in each of the engine components. Advancing fan and compressor and turbine aerodynamics (to allow higher-blade loading) is the focus of the work of Professors Shreeve and Hobson at the Turbopropulsion Laboratory. The general approach is to use the laboratory's exceptional experimental facilities to validate CFD codes being developed for use in advanced design. The off-design and stalling behavior of controlled-diffusion compressor blading is being measured in a very large-scale subsonic cascade wind tunnel. The alleviation of shock boundary-interaction losses is being studied in a transonic blow-down wind tunnel model simulation of the flow through fan passages. The details of flow in the tip region of high speed turbines is to be studied using, as a tool, the Space-Shuttle Main-Engine fuel-pump turbine and an annular cascade. Two- and three-dimensional traversing Laser-Doppler Velocimeter (LDV) systems have been developed for velocity field mapping. The development of successful diagnostic techniques to resolve small- scale, three-dimensional effects near to walls is necessary to achieve the goals of this and the IHPTET program.

Professor Netzer's work at the Combustion Laboratory is directed at several missile and gas turbine areas; (1) development of a small, low cost, long-range, combined-cycle motor for lethal UAV or helicopter (BMDO), (2) fuel additive effects on plume IR signature of liquid rocket motors, (3) effects of particulates on supersonic shear layer mixing and plume IR signature (ONR), (4) combustion behavior of high energy liquid and solid fuels (NAWCD), and (5) optimization of inlets and fuel distribution for liquid-fuel ramjets (NAWCWD). Professors Biblarz and Netzer are developing an instrument for the on-line determination of soot concentration within the test cell environment (NAWCAD).

Spacecraft Design, Attitude Control, Maneuver & Smart Structures

In Spacecraft Design, under Professor Agrawal's supervision, three design projects were completed: a Topaz II Nuclear Powered SAR Satellite, a Tomographic Spacecraft to Reconstruct an Image of the Ionosphere, and a Spacecraft for Measurement of Atomic Oxygen and Demonstration of Vibration Isolation Technology. The Topaz II project won second place in the AIAA Graduate Teams Space Design competition. Professor Scrivener has analyzed structural dynamics test data on Topaz II and has also looked at structural aspects of PANSAT satellites. Professors Agrawal and Bang developed a new switching function for robust control of slew maneuvers using thrusters. LT Janvier and Professor Agrawal developed and adaptive control law for a space based, two-link robotic manipulator. Mr. McClelland from NRL and Professor Agrawal analyzed pulse-width pulse-frequency (PWPF) modulator thruster control methods. LCDR Fuerstein and Professor Agrawal analyzed different control methods for vibration suppression of flexible structures using piezoceramic actuators. Vibration suppression using H-infinity control was also analyzed.

Astrodynamics

Astrodynamics is the study of natural and artificial bodies in space. In support of DoD's role in the prediction and control of spacecraft motion, Professor Ross conducts research in the area of trajectory maneuver and optimization, singular control and mission design. A "bang-bang" maneuver called aerobang was developed by Professor Ross for the purpose of minimizing propellant use for orbital plane-change maneuvers. He and his students have mapped the efficacy regions for the maneuver and are currently working on optimizing the trajectory. Under Professor Ross' guidance, a team of students designed single and dual burn maneuvers for low-Earth-orbit maintenance. In support of the Air Force Space Command, another team of students, guided by Professor Ross and Alfriend (Navy TENCAP Chair Professor), are currently working on mission design for near-Earth-orbit interception. Professor Scrivener has been developing computer codes for time optimal attitude maneuvers.

Aircraft Combat Survivability and Lethality Assessment

Professor Ball originated the study of aircraft combat survivability at NPS in 1974 and has provided technical support for the Naval Air Systems Command (NAVAIR) and the Joint Technical Coordinating Group on Aircraft Survivability (JTCG/AS); (1) by writing a textbook in aircraft combat survivability ("The Fundamentals of Aircraft Combat Survivability and Design," published by the American Institute of Aeronautics and Astronautics (AIAA) in 1985), (2) by conducting short courses in survivability since 1978, (3) by developing the NPS/NAVAIR Survivability and Lethality Assessment Center (SLAC), and (4) by conducting a variety of studies on the survivability of US aircraft and the lethality of US air defense systems. In FY 1994, the majority of efforts were devoted to; (1) the continued development of the second edition of the AIAA survivability textbook, (2) the presentation of three 3-day short courses: one at the Army Aviation and Troop Command in St. Louis, one at the Army Aviation System Command in Newport News, and the third at the Naval Air Warfare Center - Aircraft Division at Patuxent River, (3) the continued development of the SLAC, and (4) two new studies on the survivability of aircraft. The two studies were student MS theses. One thesis developed a procedure for conducting test and evaluation of electronic warfare equipment. The second thesis examined the safety and survivability issues related to a number of engines on tactical aircraft.

SPACECRAFT SYSTEMS

B.N. Agrawal, Professor
Department of Aeronautics and Astronautics
Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: The goal of this project was to develop three spacecraft laboratories at NPS: Fltsatcom Laboratory, Spacecraft Test Laboratory, and Spacecraft Dynamics and Control Laboratory. It is a continuing project.

SUMMARY: The Ling vibration control system became operational. A new switching function was developed for robust control of slew maneuvers using thrusters. The switching function provided the capability to make trade-offs between slew maneuver time and propellant consumption. An adaptive control law was developed for a space based two-link robotic manipulator. The adaptive controller is found to be superior to the nonadaptive controllers for a high level of system parameter uncertainty. Pulse-width-pulsefrequency (PWPF) modulator thruster control methods over conventional bang-bang thruster control methods were analyzed. Simulations were performed for flexible spacecraft using a describing function model of the modulator. Stability margin with respect to the structural mode limit cycle is predicted and verified.

PUBLICATIONS:

Bang, H. and Agrawal, B., "Application of Constraint Dynamics for Spacecraft Maneuver," AIAA-963625-CP, Proceedings of AIAA Guidance, Navigation and Control Conference, Scottsdale, AZ, 1-3 August 1994.

Yale, G. and Agrawal, B., "Cooperative Control of Multiple Space Manipulators," AIAA-943625-CP, Proceedings of AIAA Guidance, Navigation and Control Conference, Scottsdale, AZ, 13 August 1994.

Janiver, G., IV and Agrawal, B., "Adaptive Control for a Space Robotic Manipulator," 45th Congress of the International Astronautical Federation, Jerusalem, Israel, 9-14 October 1994.

Agrawal, B. and Bang, H., "Robust Closed-loop Control Design for Spacecraft Slew Maneuver Using Thrusters," accepted for publication in the AIAA Journal of Guidance, Control, and Dynamics.

THESES DIRECTED:

McClelland, R., "Spacecraft Attitude Control Performance with Pulse-Width-Pulse Frequency Modulated Thrusters," Master's Thesis, March 1994.

Janiver, G., IV, Lt. USN, "Adaptive Control for a Spacecraft Robotic Manipulator," Master's Thesis, December 1993.

OTHER:

Yale, G.E. and Agrawal, B.N., "A Lyapunov Controller For Cooperative Space Manipulators," submitted for publication in AIAA Journal of Guidance, Control, and Dynamics.

Submitting patent entitled "Robust Cosed-loop Control Design for Spacecraft Slew Maneuver Using Thrusters."

DOD KEY TECHNOLOGY AREA: Design Automation

KEYWORDS: Spacecraft Design, Adaptive Structures, Space Attitude Control

ADAPTIVE SPACECRAFT STRUCTURES

B.N. Agrawal, Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Postgraduate School

OBJECTIVE: The goal for the project was to improve adaptive structures (smart structures) technologies for spacecraft application.

SUMMARY: The focus of the research was to minimize the vibration at the end of flexible arm supporting an antenna by using piezo-ceramic sensors and actuators. Hinfinity wave absorbing controller for vibration suppression of the arm was analyzed. A new control technique for selecting gains for multi-sensors and actuators was developed. It was based on optimization approach to minimize the cost function representing the vibration at the end of flexible arm. These control laws were implemented on AC- 100 for experiments. The new control laws provided good performance.

PUBLICATIONS:

Agrawal, B. and Bang, H., "Adaptive Structures for Large Precision Antennas," IAF-94I.4.202, 45th Congress of the International Astronautical Federation, Jerusalem, Israel, 9-14 October 1994.

Bang, H. and Agrawal, B., "A Generalized Second Order Compensator Design for Vibration Control of Flexible Structures," AIAA-94-1626, Proceedings of 35th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, Hilton Head, SC, 18-20 April 18-20 1994.

THESIS DIRECTED:

Feuerstein, M., LCDR, USN, "A Comparison of Different Control Methods for Vibration Suppression of Flexible Structures Using Piezoelectric Actuators," Master's Thesis, June 1994.

DOD KEY TECHNOLOGY AREA: Material and Processes

KEYWORDS: Smart Materials, Adaptive Structures, Vibration Isolation

NASA/USRA ADVANCED DESIGN PROGRAM

B.N. Agrawal, Professor
Department of Aeronautics and Astronautics
Sponsor: NASA/University Space Research Association

OBJECTIVE: The goal of the project was to promote engineering education in space and astronautics through design.

SUMMARY: Two spacecraft system design projects were completed: Topaz II Nuclear Powered SAR Satellite and Design Concept for the Tomographic Satellite System (TOMSAT). The primary specifications for the Topaz II Nuclear Powered SAR Satellite were based on an ALAA Lockheed Corporation Graduate Team Space Design Competition data package. The NPS design won second place in this national design competition. The satellite mission was to provide SAR imagery of open ocean and land mass areas over L, C, X frequency bands using dual polarization and using TOPAZ II as electric power source. The mission of TOMSAT was to provide ionosphere mapping of the earth through a process similar to that used in medical CAT scanning technology.

PUBLICATION:

Feuerstein, M. and Agrawal, B., "Topaz II Nuclear Powered SAR Satellite," AIAA 94-4688, AIAA Space Program and Technologies Conference, Huntsville, AL, 27-29 September 1994.

DOD KEY TECHNOLOGY AREA: Design Automation

KEYWORDS: Spacecraft Design, Nuclear Power, Ionosphere Mapping

NPS SURVIVABILITY SUPPORT

R.E. Ball, Professor
Department of Aeronautics and Astronautics
Sponsor: Joint Technical Coordinating Group on Aircraft Survivability (JTCG/AS)

OBJECTIVE: The objective of this effort is to continue the technical support provided to the JTCG/AS for the past 21 years by conducting research, presenting short courses, developing educational material, and performing analyses in aircraft combat survivability. The accomplishments during FY94 are given below.

SUMMARY:

(1) Short and Shorter Courses: Since 1979, the one week NPS/NAVAIR/JTCG/AS short course has been offered biennially by Prof. Ball. The most recent offering was in Monterey in April, 1993, and over 150 US military officers and DoD and US aerospace engineers and managers attended. In order to make the material available to more people, Prof. Ball developed an 18 hour shorter version of the one week course in 1991. Between 1991 and 1993, he conducted four shorter courses. In 1994, he conducted his shorter course for the USAF Combat Rescue School at Nellis AFB, NV.

(2) Educational Materials: Professor Ball continued the development of the second edition of his AIAA textbook, "The Fundamentals of Aircraft Combat Survivability Analysis and Design." Progress in FY94 consisted of rough drafts of the Front Material, Chapter 1 and a new Appendix on Probability Theory and Its Application to Survivability Assessment.

(3) Projects: One special project was completed in FY94 with the help of LT Dale Feddersen. It consisted of a major conversion of the Macintosh Survivability Assessment Program (MACSAP) to the Helicopter Interactive Survivability Assessment Program (HISAP). MACSAP is used to assess the payoffs and penalties associated with survivability enhancement features in the conceptual design phase of fixed wing aircraft. It has been distributed to over 30 organizations. HISAP was developed for helicopters.

THESES DIRECTED:

Student, LT Dale Feddersen, USN, received the VICE ADMIRAL James B. Wilkinson award. His project was the development of HISAP.

DOD KEY TECHNOLOGY AREA: Other (Modeling and Simulation)

KEYWORDS: Aircraft, Survivability, Modeling, Simulation

NPS/NAVAIR SURVIVABILITY & LETHALITY ASSESSMENT CENTER

R.E. Ball, Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Systems Command, Code 5164

OBJECTIVE: The objectives of this research project are (1) to develop a survivability and lethality assessment center within the NPS Wargaming Analysis & Research Laboratory, and (2) to use the center to conduct survivability and lethality studies. The computer programs in the center are available to the students and faculty at NPS for research in specific survivability and lethality topics on land, sea, air, and space targets as well as research on the programs themselves. The following efforts were completed or are still underway at the end of 1993.

SUMMARY: The major accomplishment in 1994 was the acquisition and installation of IVAMOD, a program for computing the vulnerable area of an aircraft. This program will be used in theses studies and in AA 3251 as an illustration of the methodology for computing vulnerable area.

DOD KEY TECHNOLOGY AREA: Other (Modeling and Simulation)

KEYWORDS: Aircraft, Air Defense, Survivability, Lethality, Modeling, Simulation

F–14A/B UPGRADE PROGRAM SURVIVABILITY ASSESSMENT

R.E. Ball, Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Weapons Center – Weapons Division (Point Mugu)

OBJECTIVE: The objectives of this project are (1) to develop a methodology that can be used to assess the enhanced survivability of an aircraft due to the six susceptibility reduction concepts (threat warning, noise jamming and deceiving, signature reduction, expendables, threat suppression, and tactics), (2) to determine the impact of a digital avionics data bus upon survivability, and (3) to assess the enhanced survivability of the F–14A/B due to the 1991 Upgrade Program.

SUMMARY: The F–14 A and B versions of the Tomcat are undergoing an Electronic Combat system upgrade in order to meet current and future threats and to improve its combat survivability. The Upgrade Program consists of an improved radar warning system and displays – the ALR–67D(V)2), an improved active electronic countermeasures system – the ALQ–126B, and a significant increase in expendable chaff – the BOL system. In addition, a digital data bus will be added. In 1993, a methodology was developed to assess the effects of susceptibility reduction. In 1994, the study of the impact of the avionics architecture upon the survivability of an aircraft was begun. This task will be completed in 1995.

DOD KEY TECHNOLOGY AREA: Other (Aircraft Survivability)

KEYWORDS: Aircraft, F–14, Survivability, Susceptibility

GOVERNMENT AND INDUSTRY SURVIVABILITY EDUCATION TASK PLAN

R.E. Ball, Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Weapons Center – Weapons Division, China Lake

OBJECTIVE: The objective of this task is to develop a training plan that identifies the training required to develop competency in the discipline of survivability testing and analysis. This plan will address the needs for academic and on–the–job training. The plan will coordinate Navy efforts with other ongoing activities, such as training programs associated with the JTCG/AS and JTCG/ME

SUMMARY: This project started in the summer of 1994. Professor Ball's role in this task is to provide information regarding the opportunities for education in survivability and advice regarding the material that should be covered. Although this project is a continuing project, it has been inactive since the end of the summer of 1994.

DOD KEY TECHNOLOGY AREA: Other (Aircraft Survivability)

KEYWORDS: Survivability, Susceptibility, Vulnerability, Test and Evaluation

A SHORTER COURSE IN AIRCRAFT COMBAT SURVIVABILITY FOR THE AIR FORCE COMBAT RESCUE SCHOOL

R.E. Ball, Professor
Department of Aeronautics and Astronautics
Sponsor: U.S. Air Force Combat Rescue School

OBJECTIVE: The objective of this task is to present a three day shorter course in aircraft combat survivability to the U.S. Air Force Combat Rescue School at Nellis Air Force Base, Las Vegas, NV.

SUMMARY: The U.S. Air Force stood up the Combat Rescue School in the summer of 1993. A curriculum is being developed for this new school using many of the concepts and material presented in Prof. Ball's survivability courses. Consequently, Prof. Ball was invited to present this material to the staff members of the School so they would have a first hand opportunity to learn the material and include it in the curriculum.

DOD KEY TECHNOLOGY AREA: Other (Aircraft Survivability)

KEYWORDS: Survivability, Susceptibility, and Vulnerability

EFFECTS OF BOUND CLUSTERS ON THE OPTICAL AND THERMAL PROPERTIES OF HIGH-ENERGY LASER MIRRORS

O. Biblarz, Professor
Department of Aeronautics and Astronautics
Sponsor: NAWC Physics Division, China Lake
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project is to investigate possible cluster contributions to mirror damage and to the operation of uncooled optics in high energy laser applications.

SUMMARY: High energy laser mirrors exhibit damage of as yet unknown origin. Bound clusters from the

substrate have the same chemical elements as the rest of the surface but manifest a different structure. They have, therefore, different properties, both optical and thermal. The existence of these clusters is predicted from equilibrium relationships. The study of melting has yielded some interesting insights in that the coatings with the highest melting point are the least susceptible to damage. Melting of refractory metals such as tungsten are scrutinized with the model of intrinsic clusters permeating the crystalline matrix and representing a "molten fraction" at any temperature.

DOD KEY TECHNOLOGY AREA: Materials and Processes

KEYWORDS: Clusters, HEL Mirrors, Melting, Mirror Damage

ALTERNATE PROPELLANTS FOR NUCLEAR ELECTRIC PROPULSION

O. Biblarz, Professor
Department of Aeronautics and Astronautics
Sponsor: Phillips Labs, Kirkland AFB

OBJECTIVE: The goal of this project is to relate to the Nuclear Electric Propulsion (NEP) space test mission of the AF Phillips Laboratory. Electrical power generation by direct conversion together with electric propulsion are included a bimodal concept for space nuclear reactor utilization.

SUMMARY: The Space Power and Thermal Management Division of the AF Phillips Labs runs a number of programs in which the Naval Postgraduate School is able to contribute expertise. One of these is the TOPAZ II thermionic power generator, purchased from the former USSR and being tested and evaluated by the TOPAZ International Program (TIP). Prior to propulsion applications, the thermionic power generator thermal and electric characteristics are being studied and these studies comprised the effort during this reporting period. It was found that useful power can be produced by the thermionic fuel elements at low heating levels. The test stand for single cell elements (TFEs) was investigated and critical thermal resistances identified.

THESIS DIRECTED:

Benke, S.M., LT USN, "Operational Testing and Thermal Modelling of a TOPAZ-II Single-Cell Thermionic Fuel Element Stand," Master's Thesis, December 1994.

OTHER:

Briefing to the TOPAZ International Program group in Albuquerque, NM, on 10 August 1994.

Benke, S.M. and Venable, J.R., "Operational Testing and Thermal Modelling of a TOPAZ-II Single-Cell Thermionic Fuel Element Stand," Twelfth Symposium on Space Nuclear Power and Propulsion, Albuquerque, New Mexico, forthcoming 8-12 January 1995. [Full paper in Conference proceedings.]

DOD KEY TECHNOLOGY AREA: Propulsion and Energy Conversion

KEYWORDS: Nuclear Electric Propulsion, Bimodal, Thermionic Power Generation

A FUNDAMENTAL STUDY OF THE COMPRESSIBILITY EFFECTS ON DYNAMIC STALL OF FIXED AND ADAPTIVE AIRFOILS

M.S. Chandrasekhara, Research Associate Professor
M.F. Platzer, Professor
Department of Aeronautics and Astronautics
Sponsor/Funding: U.S. Army Research Office

OBJECTIVE: To study compressibility effects on an airfoil in unsteady motion while it adapts locally to overcome the forces causing unsteady flow separation. The research has applications in active control of helicopter "retreating blade stall". Initiated in April 1994, as a follow-on to the previous research efforts.

SUMMARY: The flow over a helicopter retreating blade is being studied when the blade geometry is changed during active control of dynamic stall under compressible flow conditions. A dynamically deforming leading edge airfoil was developed under a separate (AFOSR) grant. The shape of the airfoil changes as it adapts to different flow conditions while it maintains attached flow (and hence dynamic lift) over it. The fundamental fluid dynamic issues under such conditions is being investigated. Also, a high-speed, real-time movie-record of the flow over a fixed airfoil was generated with special instrumentation developed for the AFOSR project. A video of the developing dynamic stall flow at a Mach number of 0.3 was created and is now being analyzed.

CONFERENCE PRESENTATION:

Chandrasekhara, M.S. and Carr, L.W., "Compressibility Effects on Dynamic Stall of Oscillating Airfoils," AGARD-CP-552, Proceedings of the AGARD 75th Fluid Dynamics Panel Meeting on Aerodynamics and Aeroacoustics of Helicopters, pp. 3.13.15, Berlin, Germany, 10-13 October 1994.

OTHER:

A seminar titled "Compressibility Effects on Dynamic Stall of Oscillating Airfoils" was presented at DLR, Gottingen, Germany, on 13 October 1994 by Professor M.S. Chandrasekhara.

DOD KEY TECHNOLOGY AREA: Other (Aerodynamics)

KEYWORDS: Dynamic Stall, Helicopter Blade Stall, Interferometry, Adaptive Wing Flow

COMPRESSIBILITY EFFECTS ON AND CONTROL OF DYNAMIC STALL OF OSCILLATING AIRFOILS

M.S. Chandrasekhara, Research Associate Professor
M.F. Platzer, Professor
Department of Aeronautics and Astronautics
Sponsor/Funding: U.S. Army Research Office

OBJECTIVE: To study the effects of compressibility effects on dynamic stall of oscillating airfoils and control the process of dynamic stall. The research has applications in helicopter "retreating blade stall." Completed in April 1994.

SUMMARY: The flow over a helicopter retreating blade was simulated in the compressible dynamic stall facility (CDSF) for a range of conditions corresponding **to that** encountered by a helicopter blade as it moves away from the flow stream. Intricate flow details such as formation of multiple shocks over the airfoil leading edge were documented. The supersonic flow region and the shocks were analyzed by a custom interferogram analysis software package developed in-house as part of the research effort. In an attempt to extend the applicability of

the test results to the much higher Reynolds number full-scale helicopter, more tests were conducted by tripping the airfoil boundary layer. Owing to lack of proper recommendations of a trip suitable for the purpose, a systematic investigation of boundary layer tripping methods and the possible effects of these on dynamic stall development was undertaken. A distributed roughness of height comparable to the local boundary layer was found to be the most ideal trip. Analysis of interferograms of the flow showed that the ability of the airfoil boundary layer to overcome the adverse pressure gradient decreases with increasing Mach number, revealing that the major effect of compressibility is to weaken the boundary layer, leading to premature stall and loss of dynamic lift.

PUBLICATIONS:

Ahmed, S. and Chandrasekhara, M.S., "Reattachment Studies of an Oscillating Airfoil Dynamic Stall Flow Field," AIAA Journal, Vol. 32, No. 5, pp. 1006-1012, May 1994.

Carr, L.W., Chandrasekhara, L.W., and Brock, N., "A Quantitative Study of Unsteady Compressible Flow on an Oscillating Airfoil," Journal of Aircraft, Vol. 31, No. 4, pp. 892-898, July/August 1994.

Carr, L.W., Chandrasekhara, L.W., Ahmed, S., and Brock, N., "A Study of Dynamic Stall Using Real-Time Interferometry," Journal of Aircraft, Vol. 31, No. 4, pp. 995-996, July/August 1994.

CONFERENCE PRESENTATIONS:

Chandrasekhara, M.S., Wilder, M.C., and Carr, L.W., "Boundary Layer Tripping Studies of Compressible Dynamic Stall Flow," AIAA Paper No. 94-2340, presented at the AIAA 25th Fluid Dynamics Conference, Colorado Springs, CO, 20-23 June 1994.

Van Dyken, R.D., Ekaterinaris, J.A., Chandrasekhara, M.S., and Platzer, M.F., "Analysis of Compressible Steady and Oscillatory Airfoil Flows at Transitional Reynolds Numbers," AIAA Paper No. 94-2225, presented at the AIAA 25th Fluid Dynamics Conference, Colorado Springs, CO, 20-23 June 1994.

Ekaterinaris, J.A., Chandrasekhara, M.S., and Platzer, M.F., "Analysis of Low Reynolds Number Airfoil Flows," AIAA Paper No. 94-0534, presented at the AIAA 32nd Aerospace Sciences Meeting, Reno, NV, 10-13 January 1994.

OTHER:

Chandrasekhara, M.S., "Compressibility Effects on and Control of Dynamic Stall of Oscillating Airfoils," Final Report submitted to U.S. Army Research Office, December 1994.

DOD KEY TECHNOLOGY AREA: Other (Aerodynamics)

KEYWORDS: Dynamic Stall, Helicopter Blade Stall, Interferometry, Boundary Layer Tripping

CONTROL OF DYNAMIC STALL OF AND COMPRESSIBILITY EFFECTS ON TRANSIENTLY PITCHING AIRFOILS USING ADAPTIVE GEOMETRIES

M.S. Chandrasekhara, Research Associate Professor
M.F. Platzer, Professor
Department of Aeronautics and Astronautics
Sponsor: U.S. Air Force Office of Scientific Research

OBJECTIVE: To develop deployable means of controlling the unsteady separated flows over a maneuvering wing by using wing geometries that adapt to the instantaneous flow over it. The research has applications in enhancing the maneuverability of fighter aircraft. Ongoing since October 1992.

SUMMARY: Based on earlier research, it was deduced that the key to controlling the separation of flow over maneuvering wings is the alleviation of the strong adverse pressure gradients and delay the onset of compressibility effects on the wing. Hitherto, this was not easily possible. However, a new approach has been developed in this project, which relies on developments in composite materials and advanced instrumentation control, both of which together have permitted real-time adaptation of the wing to the instantaneous flow over it. During the reporting period, the engineering design and fabrication of an airfoil with a composite skin leading-edge were completed. Also the tuning of the control system for dynamically changing the airfoil leading edge shape as it executes a rapid oscillatory motion was performed. The system is capable of producing significant changes to the airfoil leading edge curvature in less than 10 millisec. A high-speed, real-time interferometry system to record the flow changes in this extremely short time was designed, built and satisfactorily tested. Tests to assess the mechanical integrity of this dynamically deforming wing are ongoing.

PUBLICATION:

Chandrasekhara, M.S., Carr, L.W., and Wilder, M.C., "Interferometric Investigations of Compressible Dynamic Stall Over Transiently Pitching Airfoils," AIAA Journal, Vol. 31, pp. 576-583, March 1994.

CONFERENCE PRESENTATION:

Chandrasekhara, M.S., Squires, D.D., Wilder, M.C., and Carr, L.W., "A Phase-Locked, High-Speed, Real-Time, Interferometry System for Large Amplitude Unsteady Flows," Proceeding of the 7th International Symposium on Applications to Fluid Mechanics, Lisbon, Portugal, pp. 38.3.1-38.3.8, 11-14 July 1994.

OTHER:

The AIAA journal paper cited above received the NASA Ames Research Center, Fluid Dynamics Division Joseph L. Steger Award for the Best Paper published in the Division in 1994.

A seminar titled "Compressibility EfFects on Dynamic Stall of Transiently Pitching Airfoils" was presented at the National Aerospace Laboratory, Bangalore, India on 28 August 1994 by Professor M.S. Chandrasekhara.

DOD KEY TECHNOLOGY AREA: Other (Aerodynamics)

KEYWORDS: Flow Control, Smart Materials, Advanced Flow Instrumentation

FAN & COMPRESSOR STALL AND OFF-DESIGN PERFORMANCE IMPROVEMENT

G.V. Hobson, Associate Professor
R.P. Shreeve, Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Warfare Center, Aircraft Division

OBJECTIVE: The overall goal of this continuing project is to validate off-design performance and stall prediction for controlled-diffusion (CD) compressor blading experimentally and to obtain information necessary to the development of higher blade loading designs.

SUMMARY: The flow angle was increased to 50 degrees in a linear cascade wind tunnel containing CD compressor stator blading designed for an inlet air angle of nearly 40 degrees by Nelson Sanger. Intermittent stall was found to be present. Blade surface pressures indicated a drop off in normal force. Detailed LDV measurements were made ahead of, over the suction surface and in the wake of one test blade. Laser sheet flow visualization was used to video-record the unsteady stalling behavior and a qualitative correlation was obtained with the unsteady LDV data. These tests established stalling incidence and stall behavior of this well-documented blading design for the first time. Associated attempts to predict stalling using CFD codes were not completed.

CONFERENCE PUBLICATION:

Hobson, G.V. and Dober, D.M., "Three-Dimensional Fiber-Optics LDV Measurements in the Endwall Region of a Linear Cascade of Controlled-Diffusion Stator Blades," Paper No. 94-GT-352, presented at the 39th ASME International Gas Turbine and Aeroengine Congress/Users Symposium & Exposition, The Hague, The Netherlands, 13-16 June 1994.

THESES DIRECTED:

Wakefield, B.E., "Hotwire Measurements of the Turbulent Flow into a Cascade of Controlled-Diffusion Compressor Blades," Master's Thesis, December 1993.

Ganaim, R.H.J., "Laser-Doppler Velocimetry Measurements and Flow Visualization in a Cascade of Controlled-Diffusion Compressor Blades at Stall," Master's Thesis, June 1994.

OTHER:

A paper entitled "Stator-Relative, Rotor Blade-to-Blade Near-Wall Flow in a Multistage Axial Compressor with Tip-Clearance Variation," by Moyle, I.N., Shreeve, R.P. and Walker, G.J. will appear in the Journal of Propulsion and Power.

DOD KEY TECHNOLOGY AREA: Propulsion and Energy Conversion

KEYWORDS: Controlled-Diffusion Blade Stall; LDV Measurements; Compressor Cascade Stall

THREE DIMENSIONAL FLOWS IN AN ANNULAR TURBINE CASCADE

G.V. Hobson, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Postgraduate School

OBJECTIVE: This research project is aimed at obtaining detailed three-dimensional viscous flow measurements in an annular turbine cascade (ATC). Eventually the aim is to be able to measure the vortex flowfield

downstream of a turbine cascade which has formed as a result of tip leakage.

SUMMARY: Three-component LDV measurements have been performed in the corner vortex flow of the Low Speed Cascade (Ref. 1). LCDR Spitz performed preliminary two-component measurements in the ATC. These LDV measurements compared well with previous three-hole probe measurements, however; the measurement location was not readily determined. LCDR Spitz also predicted (later verified by experiment) the blade surface pressure distribution with a three-dimensional Navier-Stokes code. Lt. Donovan has performed blade surface pressure measurements at various pressure ratios (up to the maximum mass flow rate or choking condition) and compared these distributions to full three-dimensional viscous flow calculations. He is currently setting up the tunnel to perform LDV measurements in the wake region. He will initially be repeating LCDR Spitz's measurements to accurately determine the measurement location.

CONFERENCE PRESENTATION:

Hobson, G.V. and Dober, D.M., "Three-Dimensional Fibre-Optics LDV Measurements in the Endwall Region of a Linear Cascade of Controlled-Diffusion Stator Blades," IGTI conference in the Hague, Holland, 1994.

THESIS DIRECTED:

Spitz, J.D., "Laser Anemometry and Viscous Computation of the Flow Through an Annular Turbine Cascade," Master's Thesis, March 1994.

DOD KEY TECHNOLOGY AREA: Propulsion and Energy Conversion

KEYWORDS: Turbine, Laser-Doppler, Velocimetry

TURBINE TIP-LEAKAGE FLOWS

G.V. Hobson, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: NAWC Aircraft Division, Patuxent River

OBJECTIVE: The objective of this project is to develop techniques necessary to obtain non-intrusive LDV data in the tip-leakage region of operating turbines, as these flows account for significant losses. The problems associated with optical access windows, and seeding material are to be addressed in an annular turbine cascade (ATC), and then LDV measurements will be performed in the turbine of the High Pressure Fuel TurboPump (HPFTP) for the Space Shuttle Main Engine (SSME).

SUMMARY: This project entails the systematic measurements of highly swirling turbine flows, with a three-component fibre-optics laser Doppler velocimeter (LDV), in test articles of small size at realistic Mach numbers. The turbine of the High Pressure Fuel Turbopump for the Space Shuttle Main Engine was successfully commissioned into the turbine test rig at the Turbopropulsion Laboratory and preliminary performance measurements were performed, during this study. During these runs the turbine attained a maximum speed of 9600 rpm (design speed is approx. 7500 rpm). The design of a new outer casing for the turbine with optical access windows is currently underway. The configuration will be similar to the one used in the ATC. Currently the turbine is being overhauled after being dismantled for inspection purposes. The rebuild will include the new outer casing with the LDV windows, so that those measurements can commence.

THESIS DIRECTED:

Rutkowski, R.J., "Cold Flow Simulation of the Alternate Turbopump Development Turbine of the Space Shuttle

Main Engine High Pressure Fuel Turbopump," Master's Thesis, March 1994.

DOD KEY TECHNOLOGY AREA: Propulsion and Energy Conversion

KEYWORDS: Turbine, Laser-Doppler, Velocimetry

STRAKE AND WING BLOWING FOR VORTEX FLOW CONTROL ON A CROPPED DOUBLE-DELTA CONFIGURATION

R.M. Howard, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Postgraduate School

OBJECTIVE: The goal of this project was to study the application of pneumatic blowing over a strake-wing configuration as a means of providing vortex flow control and enhanced lift.

SUMMARY: The maintenance of air superiority depends on an ability to perform rapid transient maneuvers at high angles of attack, often into the post-stall flight regime. Enhanced lift during maneuvering is often compromised by the breakdown of vortices shed from strake and wing-leading-edge surfaces. Blowing was applied at multiple locations, inclination angles, sweep angles, and values of blowing coefficient. A maximum lift enhancement of 9% was found blowing near the strake apex at an angle of attack of 20 degrees, a sweep angle of 60 degrees, an inclination angle of zero degrees, and a blowing coefficient of 0.0171. Trends were found to be linear with applied blowing coefficient.

PUBLICATION:

Howard, R.M. and O'Leary, J.F., "Flowfield Study of a Close-Coupled Canard Configuration," Journal of Aircraft, Vol. 31, No. 4, pp. 908-914, July-August 1994.

CONFERENCE PRESENTATION:

Howard, R.M., Willson, J.G., and Zgraggen, C.J., "Lift Enhancement of a Wing/Strake Configuration Using Pneumatic Blowing," AIAA Paper 94-3478, AIAA Atmospheric Flight Mechanics Conference, Scottsdale, AZ, 1-3 August 1994.

OTHER:

The investigator is preparing an Engineering Note for submission for publication in the AIAA Journal of Aircraft. Completion is expected later this year.

DOD KEY TECHNOLOGY AREA: Other (High-angle-of-attack aerodynamics)

KEYWORDS: Vortex flow control, blowing, high angle of attack

DEVELOPMENT OF A TRAINING AID FOR AIRCRAFT FLYING IN CLOSE PROXIMITY

R.M. Howard, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Systems Command

OBJECTIVE: The goal of this project was to carry out a numerical study of the aerodynamic interference of aircraft flying in close proximity, and to produce a narrated video to be used as a training tool for Naval aviation education.

SUMMARY: During an emergency such as an unsafe landing-gear inspection, a second aircraft may be sent aloft for a visual inspection. Such an operation may lead to an inherently unsafe flight condition, particularly if the aircraft are dissimilar in size and wing loading. An F-14 and a T-34 aircraft were modeled flying in vertical formation using a widely-used panel code. It was determined that the T-34 will lose half its lift as it closes to within one wingspan beneath the F-14 while flying at a constant pitch angle, with an accompanying nose-up pitch change requiring 4 degrees of elevator trim change. Confusing cues of being "pushed away" yet being pitched into the lead aircraft may cause the inexperienced pilot to become disoriented and may lead to a possible collision. A 10-minute video using computer graphics was produced to educate fleet aviators of these problems.

CONFERENCE PRESENTATION:

Porter, D.B. and Howard, R.M., "Dissimilar Aircraft Flying in Close Proximity," AIAA Paper 94-3484, presented at the AIAA Atmospheric Flight Mechanics Conference, Scottsdale, AZ, 1-3 Aug. 1994.

OTHER:

A 10-minute computer-graphic video titled "Aerodynamic Interference Associated with Formation Flying" is being completed and will be sent to NAVAIR for distribution to flight training facilities. An accompanying booklet designated Report NPS-AA-95-001 is also in preparation and will be delivered with each video, to be completed by spring 1995.

DOD KEY TECHNOLOGY AREA: Computers, Human-System Interfaces

KEYWORDS: Formation flying, panel code, aerodynamics

AIR-MOBILE GROUND SECURITY SYSTEM PLATFORM ASSESSMENT

R.M. Howard, Associate Professor
I.I. Kaminer, Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Command, Control and Ocean Surveillance Center

OBJECTIVE: Advanced technology proposals were solicited to support the Air-Mobile Ground Security System Program under the management of the Physical Security Equipment Management Office and the technical direction of NRaD. The expertise of the principal investigators was used to assist in the evaluation of contract responses in the areas of vehicle performance, stability and control, guidance and navigation, and communications.

SUMMARY: The Naval Command, Control and Ocean Surveillance Center, RDT&E Division (NRaD), solicited advanced development technology proposals to support the Air-Mobile Ground Security System Program. The mission required an unmanned platform to fly to and land at an unprepared site and perform security functions on the ground over a 24-hour period, reposition to another location, and return to the

original takeoff location. Tradeoff studies involving such issues as handling, unprepared-site takeoff, sensor-package incorporation, power generation, restart capabilities, and autoland were reviewed, and contractors were chosen for system development. A computer code was produced to estimate the hover performance of various single- and dual-rotor ducted-fan configurations to help provide an effective evaluation tool.

THESIS DIRECTED:

Schachterle, M.B., LT, USN, "VTOL Unmanned Air Vehicle Design Performance Study," Master's Thesis, June 1994.

OTHER:

A FORTRAN computer program predicting the hover performance of a given single- or dual-rotor ducted-fan air vehicle was developed to provide an effective tool for evaluation and comparison of the various plat^V forms. The program was given to NRaD for their use in this program or in similar programs in the future.

DOD KEY TECHNOLOGY AREA: Sensors, Software

KEYWORDS: VTOL, UAV, ducted fan, performance

APPLICATION OF H∞ AND MIXED H TWO/H INFINITY SYNTHESIS TO THE DESIGN OF ROBUST TRACKING CONTROLLERS AND RELATED

I.I. Kaminer, Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Postgraduate School

OBJECTIVE: The ongoing goal of this project is to investigate the application of H_infinity and mixed H two/H_infinity synthesis techniques to the design of robust tracking controllers. Furthermore, should there be a lack of theoretical tools needed to accomplish this task, such tools will be developed.

SUMMARY: In the work covered by this proposal we addressed certain issues which are important to the design of control systems for combat aircraft. In particular, we applied recently developed robust control design methodologies to synthesize an automatic carrier landing controller for F-14. In general such controllers are designed for linear models of the plant around a number of nominal operating conditions. It turns out that for a certain class of nonlinear plants such designs result in gain-scheduled controllers. The issue of properly implementing such controllers has received little attention in the literature. Therefore, we are in the process of developing a methodology to properly design and implement gain-scheduled controllers on the nonlinear plants with applications to motion control of rigid bodies. Furthermore, we have developed a new methodology for the integrated aircraft control power/feedback controller design. The main approach is to rewrite the performance requirements as Linear Matrix Inequalities. Finally, a significant effort was dedicated to the development of the rapid prototyping system for flight control law analysis and hardware-in-the-loop testing for Unmanned Air Vehicles.

PUBLICATIONS:

Sivashankar, N., Kaminer, I., and Khargonekar, P.P., "Optimal Controller Design with D-Stability," Automatica, Vol. 30, pp. 1003-1008, 1994.

Niewhoener, R.J. and Kaminer, I., "Design of an Autoland Controller for a Carrier Based F-14 Aircraft using \Hi output Feedback Synthesis," Proceedings of 1994 American Control Conference, pp. 2501-2505, Baltimore, MD,

1994.

Niewhoener, R.J. and Kaminer, I., "On Integrated Aircraft/Controller Design Using Linear Matrix Inequalities," Proceedings of 1994 AIAA Conference on Guidance, Navigation and Control, Phoenix, AZ, 1994.

Sivashankar, N., Kaminer, I., and Kuechenmeister, D., "Design, Analysis and Hardware-in-the-Loop Simulation of a MIMO Controller for a VTOL UAV using H_infinity synthesis," Proceedings of 1994 American Control Conference, pp. 2506-2510, Baltimore, MD, 1994.

Kaminer, I., Pascoal, A.M., Khargonekar, P.P., and Coleman, E., "A Velocity Algorithm for the Implementation of Nonlinear Gain-Scheduled Controllers," accepted for publication in Automatica.

CONFERENCE PRESENTATION:

Kaminer, I., "Design, Analysis and Hardware-in-the-Loop Simulation of a MIMO Controller for a VTOL UAV using H_infinity synthesis," presented at the 1994 American Control Conference, Baltimore, MD, 1994.

THESES DIRECTED:

Niewoehner, R.J., "Plant/Controller Optimization by Convex Methods," Doctoral Dissertation, June 1994.

Hallberg, E.N., "Design of a GPS Aided Guidance, Navigation and Control System for Trajectory Control of an Air Vehicle," Master's Thesis, March 1994.

Lagier, M.T., "An Application of Virtual Prototyping to the Flight Test and Evaluation of an Unmanned Air Vehicle," Master's Thesis, March 1994.

Selnick, A.P., "Virtual Prototyping as an Aid to Control Systems Design," Master's Thesis, September 1994.

Moats, M.L., "Automation of Hardware-in-the-Loop Testing of Control Systems for Unmanned Air Vehicles," Master's Thesis, September 1994.

Foley, B.T., "Design and Evaluation of an LQR Controller for the Bluebird Unmanned Air Vehicle," Master's Thesis, September 1994.

OTHER:

Niewhoener, R.J. and Kaminer, I., "Design of an Autoland Controller for a Carrier Based F-14 Aircraft using \Hi output Feedback Synthesis," submitted to AIAA Journal of Guidance, Navigation and Control.

Niewhoener, R.J. and Kaminer, I., "On Integrated Aircraft/Controller Design Using Linear Matrix Inequalities," submitted to AIAA Journal of Guidance, Navigation and Control.

Costello, D., Kaminer, I., Carder, K., and Howard, R.M., "Unmanned Vehicles: Scenarios for Joint AUV/UAV Missions," to be in Proceedings of 1995 Workshop on Intelligent Control of Autonomous Vehicles, Lisbon, Portugal, forthcoming in March 1995.

Howard, R.M. and Kaminer, I., "Survey of Unmanned Air Vehicles," accepted for presentation at 1995 American Control Conference.

Kaminer, I, Hallberg, E.N., Pascoal, A.M., and Silvestre, C., "On Design and Implementation of Integrated Guidance and Control System for a Fixed Wing UAV," accepted for presentation at 1995 American Control

Conference.

Pascoal, A.M., Silvestre, C., Olivera, P., and Kaminer, I., "On Design and Implementation of Integrated Guidance, Navigation and Control System for an Autonomous Underwater Vehicle Marius," accepted for presentation at 1995 American Control Conference.

DOD KEY TECHNOLOGY AREA: Other (Flight Control Systems, Unmanned Air Vehicles)

KEYWORDS: Flight control systems, gain-scheduled controllers, nonlinear control, robust control

COMBUSTION BEHAVIOR IN AIRBREATHING MISSILES

D.W. Netzer, Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Warfare Center Weapons Division

OBJECTIVE: To determine a liquid-fuel ramjet combustor geometry which can provide high combustion efficiency with combustion stability over wide operating limits.

SUMMARY: In FY93 three inlet-side-dump ramjet-combustor geometric configurations were investigated using non-intrusive water-tunnel flow visualization techniques to qualitatively determine optimum flame-stabilization dome lengths and fuel-injection locations and to investigate whether new configurations may be more capable of providing high combustion efficiencies under wide operating limits. Based upon the flow visualization results a dual, axially-in-line, side-dump, liquid-fueled ramjet combustor was designed and tested. Particle size distributions from the fuel atomizers were measured both in ambient conditions and under hot-air, contra-flow engine conditions. Data obtained under ambient conditions were found to have little value for the engine flow environment. The dual, axially-in-line geometry provided improved flammability limits and combustion efficiency at lean fuelair ratios. Direct fuel injection into the recirculation zone was required for sustained combustion at lean equivalence ratios for the single side-dump configuration, but not for the dual in-line configuration. The fuel distribution in the inlet duct that was required for good flammability limits and combustion efficiency was opposite to that required to prevent pressure oscillations. A dump angle of 45° resulted in lower than desired combustion efficiencies, apparently due to poor mixing from the aft inlet.

PUBLICATIONS:

Natan, B. and Netzer, D.W., "Boron Carbide Combustion in Solid-Fuel Ramjets Using Bypass Air, Part I. Experimental Investigation," accepted for publication in Propellants, Explosives and Pyrotechnics.

Natan, B. and Netzer, D.W., "Boron Carbide Combustion in Solid-Fuel Ramjets Using Bypass Air, Part II. Theoretical Analysis," accepted for publication in Propellants, Explosives and Pyrotechnics.

CONFERENCE PRESENTATION:

Deppe, M.W., Salyer, R.F., and Netzer, D.W., "An Investigation of the Side-Dump Dual In-Line Ramjet Combustor," 31st JANNAF Combustion Subcommittee Meeting, Sunnyvale, CA, 17-19 October 1994.

THESIS DIRECTED:

Deppe, M.W., "Combustion Efficiency in a Dual-Inlet Side-Dump Ramjet Combustor," Master's Thesis, June 1994.

DOD KEY TECHNOLOGY AREA: Propulsion and Energy Conversion

KEYWORDS: Airbreathing Missiles, Combustion Efficiency, Combustion Stability

MEASUREMENT OF PARTICULATE AND PLUME CHARACTERISTICS FOR SOLID PROPELLANT ROCKET MOTORS

D.W. Netzer, Professor
Department of Aeronautics and Astronautics
Sponsor: Air Force Phillips Laboratory

OBJECTIVE: (1) To upgrade an existing combined optical/collection probe for plume particle size measurements by replacing an ensemble particle sizer with a phase-Doppler particle analyzer (PDPA) in conjunction with multiple-wavelength extinction measurements; (2) To determine if alternative fuels can be used to reduce plume IR signature without significant effects on motor performance. (3) To examine the effects of nozzle residence time on the plume particle size distribution.

SUMMARY: Probe/PDPA data obtained in the plume on the nozzle centerline and radially displaced, Malvern data obtained across the entire plume width and multiple-wavelength extinction measurements in the plume edges show that the size distribution changes rapidly with plume radius. D_{32} decreased from approximately 18μ on the centerline to < 0.3μ in the plume edge and was 1-5μ when measured across the whole plume width. At the nozzle exit, D_{43} was 1.2-12μ (but typically 2.5-5.5μ) compared to 2.3μ from the SPP correlation. The probe has recently been modified to permit 3-wavelength extinction measurements through the same probe volume used by the PDPA. Successful measurements have been made with the combined probe optical techniques. Replacement of some of the aluminum in the propellant with silicon results in the formation of SiO2 and $Al_6Si_2O_{13}$ at the expense of Al_2O_3. Although the total mass of particulate is not changed the average emissivity of the particulate material appears to have been reduced. Two nozzle configurations were utilized to determine the effect of nozzle residence time on the plume particle size distribution since full-scale motors have significantly larger t_{res} than subscale motors. The nozzle residence time was increased from 0.06 ms to 0.127 ms by changing the converging and diverging half-angles. The increased residence time enhanced particle breakup, increasing the % volume with diameters < 2μ, but it did not significantly change D_{32} or D_{43}.

PUBLICATIONS:

Laredo, D., McCrorie II, J.D., Vaughn, J.K., and Netzer, D.W., "Motor and Plume Particle Size Measurements in Solid Propellant Micromotors," Journal of Propulsion and Power, Vol. 10, No. 3, pp. 410-418, May-June 1994.

Laredo, D. and Netzer, D.W., "Application of Optical Diagnostics to Particle Measurements in Solid Propellant Rocket Motors and Exhaust Plumes," Particulate Science and Technology, Vol. 11, No. 3-4, pp. 175-192, July-December 1993, (published in 1994).

Gomes, P.V., Roddenberry, D.S., Snaza, C.J., Yakin, B., Yi, C.M., and Netzer, D.W., "Nozzle Geometry and Additive Effects on Plume Particulate Behavior in Subscale Solid Propellant Rocket Motors," 21st JANNAF Exhaust Plume Technology Subcommittee Meeting, Sunnyvale, CA, 19-21 October 1994.

THESES DIRECTED:

Gomes, P.V., "Validation and Implementation of Optical Diagnostics for Particle Sizing in Rocket Motors," Master's Thesis, December 1993.

Yakin, B., "Combustor and Nozzle Effects on Particulate Behavior in Solid Rocket Motors," Master's Thesis,

December 1993.

Snaza, C.J., "Investigation of the Effects of Solid Rocket Motor Propellent Composition on Plume Signature," Master's Thesis, June 1994.

DOD KEY TECHNOLOGY AREA: Propulsion and Energy Conversion

KEYWORDS: Particle Sizing, Solid Rocket Motors, Aluminum Oxide

MEASUREMENT OF SOOT EMISSIONS FROM GAS TURBINE ENGINES

D.W. Netzer, Professor
O. Biblarz, Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Warfare Center Aircraft Division

OBJECTIVE: To adapt a three-wavelength laser extinction measurement system with a retroreflector or equivalent for measurements of plume soot size and concentration. To compare results from a newly developed direct soot concentration measurement technique to those obtained using assumed soot optical properties.

SUMMARY: An apparatus was developed for determining soot particle densities by measuring laser light extinction through an exhaust plume. A two-pass technique with both a retroreflector and an optical phase conjugator crystal has been utilized. Although the conjugator returned the laser beam, showing proof of principle, a portion of the beam was not received back at the photodetector.

PUBLICATIONS:

Biblarz, O. and Netzer, D.W. "Evaluation of UTSI-CLA Program on Optical Measurements of Turbine Engine Exhaust Particulates," NPS Technical Report NPS-AA-94-001CR, January 1994.

Netzer, D.W. and Biblarz, O., "Particle Sizing in Propulsion Systems," Tutorial Notes provided to NAWCAD.

CONFERENCE PRESENTATION:

Netzer, D.W. and Biblarz, O., "Measurement of Soot Emissions from Gas Turbine Engines," Plume Visibility and Particulate Measurement Symposium (Sponsored by The Naval Air Warfare Center Trenton and the University of Nevada Reno), 17-19 May 1994, Reno, NV, Paper 3, Section 3, Module F of Proceedings, Alpha-Gamma Technologies, Inc., 1994.

THESIS DIRECTED:

Glaros, G.E., LT USN, "Soot Particle Density Determination from a Laser Extinction Multipass Technique," Master's Thesis, September 1994.

PATENT APPLICATION:

Biblarz, O. and Netzer, D.W., "Determination of Soot Concentration from Transmission Measurements," application submitted 24 February 1994.

DOD KEY TECHNOLOGY AREA: Propulsion and Energy Conversion

KEYWORDS: Plumes, Soot Concentration Measurement, IR Signature

THE NASA/USRA UNIVERSITY ADVANCED DESIGN PROGRAM IN AERONAUTICS AT THE NAVAL POSTGRADUATE SCHOOL

C.F. Newberry, Professor
Department of Aeronautics and Astronautics
Sponsor: National Aeronautics and Space Administration (NASA)/ Universities Space Research Association (USRA)

OBJECTIVE: The goal of the NASA/USRA University Advanced Design Program in Aeronautics is to improve and enhance aeronautical design instruction at the Naval Postgraduate School. Calendar fiscal year 1994 is the reporting period for this continuing instructional enhancement research effort.

SUMMARY: The primary focus of the advanced design program of instruction is the innovative design of deck-launched waverider configured aircraft. However, due to student interest, conventional aircraft, helicopter, aircraft engine and missile system design projects were also completed. Automated design tools were both developed and purchased. Student aircraft, missile and helicopter design products were entered in national competitions. Thesis research efforts in low-speed waverider aerodynamic and performance characteristics supported design class projects. Two computer workstations were purchased to enhance the quality and effectiveness of the design laboratory supporting aircraft, missile, engine and helicopter aeronautical design.

PUBLICATION:

Newberry, C.F., "Waverider and Maritime Patrol Strike Aircraft; Missiles; and Supportive Aeronautical Research," NASA/USRA ADP Annual Report, 1994.

CONFERENCE PRESENTATION:

Cedrun, M.E. and Murray, J.C., "Missile Design and Waverider Design/Research at the Naval Postgraduate School," NASA/USRA Universities Advanced Design Program 10th Annual Summer Conference, Pasadena, CA, 12-16 June 1994.

Additional conference presentations are scheduled for fiscal/calendar year 1995.

DOD KEY TECHNOLOGY AREA: Other (integrated system design)

KEYWORDS: Waverider, strike, design integration, subsonic, aerodynamic testing and hypersonic

LOW-SPEED AERODYNAMIC ANALYSIS OF A WAVERIDER CONFIGURED MODEL

C.F. Newberry, Professor
Department of Aeronautics and Astronautics
Sponsor: NASA Ames Research Center

OBJECTIVE: The goal of this project is to determine the low-speed vortex flow, lift, drag and pitching moment characteristics of a M_∞=6 waverider design. Calendar/fiscal year 1994 is the reporting period for this continuing research effort.

SUMMARY: During calendar year 1994, low-speed flowfield visualization tests were performed, using an eight inch root chord model, in the Naval Postgraduate School (NPS) water tunnel. Low-speed subsonic tests of a fifteen inch root chord model were performed in one of the low-speed subsonic NPS wind-tunnels. Lift, drag and pitching moment data were recorded during the subsonic wind tunnel tests.

The flowfield visualization studies suggested that upper surface vortices over waverider configurations are less strong than those associated with similar delta wing configurations, possibly due to the constantly changing sweep of the waverider configuration leading edge. Flowfield visualization studies also suggest that complete flowfield upper surface separation occurs on the Price waverider at an angle-of-attack somewhere between fifteen and twenty degrees.

The wind tunnel studies suggest that the Price waverider has a lift-curve slope approximately of $C_{L_\alpha}=0.053$ per degree and stalls at approximately α=30°. The slope of the pitching moment versus angle-of-attack curve tends to be positive, suggesting that the basic configuration is statically unstable. The Price waverider drag polar exhibits the expected smooth parabolic slope with a minimum drag coefficient of approximately $C_{D_o}=0.02$.

THESES DIRECTED:

Johnson, L.M., LT, USN, "Hydrodynamic Flowfield Visualization Studies of a Mach 6 Waverider," Master's Thesis, March 1994.

Cedrun, M.E., LT, USN, "Low-Speed Wind Tunnel Testing of the NPS/NASA Ames Mach 6 Optimized Waverider," Master's Thesis, June 1994.

DOD KEY TECHNOLOGY AREA: Other (System Design)

KEYWORDS: Waverider, design integration, flowfield visualization, subsonic, aerodynamic testing and hypersonic

NUMERICAL STUDIES OF SEPARATION BUBBLES

M.F. Platzer, Professor
J.A. Ekaterinaris, Research Associate Professor
Department of Aeronautics and Astronautics
Sponsor: NASA Lewis Research Center, Cleveland, OH

OBJECTIVE: The objective of this project is the investigation of steady and unsteady subsonic airfoil flows with separation bubbles using Navier-Stokes codes in conjunction with transition modelling.

SUMMARY: Navier-Stokes solutions were obtained which showed that the predicted dynamic stall hysteresis loops were in good agreement with the experimental loops.

CONFERENCE PRESENTATIONS:

Ekaterinaris, J.A. and Platzer, M.F., "Numerical Investigation of Stall Flutter," ASME Paper 94-GT-206, International Gas Turbine and Aeroengine Congress, The Hague, Netherlands, 13-16 June 1994.

Ekaterinaris, J.A. and Platzer, M.F., "Progress in the Analysis of Blade Stall Flutter," 7th International Symposium on Unsteady Aerodynamics and Aeroelasticity of Turbomachines, Fukuoka, Japan, 25-29 September 1994.

Chen, H.H., Platzer, M.F., and Cebeci, T., "Analysis of Airfoils at Low Reynolds Numbers," 7th International Symposium on Unsteady Aerodynamics and Aeroelasticity of Turbomachines, Fukuoka, Japan, 25-29 September 1994.

DOD KEY TECHNOLOGY AREA: Other (Aerodynamics)

KEYWORDS: Computational Fluid Dynamics, Separated Flows

AERODYNAMICS OF OSCILLATING DEVICES AT LIFT AUGMENTORS

M.F. Platzer, Professor
S.K. Hebbar, Research Associate Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Systems Command

OBJECTIVE: Investigate the unsteady flow of physics of multi-element airfoils for potential application to enhance the aerodynamic performance characteristics of aircraft.

SUMMARY: A Navier-Stokes analysis of flapping airfoils and airfoil combinations was completed which demonstrated that the tandem configuration can achieve very high propulsive efficiencies. Also, flow visualization studies were completed in the water tunnel which showed the potential of airfoil flapping to suppress boundary layer separation.

CONFERENCE PRESENTATIONS:

Tuncer, I.H., Ekaterinaris, J.A., and Platzer, M.F., "A Novel Viscous-Inviscid Interaction Method with Inviscid Wake Modelling," AIAA Paper 94-0178, 32nd Aerospace Sciences Meeting, Reno, NV, 10-13 January 1994.

Tuncer, I.H., Ekaterinaris, J.A., and Platzer, M.F., "Computational Analysis of Flapping Airfoil Aerodynamics," ASME Fluids Engineering Conference, Lake Tahoe, 20-23 June 1994, Advanced in Computational Methods in Fluid Dynamics, FED Vol. 196, pp. 9-18.

Platzer, M.F. and Turner, M.A., "A Panel Code for the Analysis of Blade Flutter and Blade Interference Effects in Incompressible Flow," 7th International Symposium on Unsteady Aerodynamics and Aeroelasticity of Turbomachines, Fukuoka, Japan, 25-29 September 1994.

THESIS DIRECTED:

Turner, M.A., "A Computation Investigation of Wake-Induced Airfoil Flutter in Incompressible Flow and Active Flutter Control," Master's Thesis, March 1994.

DOD KEY TECHNOLOGY AREA: Other (Aerodynamics)

KEYWORDS: Unsteady Aerodynamics, Viscous-Inviscid Interactions, Flow Control, Airfoil Flutter

NUMERICAL INVESTIGATION OF HIGH ANGLE OF ATTACK MISSILE AERODYNAMICS

M.F. Platzer, Professor
J.A. Ekaterinaris, Research Associate Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Warfare Center, Weapons Division

OBJECTIVE: Develop Navier-Stokes solutions for the vortical flow over complete missile configurations in steady or maneuvering high angle of attack flight.

SUMMARY: Navier-Stokes computations were completed for subsonic flow over delta wings and over a complete missile configuration at high angle of attack. In addition, a new viscous-inviscid interaction method was developed for two-dimensional unsteady compressible airfoil flows. Also, force and moment data were acquired on a NAWC-designed missile.

PUBLICATIONS:

Ekaterinaris, J.A., Cricelli, A.S., Platzer, M.F., "Zonal Method for Unsteady, Viscous, Compressible Airfoil Flows," Journal of Fluids and Structures, Vol. 8, pp. 107-123, January 1994.

Smith, E.H., Hebbar, S.K., Platzer, M.F., "Aerodynamic Characteristics of a Canard-Controlled Missile at High Angles of Attack," Journal of Spacecraft and Rockets, Vol. 31, No. 5, pp. 766-772, September/October 1994.

Ekaterinaris, J.A. and Schiff, L.B., "Numerical Prediction of Incidence and Sweep Effects on Delta Wing Vortex Breakdown," Journal of Aircraft, Vol. 31, No. 5, pp. 1043-1049, September 1994.

Ekaterinaris, J.a. and Menter, F.R., "Computation of Oscillating Airfoil Flows with One- and Two-Equation Turbulence Models," AIAA Journal, Vol. 32, No. 12, pp. 2359-2365, December 1994.

Ekaterinaris, J.A., "Effects of Spatial Order of Accuracy on the Computation of Vortical Flowfields," AIAA Journal, Vol. 32, No. 12, pp. 2471-2474, December 1994.

CONFERENCE PRESENTATIONS:

VanDyken, R.D., Ekaterinaris, J.A., Chandrasekhara, M.S., and Platzer, M.F., "Analysis of Compressible Steady and Oscillatory Airfoil Flows at Transitional Reynolds Numbers," AIAA Paper 94-2225, AIAA 25th Fluid Dynamics Conference, Colorado Springs, CO, 20-23 June 1994.

Ekaterinaris, J.A., "Computation of Flowfields over Missile Configurations," AIAA Paper 94-1915, AIAA 12th Applied Aerodynamics Conference, Colorado Springs, CO, 20-23 June 1994.

Ekaterinaris, J.A., Chandrasekhara, M.S., and Platzer, M.F., "Analysis of Low Reynolds Number Airfoil Flows," AIAA Paper 94-0534, 32nd Aerospace Sciences Meeting, Reno, NV, 10-13 January, 1994.

DOD KEY TECHNOLOGY AREA: Other (Aerodynamics)

KEYWORDS: Missile Aerodynamics, Vortical Flows, Computational Fluid Dynamics

SMALL-SCALE INVESTIGATION OF JET-INDUCED GROUND EFFECTS

M.F. Platzer, Professor
S.K. Hebbar, Research Associate Professor
Department of Aeronautics and Astronautics
Sponsor: NASA Ames Research Center, Moffett Field, CA

OBJECTIVE: Perform small-scale flow visualization tests to determine the jet-induced ground effects and the effect of support struts on fountain formation relevant to ASTOVL aircraft.

SUMMARY: The flow visualization tests showed that the proposed strut configurations had only a minor aerodynamic interference effects.

THESES DIRECTED:

Dooley, W., " An Experimental Investigation of Jet-Induced Ground Effects and Support Strut Interference on a STOVL Aircraft Configuration in Hover," Master's Thesis, June 1994.

Enochs, E.R., "An LDV Investigation of Support Structure Influence on the Flowfield near the Wing Tip of a STOVL Configuration in Hover," Master's Thesis, September 1994.

DOD KEY TECHNOLOGY AREA: Other (Aerodynamics)

KEYWORDS: Aircraft Aerodynamics, Short Take-Off and Landing Aircraft, Ground Interference Effects

DYNAMIC LIFT STUDIES FOR ENHANCED FIGHTER MANEUVERABILITY

M.F. Platzer, Professor
S.K. Hebbar, Research Associate Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Warfare Center, Aircraft Division, Johnsville, PA

OBJECTIVE: Identify promising methods for the generation and exploitation of dynamic lift in order to achieve enhanced fighter aircraft maneuverability. To this end, perform detailed experimental studies on double delta wings and canard-wing configurations.

SUMMARY: Water tunnel flow visualization studies were conducted to determine the effect of fillets on the vortex development over cropped double-delta wings.

PUBLICATION:

Hebbar, S.K., Platzer, M.F., and Kim, C.H., "Experimental Investigation of Vortex Breakdown over a Sideslipping Canard-Configured Aircraft Model," Journal of Aircraft, Vol. 31, No. 4, pp. 998-1001, July/August 1994.

CONFERENCE PRESENTATION:

Hebbar, S.K., Platzer, M.F., and Al-Khozam, A., "Investigation into the Effects of Juncture Fillets on the Vortical Flow over a Cropped Double-Delta Wing," AIAA Paper 94-0178, 32nd Aerospace Sciences Meeting, Reno, NV, 10-13 January 1994.

THESES DIRECTED:

Al-Khozam, A.M., "Interaction, Bursting and Control of Vortices of a Cropped Double-Delta Wing at High Angle of Attack," Master's Thesis, March 1994.

Chang, W.H., "Effect of Juncture Fillets on Double-Delta Wings Undergoing Sideslip at High Angles of Attack," Master's Thesis, September 1994.

DOD KEY TECHNOLOGY AREA: Other (Aerodynamics)

KEYWORDS: High-lift Aerodynamics, Vortical Flows, Aircraft Maneuverability

ENDOATMOSPHERIC SPACE TRAJECTORY ANALYSIS AND OPTIMIZATION

I.M. Ross, Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Postgraduate School

OBJECTIVE: This two-year project was underwritten at investigating three problems: (1) optimality of singular trajectories, (2) development of a new synergetic orbital plane-change maneuver, and (3) analysis of uncontrolled satellite re-entry and impact prediction models.

SUMMARY: A state feedback solution to first-order singular arcs for a low-Earth-orbiting spacecraft was derived and the results were used to develop the problem of orbit maintenance. The results were also used to perform a preliminary investigation on nonlinear control; this analysis was used for writing an NSF Career Proposal. An analysis of uncontrolled satellite re-entry and impact prediction models was well received at the Air Force Space Command (AFSPACECOM) to the point that a 3-Year $100K reimbursable research contract was initiated in FY94. A second contract is also being negotiated currently. Nearly half of the RIP labor funds were returned to the department as a result of securing reimbursable funding through the PANSAT project. Finally, an analysis of the synergetic maneuver has conclusively shown that the aerobang maneuver, designed by the PI, performs superior to the widely studied aerocruise maneuver. This maneuver holds the potential for significant fuel savings for a transatmospheric vehicle.

PUBLICATIONS:

Ross, I.M. and Alfriend, K.T., "Low-Earth-Orbit Maintenance: Reboost Versus Thrust-Drag Cancellation," to appear in Journal of Guidance, Control, and Dynamics.

Ross, I.M., "A Formulation of Stability Conditions for Systems Containing Driven Rotors," accepted for publication in Journal of Guidance, Control, and Dynamics.

CONFERENCE PRESENTATIONS:

Ross, I.M., Pauls, D.D, and Wilsey, M.S., "Utility of Forced Keplerian Trajectories in Low-Earth-Orbit Maintenance," AIAA/AAS Space Flight Mechanics Meeting, AAS Paper No. 94-111, Cocoa Beach, FL, 14-16 February 1994.

Ross, I.M., "A State Feedback Solution to Coplanar First-Order Singular Thrust-Arcs in Rocket Trajectory Optimization," 45th International Astronautical Congress, IAF-94-A.2.015, Jerusalem, Israel, 9-14 October 1994.

THESES DIRECTED:

Adler, J.J., LT, USN, "Thermospheric Modeling Accuracies Using F10.7 and Ap," Master's Thesis, December 1993.

Haynes, K.L., CPT, USA, "Computer Graphics Tools for the Visualization of Spacecraft Dynamics," Master's Thesis, December 1993.

Lawrence, G.W., LT, USN, "Preliminary PANSAT Ground Station Software Design and Use of an Expert System to Analyze Telemetry," Master's Thesis, March 1994.

Victor, E.L., LT, USN, "Thermal Analysis of PANSAT Electrical Power Subsystem," Master's Thesis, June 1994.

Nicholson, J.C., LT, USN, "Numerical Optimization of Synergetic Maneuvers," Engineer's Thesis, June 1994.

Gardner, P.A., LT, USN, "An Analysis of a Single-Burn Algorithm for Low-Earth Orbit Maintenance," Master's Thesis, June 1994.

Cuff, D.J., LT, USN, "Lifetime and Reentry Prediction for the Petite Amateur Navy Satellite (PANSAT)," Master's Thesis, June 1994.

Rich, M.K., LCDR, USN, "A Systems Analysis and Project Management Plan for the Petite Amateur Navy Satellite (PANSAT), Master's Thesis, September 1994.

Stewart, J.A., LT, USN, "Computer Graphics Tools for Visualizing Gravity Gradient Torques on a Rigid Spacecraft," Master's Thesis, September 1994.

Patterson, S.A., LCDR, USN, "Thermal Analysis of PANSAT Batteries and Electrical Power Subsystem," Master's Thesis, September 1994.

OTHER:

The investigator is working on the following forthcoming publications:

Nicholson, J.C. and Ross, I.M., "Performance of Optimal Synergetic Maneuvers," AAS/AIAA Spaceflight Mechanics Meeting, AAS Paper No. 95-120, Albuquerque, NM, 13-16 February 1995.

Ross, I.M., "Optimally Steered Singular Thrust-Arcs for Rocket Flight in an Atmosphere," submitted to the Journal of the Astronautical Sciences.

DOD KEY TECHNOLOGY AREA: Design Automation

KEYWORDS: Singular Arcs, Low-Earth-Orbit Maintenance, Aeroassisted Maneuvers, Trajectory Optimization

TIME OPTIMAL ATTITUDE MANEUVERS

S.L. Scrivener, Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Postgraduate School

OBJECTIVE: To develop a computer code which will determine a control law for a given spacecraft to perform a given maneuver, in minimum time, and to compare the results of the computer model with real world spacecraft attitude control laws.

SUMMARY: The following techniques have been explored as possible solutions for the problem: Direct collocation and nonlinear programming, direct collocation on a parallel platform, and genetic algorithms for determining an optimal trajectory between two specified end states. The related problem of singular arcs in time-optimal controls is also being explored.

DOD KEY TECHNOLOGY AREA: Software

KEYWORDS: Time-optimal, attitude maneuver, computer model, optimization

STRUCTURAL DYNAMICS OF THE TOPAZ II UNIT

S.L. Scrivener, Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Postgraduate School

OBJECTIVE: To analyze the test data from a full scale shock and vibration test of the TOPAZ II unit; to correlate the test data with an existing finite element model of the structure, and to modify the model to match the physically observed behavior.

SUMMARY: On Sept. 7 and 8, 1994, the Ya-21 TOPAZ II unit was tested at Sandia National Laboratories. It was subjected to both random and sine inputs, both in the vertical (longitudinal) and horizontal (lateral) directions. The unit was also subjected to a high g shock. The data from the accelerometers mounted on the unit was recorded during the test and was transferred to NPS in December of 1994. This data is currently being analyzed by two graduate students as part of their theses.

DOD KEY TECHNOLOGY AREA: Software, Propulsion and Energy Conversion

KEYWORDS: Structural dynamics, finite elements, model correlation, shock and vibration

STRUCTURAL ASPECT OF PANSAT

S.L. Scrivener, Assistant Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Postgraduate School

OBJECTIVE: To provide thesis advising on structural design, testing and modeling related to the PANSAT project.

SUMMARY: The launch vehicle adaptor ring has been successfully designed and modeled using I-DEAS finite element software. The support structure for the electronics is currently being designed and modeled.

THESIS DIRECTED:

Gannon, B., "Design of the Launch Vehicle Adaptor Ring for PANSAT," Master's Thesis, September 1994.

DOD KEY TECHNOLOGY AREA: Design Automation

KEYWORDS: Structures, finite elements, PANSAT

TRANSONIC FAN CASCADE EVALUATION

R.P. Shreeve, Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Warfare Center, Aircraft Division and Naval Postgraduate School

OBJECTIVE: To develop the means to evaluate blade geometry effects and separation-control techniques in a fan-passage simulation model. This is required for the development of more efficient, lighter fans for military aircraft.

SUMMARY: A pilot fan-passage cascade flow model with 6 inch chord blades has been built using a small M=1.4 blow down wind tunnel, and used to verify the flow simulation, instrumentation and measurement techniques. Using a back-pressure control valve with a small bleed valve in parallel, a bleed valve on the porous wall section, and fine control on stagnation pressure, acceptable periodicity was obtained with two passages. Loss measurements were obtained for the reference conditions using a calibrated multisensor pressure probe. A follow-on study will now determine the effects of low-profile vortex generators on the shock-boundary layer interaction and overall blade loss. Toward the construction of a larger-scale, variable Mach number fan cascade experiment, fixed M=1.7 nozzle blocks were designed and built for the 4" by 4" supersonic wind tunnel and the design of a variable Mach number nozzle was initiated. Also, pressure-sensitive paint was implemented successfully and is now available throughout the Laboratory as a measurement technique and diagnostic tool.

THESES DIRECTED:

Tapp, E., "Development of a Cascade Simulation of Fan Passage Flow," Master's Thesis, December 1993.

Ausin, J.G., "Mach Number, Flow Angle and Loss Measurements Downstream of a Transonic Fan-Blade Cascade," Master's Thesis, March 1994.

DOD KEY TECHNOLOGY AREA: Propulsion and Energy Conversion

KEYWORDS: Transonic Fan Cascade Wind Tunnel; Fan Shock-Boundary Layer Interaction; Shock-Boundary Layer Losses

TRANSONIC FAN DESIGN VALIDATION

R.P. Shreeve, Professor
Department of Aeronautics and Astronautics
N. Sanger
National Aeronautics and Space Administration, Lewis R.C.
Sponsor: Naval Air Warfare Center, Aircraft Division
& National Aeronautics and Space Administration

OBJECTIVE: To replace the single-stage fan currently installed in the transonic compressor test rig at the NPS Turbopropulsion Laboratory with a new prototype stage designed with current CFD methods, and to evaluate all aspects of the aerodynamic performance using advanced intrusive and non-intrusive measurement techniques. The project goals are to provide code vs. measurement comparisons, to develop practical unsteady measurement diagnostics for use in military fan development testing, and to document a design-and-test case study for instructional purposes.

SUMMARY: The design of the stage was presented at the International Gas Turbine Institute meeting and will appear in the ASME transactions. Machine drawings of the rotor, stator and spinner were received from NASA and were transmitted electronically to the successful bidder, Turbocam, for manufacture. Completed parts were recently received and accepted. The test rig was operated with the old stage installed for familiarization prior to overhaul. A project to develop a phase-locked pressure sensitive paint technique for application to first stage fans, was initiated.

CONFERENCE PRESENTATION:

Sanger, N., "Design of a Low Aspect Ratio Transonic Compressor Stage Using CFD Techniques," Paper No. 94-GT-236, presented at the 39th ASME International Gas Turbine and Aeroengine Congress/Users Symposium & Exposition, The Hague, The Netherlands, 13-16 June 1994.

DOD KEY TECHNOLOGY AREA: Propulsion and Energy Conversion

KEYWORDS: Transonic Compressor Stage Design, Compressor Design Validation, Transonic Compressor Test

DEPARTMENT
OF
AERONAUTICS AND ASTRONAUTICS

1994
Faculty Publications
and Presentations

JOURNAL PAPERS

Ahmed, S. and Chandrasekhara, M.S., "Reattachment Studies of an Oscillating Airfoil Dynamic Stall Flow Field," AIAA Journal, Vol. 32, No. 5, pp. 1006-1012, May 1994.

Ball, R.E. and Calvano, C.N., "Establishing the Fundamentals of a Surface Ship Survivability Discipline," Naval Engineers Journal, pp. 71-74, January 1994.

Carr, L.W., Chandrasekhara, L.W., and Brock, N., "A Quantitative Study of Unsteady Compressible Flow on an Oscillating Airfoil," Journal of Aircraft, Vol. 31, No. 4, pp. 892-898, July/August 1994.

Carr, L.W., Chandrasekhara, L.W., Ahmed, S., and Brock, N., "A Study of Dynamic Stall Using Real-Time Interferometry," Journal of Aircraft, Vol. 31, No. 4, pp. 995-996, July/August 1994.

Chandrasekhara, M.S., Carr, L.W., and Wilder, M.C., "Interferometric Investigations of Compressible Dynamic Stall Over Transiently Pitching Airfoils," AIAA Journal, Vol. 31, pp. 576-583, March 1994.

Ekaterinaris, J.A., Cricelli, A.S., Platzer, M.F., "Zonal Method for Unsteady, Viscous, Compressible Airfoil Flows," Journal of Fluids and Structures, Vol. 8, pp. 107-123, January 1994.

Ekaterinaris, J.A. and Schiff, L.B., "Numerical Prediction of Incidence and Sweep Effects on Delta Wing Vortex Breakdown," Journal of Aircraft, Vol. 31, No. 5, pp. 1043-1049, September 1994.

Ekaterinaris, J.a. and Menter, F.R., "Computation of Oscillating Airfoil Flows with One- and Two-Equation Turbulence Models," AIAA Journal, Vol. 32, No. 12, pp. 2359-2365, December 1994.

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Howard, R.M. and O'Leary, J.F., "Flowfield Study of a Close-Coupled Canard Configuration," Journal of Aircraft, Vol. 31, No. 4, pp. 908-914, July-August 1994.

Howard, R.M., Lung, M.-H., Viniotis, J.J., Johnson, D.A., and Pinaire, J.A., "Wing Effects on Missile Asymmetric Vortex Behavior," Journal of Spacecraft and Rockets, Vol. 31, No. 4, pp. 705-707, July-August 1994.

Laredo, D., McCrorie II, J.D., Vaughn, J.K., and Netzer, D.W., "Motor and Plume Particle Size Measurements in Solid Propellant Micromotors," Journal of Propulsion and Power, Vol. 10, No. 3, pp. 410-418, May-June 1994.

Laredo, D. and Netzer, D.W., "Application of Optical Diagnostics to Particle Measurements in Solid Propellant Rocket Motors and Exhaust Plumes," Particulate Science and Technology, Vol. 11, No. 3-4, pp. 175-192, 1994.

Scrivener, S.L. and Thompson, R.C., "A Survey of Time-Optimal Attitude Maneuvers," Journal of Guidance, Control and Dynamics, Vol. 17, No. 2, pp. 225-233, March-April 1994.

Scrivener, S.L., Storey, G., and Fachin, K., "Treating the All-Nighter Syndrome: Increased Student Comprehension Through an Interactive In-Class Approach," Journal of Engineering Education, Vol. 83, No. 2, pp. 152-155, April 1994.

Sivashankar, N., Kaminer, I., and Khargonekar, P.P., "Optimal Controller Design with D-Stability," Automatica,

Vol. 30, pp. 1003-1008, 1994.

Smith, E.H., Hebbar, S.K., Platzer, M.F., "Aerodynamic Characteristics of a Canard-Controlled Missile at High Angles of Attack," Journal of Spacecraft and Rockets, Vol. 31, No. 5, pp. 766-772, September/October 1994.

CONFERENCE PAPERS

Agrawal, B. and Bang, H., "Adaptive Structures for Large Precision Antennas," IAF-94I.4.202, 45th Congress of the International Astronautical Federation, Jerusalem, Israel, 9-14 October 1994.

Bang, H. and Agrawal, B., "Application of Constraint Dynamics for Spacecraft Maneuver," AIAA-963625-CP, Proceedings of AIAA Guidance, Navigation and Control Conference, Scottsdale, AZ, 1-3 August 1994.

Bang, H. and Agrawal, B., "A Generalized Second Order Compensator Design for Vibration Control of Flexible Structures," AIAA-94-1626, Proceedings of 35th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, Hilton Head, SC, 18-20 April 18-20 1994.

Biblarz, O., "Things Your BAB (Basic Aerodynamics Book) Never Told You," Preprint #AIAA 94-0849, 32nd Aerospace Sciences Meeting and Exhibit, Reno, NV, 10-13 January 1994.

Biblarz, O. and Pryono, E., "Transonic Pressure Drag Coefficient for Axisymmetric Bodies," ICAS-94-2.5.2, Proceedings of the 19th Congress of the International Council of the Aeronautical Sciences, Anaheim, CA, pp. 1565-1571, 18-23 September 1994.

Chandrasekhara, M.S. and Carr, L.W., "Compressibility Effects on Dynamic Stall of Oscillating Airfoils," AGARD-CP-552, Proceedings of the AGARD 75th Fluid Dynamics Panel Meeting on Aerodynamics and Aeroacoustics of Helicopters, pp. 3.13.15, Berlin, Germany, 10-13 October 1994.

Chandrasekhara, M.S., Squires, D.D., Wilder, M.C., and Carr, L.W., "A Phase-Locked, High-Speed, Real-Time, Interferometry System for Large Amplitude Unsteady Flows," Proceeding of the 7th International Symposium on Applications to Fluid Mechanics, Lisbon, Portugal, pp. 38.3.1-38.3.8, 11-14 July 1994.

Feuerstein, M. and Agrawal, B., "Topaz II Nuclear Powered SAR Satellite," AIAA 94-4688, AIAA Space Program and Technologies Conference, Huntsville, AL, 27-29 September 1994.

Hobson, G.V. and Dober, D.M., "Three-Dimensional Fiber-Optics LDV Measurements in the Endwall Region of a Linear Cascade of Controlled-Diffusion Stator Blades," Paper No. 94-GT-352, presented at the 39th ASME International Gas Turbine and Aeroengine Congress/Users Symposium & Exposition, The Hague, The Netherlands, 13-16 June 1994.

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Janiver, G., IV and Agrawal, B., "Adaptive Control for a Space Robotic Manipulator," 45th Congress of the International Astronautical Federation, Jerusalem, Israel, 9-14 October 1994.

Netzer, D.W. and Biblarz, O., "Measurement of Submicron-Particle Concentrations in Plumes," Proceedings of the Plume Visibility and Particulate Measurement Symposium, Paper 3, Section 3, Module F, Reno, NV, 17-19 May 1994.

Netzer, D.W. and Biblarz, O., "Measurement of Soot Emissions from Gas Turbine Engines," Plume Visibility and Particulate Measurement Symposium, Paper 3, Section 3, Module F, Reno, NV, 17-19 May 1994.

Niewhoener, R.J. and Kaminer, I., "Design of an Autoland Controller for a Carrier Based F-14 Aircraft using \Hi output Feedback Synthesis," Proceedings of 1994 American Control Conference, pp. 2501-2505, Baltimore, MD, 1994.

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Porter, D.B. and Howard, R.M., "Dissimilar Aircraft Flying in Close Proximity," AIAA Paper 94-3484, presented at the AIAA Atmospheric Flight Mechanics Conference, Scottsdale, AZ, 1-3 Aug. 1994.

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Department of Computer Science

The Computer Science Department has active research in several important areas of interest to the DON. Below is a cross-sectional description of the major projects.

Artificial Intelligence

Project (1): Multimedia data are difficult to handle with traditional database technology because they can be so big. We are seeking to increase efficiency in use of multimedia data by associating them with natural language textual captions describing their contents, and checking caption information first automatically during access. This requires natural-language processing of captions and natural-language query phrases. To retrieve data as fast as a less-cooperative keyword lookup can, we use concurrency for the different parts of an access request and a hierarchy of object types and aliases. We also hope to contribute to database semantics concerning "supercaptions," full captions that describe more than one media datum, and thus can be examined first to eliminate possible captions. Supercaptions create a hierarchical structure different from the type hierarchy of domain concepts. We also will examine the semantics of the referential relationship between a caption and its multimedia datum, including the problem of necessary incompleteness of a caption description. Most of this work involves general-purpose workstations rather than graphics workstations to aid transportability. This technique is being applied to the Photo Lab of the Naval Air Warfare Center Weapons Division, China Lake, California. We are using a subset of the pictures and captions archived there. We hope to provide them with an alternative to their current slow and hard-to-use system for finding photographs in response to requests. Much of the modeling of weapons and platforms necessary for our application will also be useful for other military applications involving captions on multimedia.

Project (2) involves building a system METUTOR for helping teachers write and run tutors for tasks involving sequences of actions. With METUTOR, tutors are considerably easier to build than with conventional frame-based tools, while at the same time the resulting tutors are smarter in analyzing student behavior than those tools. METUTOR is based on means-ends analysis, and the tutors built automatically have powerful inference capabilities for finding student errors, categorizing them, and tutoring them, all the while maintaining a model of what the student is trying to do in the form of an intermediate plan. Our current versions include mapping of domain concepts to graphical elements, which are then combined into a visual display of domain state. METUTOR has been applied to a number of military applications including fire-fighting on Navy ships, replenishment at sea, and training for cardiopulmonary resuscitation. Project (3) involves developing computer programs for planning routes in advance over terrain without roads, air space, or water. Lately we have focussed on finding methods for handling anisotropism, or situations where it cost more to go in certain directions than in other directions, a problem not much studied before. Some of this was used in a project on hydrographic survey planning. Project (3) has been applied to planning for Army tank routes (sponsored by Army AI Center, Washington) and cruise missile paths (sponsored by Naval Air Warfare Center, Washington).

Software Engineering

Reducing costs and improving quality of software is a major concern in DoD. Software maintenance and evolution accounts for the lion's share of the cost. Software Engineering addresses these issues via development of methods that support partial automation, particularly in software maintenance and evolution. The software engineering researchers at NPS have developed a formal specification language specifically designed for large scale applications that include parallel, distributed, and real-time systems. We are currently investigating a variety of methods and tools for partially automating many aspects of software development. This work has potential applications to software maintenance, view integration in specifications, version control in design databases, and multiple inheritance in specification or programming languages.

Embedded software systems with hard real-time constraints are used for many control functions in mission-critical

military applications. Development of embedded systems have special problems: they are plagued by incorrect requirements, inadequate reliability, and excessive maintenance cost. Therefore work is being carried out which addresses these problems. This work has resulted in computer aid for validating requirements to a high level of confidence via an iterative prototype-demonstrate-adjust method that removes uncertainties about the requirements before the massive detailed implementation effort begins. Computer aid speeds up the process, reduces costs, and enables assessment of feasibility for interacting real-time constraints that are too complex for reliable assessment by manual methods. Automated methods for constructing schedules guarantee that all deadlines will be met under all specified operating conditions, eliminating transient timing faults. Prototyping and automatic code generation reduce maintenance costs by ensuring that modified requirements are valid before they are implemented and by alleviating the brittleness of manually constructed code with respect to real-time constraints.

Database Engineering

The Department of Defense has recognized the importance of data sharing (or exchange) and resource consolidation in DoD and DoN, since both DoD and DoN use large numbers of heterogeneous databases and systems. They are all run in the respective organizations as stand-alone databases and systems individually. There is no data sharing and no resource consolidation among these databases and systems in either respective organizations.

Consequently, DARPA and ONR have termed these issues as "Interoperable Information Technology Issues." They are crying for solutions. They believe these solutions will likely be the future technology for the next generation of databases and systems, known as interoperable databases and systems. Therefore, NPS is working in federated databases to solve various problems of interoperable information technology. The approach is to design and build multimodel and multilingual database interfaces.

Multimodel and multilingual database interfaces with a cross-model accessing capability provide two solutions: (1) A database user can continue to use the user's favorite data model to refer to the user's database and the user's favorite data language to write transactions for the purpose of accessing and manipulation of data in the database, (2) A database user can access and manipulate a heterogeneous database as if it is a homogeneous one. There is an addition bonus: a database computer with a multibackend configuration makes parallel database operations and clustered database distributions possible, which in turn allows the multibackend database computer to consolidate all the databases into one, thereby eliminating duplicated system software, computer hardware and support personnel.

A related system called GLAD II (Graphics Language for Accessing Database) allows users to interact with different relational DBMS by providing a common graphic language called DFQL (Data Flow Query Language) that is based on a data flow diagram. The system automatically translates a user specified DFQL query into the equivalent query statements recognized by the connected backend DBMS. At present, the prototype connects to Oracle and translates the DFQL queries into Oracle's SQL statements.

DFQL is a graphic query language based on relational algebra. It has been designed with sufficient expressive power and functionality to allow the user to easily express database queries. DFQL is relationally complete and includes an implementation of aggregate functions. An object-oriented implementation allows programmers to easily create their own DFQL operators from the primitive and other existing user-defined operations. This extensibility of query language is unique to ours. No other query language allows such extensibility. The overall intention is to provide the user with a simple to use, yet powerful and extensible tool to implement database queries. A human factor analysis comparing DFQL and SQL was done earlier, and DFQL was statistically shown to be better than SQL.

Robotics

The current trend in military applications is to accomplish the required mission with a minimum loss of life.

Consequently, many government-sponsored efforts are underway for building systems for fighting fires, handling ammunition, transporting material, conducting underwater search and inspection operations, and other dangerous tasks now performed by humans. One example of useful naval applications is a robot that inspects tanks, voids and other dangerous spaces on board a military ship. Another is robotic mine sweeping capability. These capabilities are addressed under the general heading of autonomous vehicle research.

Autonomous vehicles (AUV) are self-contained robots that have complete freedom of motion. Research activities cover the most abstract mathematical models, smooth vehicle tracking algorithm, sonar interpretation, rigid body motion planning, automated cartography, vehicle control by steering function, high-level mobile robot languages, real-time hardware/software architecture for mobile robots, motion planning for AUV, fast gait planning for underwater walking robot, software development, and practical robot construction.

The study of robotics is also achieved in the laboratory by means of real-time graphical dynamic simulation studies. That is, 3-D computer simulations of robot behavior in a virtual environment reduces the time and expense of perfecting robotic algorithms. Accurate simulation models permit not only concept evaluation, but also the development of real-time control software through "hardware in the loop" simulation studies. These simulation studies are centered around the application of unmanned submersibles to mine countermeasures. Both swimming and walking vehicles are being considered for this purpose.

Computer Systems and Architecture

Designers of high performance computing systems for military missions are increasingly turning to parallel processor systems to achieve high speed at relatively low cost. In such a system, many processing elements and memory are combined to form a parallel computer.

While the hardware has been rapidly improving, the software for such machines is still archaic. There is no agreement on how to program these machines, nor on the best way to design a parallel programming language, compiler, operating system, or application program. Thus, one problem addressed by NPS researchers is how to design a parallel programming environment which supports architecture-independent parallel programming.

Another kind of parallel computer is called digital signal processors. The AN/USY-2 military computer is one example. The AN/USY-2 is employed by USN for the purpose of real-time(RADAR/SONAR) signal processing on board of ships. As the AN/USY-2 employs a Large Grain Data Flow (LGDF) processing methodology, an application is treated as a Data Flow Graph (DFG) of nodes- each of which representing a signal processing primitive. In order to increase the utilization of the processors, and to ensure the production of output data at regular time intervals (a very important requirement for this class of real time applications), some control has to be exerted on the scheduling of the DFG nodes. AN/USY-2 run-time mechanisms dispatch ready nodes in a quasi-arbitrary manner which can yield artificial data memory congestion, lack of computation-communication overlap, and production of outputs at irregular time intervals. The goal of this research is to identify the mechanisms of AN/ USY-2 that can be used in control the dispatching times of the DFG nodes. This work has resulted in the introduction of a framework (Revolving Cylinder Scheduling) for compile time analysis and restructuring of DFGs so as to avoid the potential shortcomings- which are discussed above- of arbitrary node dispatching.

Tools have been developed to restructure DFGs in the way of realizing the Revolving Cylinder Scheduling framework. Also, a real-time LGDF multiprocessor simulator has been developed to evaluate the relative performance of the restructured graphs as compared to the original graphs.

Computer Graphics and Visual Simulation

This work is focussed on real-time, interactive 3D graphics, an essential ingredient in the development of virtual environments. The NPSNET project has produced a low-cost, visual simulator family that allows the user to

explore a 3D virtual world of terrain databases in a wide scale networked environment. NPSNET runs on commercially available Silicon Graphics, Inc. workstations of all incarnations. NPSNET reads SIMNET terrain databases and can read/write SIMNET and DIS networking formats (current and future networking standards for DoD visual simulators). NPSNET is a development platform, i.e. the goal is to not only to produce a SIMNET-compatible visual simulator but to put that system and the techniques used to build it into the public domain.

Research work currently underway includes the integration of NPSNET with traditional Army combat models (Janus and Eagle), the connection of NPSNET to the Defense Simulation Internet via a T1 DSI link, the addition of dynamic terrain, the addition of aural cues to the NPSNET virtual world, the integration of a hypermedia capability (compressed video, audio,...) into a system called Hyper-NPSNET, the addition of vehicle dynamics (air and ground), the integration of autonomous forces with NPSNET, and other tasks as requested by reimbursable sponsors.

A major component of this research is the distribution of the simulation across any network. This allows multiple users to interact with each other in a virtual environment. This is one of the key premises of DIS, inserting humans into the virtual environment where they can "free-play" different scenarios. While this sounds simple, the problems of networks, human/computer interfaces, and data management are significant research topics. While the humans in the virtual environment comprise an integral component of the system, there are not enough manned simulators to sufficiently populate the world. To provide the additional entities, we are conducting research in the use of traditional constructive combat models and autonomous agents to populate the world. By providing an interface to the traditional models, we can leverage off the work that has been done before in combat modeling. This, combined with the research on autonomous agents, provides a mechanism to provide friendly and opposing forces to complement the manned simulators. One of the key components of a military virtual environment is the geometric description of the terrain database. To address the importance of the terrain database, we have active research projects in the areas of terrain modifications, culling, and polygon reduction. In addition to research projects, NPS is quickly becoming one of the leading organizations within DoD for the understanding and conversion of terrain database formats. 3.0

As the defense budget continues to shrink, there will be an increasing reliance on the use of Networked Simulation to train, test, and develop all facets of military training, doctrine, and equipment. The work being done at the Naval Postgraduate School places it at the technological forefront in use of Commercial Off The Self (COTS) workstations as visualization platforms in a DIS environment. Officially, our work has been distributed to over seventy DoD, contractor, academic, and industry organizations to aid in the development of their systems. Unofficially, there are over one hundred users of our systems. This results in significant cost savings and reduced development times.

HIGH RESOLUTION TERRAIN AND REALISTIC BATTLEFIELD SIMULATION

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Sponsor: TRADOC Analysis Command, supported by the following research contracts: TEXCOM, TRADOC, Army Research Laboratory, and Army Missile Command

OBJECTIVE: The research objectives are directed toward the development and evaluation of highly realistic tactical battlefield databases and simulation systems for weapons test, training, mission rehearsal, and analysis applications.

SUMMARY: A legacy of highly realistic battlefield simulation systems exists through the development of voxel based "Real Scene" technology originally developed by Hughes and applied toward the construction of the PEGASUS data base and simulator for Ft. Hunter Liggett, CA. The PEGASUS system generates a 1 meter terrain and one centimeter target database. The data represents measured ground geometry and radiance characteristics of sufficient accuracy so that video realistic perspective views can be calculated over a 400sq. km. test area. Transputer and PowerPC parallel processing equipment is used to perform interactive joystick controlled perspective view generation at real time rates. The realism, accuracy and fidelity of the generated perspective view roughly equals a that of a video camera mounted in a low flying helicopter.

Research activities center upon the development of parallel processing technologies and algorithms for the generation of realistic high speed battlefield visualizations. Specific research projects include the introduction of highly realistic environmental effects including cloud models and battlefield obscurants, rendering of local vertical battlefield details for ground to ground views, and the applicability of high resolution terrain data to problems of deterministic line of sight calculations and target detection and acquisition.

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DOD KEY TECHNOLOGY AREA: Software

KEYWORDS: Battlefield Simulation, Terrain Simulation, High Resolution Simulation

AUTOMATICALLY COMBINING CHANGES TO SOFTWARE SYSTEMS

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Sponsor: Army Research Office

OBJECTIVE: Combining changes to software is a fundamental problem in software engineering with widespread applications in the design and evolution of software systems. This process is important in all phases of developing large software systems, where multiple changes must be developed concurrently and then combined.

We seek to develop both theory and practical methods for combining several changes to a software system with mathematically provable guarantees of correctness. The proposed work has important potential applications to software maintenance, view integration in specifications, version control in engineering databases, and multiple inheritance in specification or programming languages. This is a continuing project.

SUMMARY: We developed a model of change merging that is a uniform extension of standard denotational semantics. This model handles merging of arbitrary changes to programs, and contains a suitably extended set of conflict elements to support formal location of inconsistencies. Our model is used to determine some general properties of change merging, and in particular to explore the degree to which changes to the components of a functional composition (modules related by data flow relations) can be merged independently. Examples show that this is not possible in the general case, and some special conditions where it is possible are characterized. Our model covers most of the standard constructions of domain theory, including sums, products, function spaces, and two of the three kinds of power domain, and hence applies to a large class of programming languages. Our theoretical models have been applied to develop and implement a merging method for the prototyping language PSDL. The novel features of this language are hard real-time constraints, parallel computation, and nondeterminism. The merging method is based on an extension of the slicing idea. Correctness of the method depends on a behavioral invariance theorem for slices that was proved relative to a semantic model that captures the nondeterministic and real-time aspects of PSDL programs.

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DOD KEY TECHNOLOGY AREAS: Software

KEYWORDS: Software Evolution, Change Merging, Automation

CHANGE MERGING FOR EVOLUTION OF SOFTWARE PROTOTYPES

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Sponsor: Army Research Office

OBJECTIVE: We seek to explore several aspects of computer-aided software evolution, in support of a main proposal addressing formal models and automated methods for software change-merging. Change merging is

the problem of automatically constructing a new version of a program that incorporates the combined effect of several changes to a common base version of the program. The result of an automatic merge must be semantically correct with respect to a realistic formal model of change merging. If an engineer attempts to merge semantically incompatible changes, then a change merging tool should detect and locate the incompatibilities. The project focuses on developing the aspects of change merging technology related to software evolution, software prototyping and software reuse, and for trial application and evaluation of these technologies. This is a continuing project.

SUMMARY: Our theoretical results from other projects have been applied to develop and implement a merging method for the prototyping language PSDL. The merging method is based on an extension of the slicing idea. Correctness of the method depends on a behavioral invariance theorem for slices that was proved relative to a semantic model that captures the nondeterministic and real-time aspects of PSDL programs. An implementation of this method has been developed and integrated into the computer-aided prototyping system CAPS.

THESIS DIRECTED:

Dampier, D., "A Formal Method for Semantics-Based Change-Merging of Software Prototypes," Doctoral Dissertation, June 1994.

DOD KEY TECHNOLOGY AREA: Software

KEYWORDS: Software Evolution, Change Merging, Automation

INTEROPERABLE DATABASE SYSTEMS

D.K. Hsiao, Professor
C.T. Wu, Associate Professor
Department of Computer Science
Sponsor: Naval Air Warfare Center Weapons Division

OBJECTIVE: This is a part of ongoing research project in the area of interoperable, heterogeneous database systems. Our main objective for this year is to develop functional data model interface and the visual interface to our prototype backend multi-lingual and multi-model backend database systems. In addition, we will redesign an EWIR database using a generic object-oriented data model.

SUMMARY: Functional data model interface was implemented. As a part of this implementation work, we identified components of attribute-based kernel system that need to be modified. Modifications are required to fully support the object-oriented data model interface planned for the subsequent years. In conjunction to the implementation of the functional data model interface, the old prototype system was ported from the ISI workstation to the Sun workstation platform. We redesigned EWIR database, currently in the relational format, using a generic object-oriented data model. We plan to use this design as a basis for testing object-oriented interface, scheduled to be built in the next fiscal year. We also created a visual query language to access the EWIR database.

PUBLICATIONS:

Hsiao, D.K. and Kamel, M., "Heterogeneous Databases: Proliferations, Issues, and Solutions," Multi-database Systems: An Advanced Solution for Global Information Sharing, A.R. Hurson, M.W. Bright, and S. Pakzad, eds., IEEE Computer Society Press, November 1994.

Hsiao, D.K., "From DBC to MDBS - A Progression in Database Machine Research," Emerging Trends in

Database and Knowledge-Based Machines: the Application of Parallel Processing to Smart Information Systems, M. Abdelguerfi, ed., IEEE Computer Society Press, December 1994.

Hsiao, D.K., "A Note About the Article entitled 'A Formal System for Information Retrieval from Files," Great Papers in Computer Science, S.W. Gupta, ed., West Publishing Co., December 1994.

Wu, C.T. and Clark, G.J., "DFQL: Dataflow Query Language for Relational Databases," Information & Management, pp. 1-15, 27 July 1994.

Wu, C.T., "A Unified Query Language for Integrating CAE Database," Proceedings of International Conference on Data and Knowledge Systems for Manufacturing and Engineering, The Chinese University of Hong Kong, pp. 624-629, 2-4 May 1994.

CONFERENCE PRESENTATION:

Wu, C.T., "A Unified Query Language for Integrating CAE Database," presented at the International Conference on Data and Knowledge Systems for Manufacturing and Engineering, The Chinese University of Hong Kong, pp. 624-629, 2-4 May 1994.

THESES DIRECTED:

Demers, W.A, CDR, USN and Rogelstad, J.M., LT, USN, "The Design and Implementation of a Functional/ Daplex Data Interface for the Multimodel and Multilingual Database System," Master's Thesis, March, 1994.

Barnes, G.B., LT, USN, "A Conceptual Approach to Object-Oriented Data Modeling," Master's Thesis, September 1994.

Free, N.C., CAPT, USA, "Translation of the Data Flow Query Language for the Multimodel, Multibackend Database System," Master's Thesis, September 1994.

DOD KEY TECHNOLOGY AREA: Software

KEYWORDS: Database, Interoperable Database Systems, Heterogeneous database systems

TESTING OF AND APPLICATIONS FOR HIGH ASSURANCE SECURE SYSTEMS

C.E. Irvine, Assistant Professor
Department of Computer Science
Sponsor: Naval Postgraduate School

OBJECTIVE: The goal of this research was to explore untrusted applications intended to execute on high assurance trusted systems and to study potential channels for illicit information flow in the context of trusted systems.

SUMMARY: The design of a file system as an untrusted application on a high assurance trusted computing base (TCB) was examined. Methods used to permit instantiation of file system subjects at previously unencountered access classes were studied. The use of TCB subsetting techniques were addressed along with the notion of Balanced Assurance.

Research on the combination of operating system techniques with high assurance technology will continue. In the area of illicit information channels, a low assurance trusted system was examined for flaws and techniques

for exploiting those flaws were explored. A software engineering methodology for development of malicious applications was prepared. Additional work in this area will be required to provide for continuity as the software development team evolves. Work to investigate the effectiveness of auditing against exploitative use of low assurance systems was initiated.

CONFERENCE PRESENTATION:

Irvine, C.E., "High and Low Assurance: What are the Differences?," presented at the Tenth Annual Computer Security Applications Conference, Orlando, FL, December 1994.

THESES DIRECTED:

Muschalek, K.E., CPT, USA, "Mandatory Security Policy Enforcement in Commercial Off the Shelf Database Management System Software: A Comparative Analysis of Informix On-Line/Secure and Trusted Oracle," Master's Thesis, September 1994.

Weatherford, M.T, LT, USN, "Interpretive Analysis of the Joint Maritime Command Information System (JMCIS) Sensitive Compartmented Information (SCI) Local Area Network (LAN) Security Requirements," Master's Thesis, September 1994.

OTHER:

Reviewer for National Security Agency guideline entitled "Trusted Network Survey," April 1994.

DOD KEY TECHNOLOGY AREA: Computers, Software

KEYWORDS: Computer Security, Applications Software, Secure Systems

SIMULATION AND CONTROL OF AUTONOMOUS UNDERWATER WALKING ROBOTS

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R.B. McGhee, Professor
Department of Computer Science
Sponsor: National Science Foundation

OBJECTIVE: The overall objectives of this project are to investigate problems related to gait planning, motion control, and their simulation on autonomous underwater walking robots. This is an international joint project operated by the Naval Postgraduate School and by the Port and Harbor Research Institute (PHRI) in Japan. The year of 1994 was the last of the three-year period.

SUMMARY: The new gait control method for axially symmetric hexapod was successfully tested and simulated. This method enables smooth body motion with variable duty ratio and variable crab angle. This gait planning algorithm is supported by a dynamic foot motion planning. The real-time control experiments of AQUAROBOT is one core research in this whole research proposal. This experiment was started at PHRI in the Summer of 1994 with involvement of Kenji Suzuki (University of Electro-Communications), Hidetoshi Takahashi (PHRI), Kan Yoneda (Tokyo Institute of Technology), and Yutaka Kanayama. Previously, we tested the new gait planning algorithm, {it extended gait planning algorithm}, by computer simulation with 3D graphics. That algorithm was perfectly implemented on the real AQUAROBOT. As a result, the robot made a smooth and faster body motion as planned. Its feet followed the dynamic motion plans to support bodies smooth motions. The experiments were video-taped cite {video}. After this success on flat terrain walking, we generalize the algorithm in order to work on uneven terrains.

Comparison between the O(N) method (using articulated body inertias) and the O(N**3) method (using composite rigid body inertias) for robotic linkage dynamics was for the first time extended to the underwater domain by inclusion of hydrodynamic and hydrostatic effects in an O(N) method. It is found that the amount of computation required in this case is increased by approximately seventy-five percent over the corresponding requirement for a single chain serial manipulator mounted on a mobile base and operating in space or air.

As a first step toward a virtual reality model for Aquarobot, we developed a purely kinematic simulation. This model assumes a level sea bottom, and proved to be very useful in supporting the development of an initial version of Aquarobot motion coordination software. The current version of this model makes use of the "Performer" software package provided by Silicon Graphics Inc. (SGI) to compute the collision of cylindrical feet with uneven terrain. Another simplified model, provides a single rigid body representation for Aquarobot in which the mass of the legs is concentrated in the body. Both of these simulations have the advantage of running in real time on low-end SGI graphics workstations. An exact O(N) articulated rigid-body graphical simulation model running slower than real-time has been delivered to PHRI.

PUBLICATIONS:

Rowe, N.C. and Kanayama, Y., "Minimum-Energy Paths on a Vertical-Axis Cone with Anisotropic Friction and Gravity Effects," International Journal of Robotics Research, Vol. 13, No. 5, pp. 408-433, 1994.

Arinaga, S., Kambara, T., Nakano, K., and Kanayama, Y., "A Layered Control Architecture Applied to AUV Navigation," Proceedings IARP Workshop on Mobile Robots for Subsea Environments, Monterey, CA, 3-6 May 1994.

Kanayama, Y., "Two Dimensional Wheeled Vehicle Kinematics," Proceedings of International Conference on Robotics and Automation, San Diego, CA, pp. 3079-3084, 8-13 May 1994.

Yoneda, K., Suzuki, K., and Kanayama, Y., "Gait and Foot Trajectory Planning for Versatile Motion of a Six Legged," Proceedings of International Conference on Robotics and Automation, pp. 1338-1343, San Diego, CA, 8-13 May 1994.

Yoneda, K., Suzuki, K., and Kanayama, Y., "An International Joint Research Project on an Autonomous Underwater Walking Robot," Proceedings of Robotics Symposium, pp. 115-120, Tokyo, Japan, 27-28 May 1994.

McMillan, S., Orin, D.E., and McGhee, R.B., "Efficient Dynamic Simulation of an Unmanned Underwater Vehicle with a Manipulator," Proceedings of 1994 IEEE International Conference on Robotics and Automation, San Diego, CA, May 1994.

McMillan, S., "Computational Dynamics for Robotic Systems on Land and Under Water," Ph.D. dissertation, Ohio State University, Columbus, OH, September 1994.

THESES DIRECTED:

Book, S.A., "Improving Software Characteristics of a Real-Time System Using Reengineering Techniques," Master's Thesis, March 1994.

Byrne, P.G., "A Mobile Robot Sonar System with Obstacle Avoidance," Master's Thesis, March 1994.

Lee, T.M., "The Stable and Precise Motion Control for an Autonomous Mobile Robot," Master's Thesis, March 1994.

Goetz, J.R., "Graphical Simulation of Articulated Rigid Body System Kinematics with Collision Detection,"

Master's Thesis, March 1994.

Kristiansen, K.J.R.W., "A Computer Simulation of Vehicle and Actuator Dynamics for a Hexapod Walking Robot," Master's Thesis, March 1994.

Michiue, M., "Research on the Sonar Hardware System on an Autonomous Mobile Robot," Master's Thesis, June 1994.

Huggins, K.L., "Constructing a Real-Time Mobile Robot Software System," Master's Thesis, September 1994.

Haight, T.A., "Layered Path Planning for an Autonomous Mobile Robot," Master's Thesis, September 1994.

Lochner, J.T., "Analysis and Improvement of an Ultrasonic Sonar System on an Autonomous Mobile Robot," Master's Thesis, December 1994.

DOD KEY TECHNOLOGY AREA: Software

KEYWORDS: Robotics, Underwater Robots, Walking Robots, Autonomous Robots, Gait Planning, Rational Behavior Model

RUSSIAN SCHOLAR EXCHANGE

T. Lewis, Professor and Chairman
Department of Computer Science
Sponsor: Office of Naval Research

OBJECTIVE: To develop the world's first portable parallel programming environment.

SUMMARY: We propose a two-year joint USA-Russia proposal to investigate new parallel programming language concepts for general-purpose parallel programming. The technical merits of this work are: 1) both large-grained and fine-grained parallelism, 2) both control-parallel and data-parallel paradigms, 3) static and dynamic task creation, and 4) target machine independence are supported. In addition, we propose an implementation phase in which a complete programming environment is prototyped. This environment will use novel program visualization and incremental compiling techniques to increase a programmer's understanding of the parallel application programs being constructed.

The tangible results of this work, in addition to the usual scientific publications, are: 1) exchange of technology between USA and Russia, 2) advancement of parallel programming language research, and 3) production of a portable parallel programming language plus its programming environment.

This is a two-year international cooperative research project involving NPS and Russian scientists. Its purpose is to design and implement a portable parallel programming environment. The work is based on the book, Foundations of Parallel Programming, by Ted Lewis (Computer Society Press, 1994). The Russian compiler technology will be combined with the American design and graphical user interface technology to deliver an advanced programming system that will work on any kind of parallel machine.

Name and Title: A Joint USA-Russia Research Program: General Purpose Portable Parallel Programming Language and its Programming Environment

PUBLICATION:

Lewis, T.G., "A Large-Grain Parallel Programming Environment For Non-Programmers," 1994 International Conference Parallel Proceedings, CRC Press, Vol 11, pp. 65-68, 15-19 August 1994.

DOD KEY TECHNOLOGY AREA: Software

KEYWORDS: Parallel Programming, Fine-grained Parallelism, International Cooperation

DOMAIN SPECIFIC ARCHITECTURE FOR COMPUTER AIDED PROTOTYPING OF C3 SYSTEMS

Luqi, Associate Professor
V. Berzins, Professor
M.-T. Shing, Associate Professor
Department of Computer Science
Sponsor: Naval Postgraduate School

OBJECTIVE: This research focuses on the formal techniques for developing reliable software for distributed real-time systems typical of C3 applications. The major objective of this work is to develop improved methods and computer aid to effectively produce and evaluate prototypes to support an iterative rapid prototyping process for formulating and assessing the requirements. The proposed work will result in high level models of timing requirements that can be used both for quantitative analysis and for automatic generation of real-time schedules and the control code that realizes the schedules in the software.

SUMMARY: The work proposed for FY94 focused on the real-time scheduling of C3 systems. We have developed new models for the timing requirements to handle communication delays between processors in typical C3 distributed systems, and developed new algorithms to analyze the additional timing requirements. The front-end of the Static Scheduler has been totally redesigned. It can now extract timing requirements directly from the PSDL description via the Ada PSDL abstract data types. The static scheduler now can make better use of the information on timing and precedence constraints to detect some of the timing constraint inconsistencies without invoking the scheduling algorithms, thus improving the efficiency and effectiveness of the scheduling algorithms. To express the behavior of distributed C3 systems, PSDL has been extended to define optional latency attributes. We have extended the scheduling algorithms to handle the data flow latency in multi-level design. The modified algorithms have been implemented in Ada and tested on several prototypes. We have included the improved static scheduler in the beta-version of the CAPS system and released the system to the DoD laboratories through the Ada Joint Program Office.

CONFERENCE PRESENTATION:

Luqi, Goguen, J., and Berzins, V., "Suggestions for Progress in Software Analysis, Synthesis and Certification," 6th International Conference on Software Engineering and Knowledge Engineering, Jurmala, Latvia, 20-23 June 1994.

THESIS DIRECTED:

Rowshanaee, M., "A Friendly Editing Environment for Computer-Aided Rapid Prototyping of Hard Real-Time Systems," Master's Thesis, December 1994.

DOD KEY TECHNOLOGY AREA: Software

KEYWORDS: Hard Real-Time Embedded Systems, Computer-Aide Rapid Prototyping

THE DESIGN OF HARD REAL-TIME SYSTEMS

Luqi, Associate Professor
V. Berzins, Professor
M.-T. Shing, Associate Professor
Department of Computer Science
Sponsor: Naval Postgraduate School

OBJECTIVE: This research focuses on the formal techniques for specifying complex hard real-time systems using a Prototyping System Description Language and the associated tools for further analysis and design. A major objective of this work is to enable the automation of a larger part of hard real-time software development via execution of real-time prototypes. A special scheme is developed to treat the hard real-time constraints and to integrate guidelines beyond conventional compiler technology.

SUMMARY: In FY94, we have completed a beta-version of the CAPS that supports the formal techniques for specification and rapid prototyping of complex hard real-time systems, and released the software to DoD laboratories through the Ada Joint Program Office. The released software provides an integrated set of tools which allow engineers to enter prototype specifications as a combination of graphics and text objects and automatically translate the specification into Ada code for a uni-processor environment. We have also finished the design of models and algorithms for scheduling hard real-time systems in a distributed prototyping environment.

PUBLICATION:

Luqi and Shing, M., "Teaching Hard Real-Time Software Development via Prototyping," Proceedings of the ACM/IEEE International Workshop on Software Engineering Education, Sorrento, Italy, pp. 199-211, 21 May 1994.

CONFERENCE PRESENTATIONS:

Luqi and Shing, M., "Teaching Hard Real-Time Software Development via Prototyping," presented at the ACM/IEEE International Workshop on Software Engineering Education, Sorrento, Italy, 21 May 1994.

Badr, S. and Luqi, "Automation Support for Concurrent Software Engineering," 6th International Conference on Software Engineering and Knowledge Engineering, Jurmala, Latvia, 1994, 20-23 June 1994.

Luqi, Goguen, J., and Berzins, V., "Formal Support for Software Evolution," presented at the Monterey Workshop 94, Monterey, CA, 7-9 September 1994.

DOD KEY TECHNOLOGY AREA: Software

KEYWORDS: Hard Real-Time Embedded Systems, Computer-Aided Rapid Prototyping

DOD KEY TECHNOLOGY AREA: Software

KEYWORDS: Hard Real-Time Embedded Systems, Computer-Aided Rapid Prototyping

A COMPUTER AIDED PROTOTYPING SYSTEM FOR REAL-TIME SOFTWARE

Luqi, Associate Professor
V. Berzins, Professor
Department of Computer Science
Sponsor: Ada Joint Program Office

OBJECTIVE: The research for this project is aimed at furthering the design and implementation of the pilot version of he Computer Aided Prototyping System (CAPS) for DoD use. CAPS is an integrated set of software tools that generate real-time Ada programs directly from requirements. The CAPS system uses the fifth-generation language PSDL to model the communication structure and the timing and control constraints that comprise the requirements for an embedded software system. This notation is used to support automatic consistency checking, design completion, and automatic generation of Ada code as well as to document requirements and prototype designs. The code generated by CAPS is used to determine and demonstrate the implications of proposed software requirements.

SUMMARY: In FY94, we have completed a beta-version of the CAPS and released the software to DoD laboratories through the Ada Joint Program Office. The released software has many new components including a new user-friendly interface, an integrated Graphics/Text PSDL editor, a prototype graphic user interface editor, and a new translator that can generate Ada code for the user defined PSDL abstract date types. The prototyping process has been simplified through use of these new components. Users can specify the requirements of the prototypes as augmented computational graphs using the graphic/text editor. The new editor allows users to process both graphic and text objects. It also detects many of the possible errors in the specification and automatically enforces consistency between the subcomponents of the prototype. Once the user finishes specifying the prototype, he/she can invoke the translator and the scheduler from the CAPS main menu to analyze the timing constraints for feasibility and automatically generate the Ada supervisor module for the prototype. For prototypes which require sophisticated graphic user interface, the user can invoke an interface editor from the CAPS main menu to edit the interface, then invoke the Ada syntax-directed editor to modify the automatically generated user interface code to match the application.

OTHER:

Software: CAPS Release 1 (70,000 lines of code) CAPS Tutorial

DOD KEY TECHNOLOGY AREA: Software

KEYWORDS: Prototyping, Real-time Software, Computer-aided System

FORMAL MODELS USED FOR AUTOMATION IN SOFTWARE DEVELOPMENT

Luqi, Associate Professor
V. Berzins, Professor
Department of Computer Science
Sponsor: Army Research Office

OBJECTIVE: The objective of the proposed research is the design of an integrated set of formal models and methods for automating a wide range of design and development tasks for real-time systems. The methods we use will focus on automation of design activities that appear in an evolutionary prototyping approach to software development. This research intends to use the state-of-the-art formal methods in software engineering to construct a cohesive set of formal models. These models are used to create and to unify a computational model to support automated processes for computer aided prototyping. Mathematical models for implementing a set of automated and integrated software tools will also be developed. This research will combine very-high-level specification abstractions and concepts with formal real-time models, automated management of software design data and human resources, transformations, change merging, and automated retrieval of reusable software components to provide automated methods for generating real-time programs and for coordinating teams of developers. The significance of the research is to improve productivity and software quality by enabling a higher level of automation in software development. The result of this research will broaden the definition of automatic programming and will make automatic programming a practical approach for increasing productivity in the software lifecycle. Automated decision support functions used will ensure software quality by decreasing the human effort required and minimizing the incidence of human error. The approach controls the complexity and high degrees of freedom of the software process by using computer-aid. Earlier user feedback for validating and refining specifications through trial use of operational system prototypes experimentally ensures that the formal specifications corresponds to user needs. Maintenance costs will be minimized by reducing the need to repair requirements errors after system deployment and by using specification-based automatic program correction methods sensitive to both syntax and semantics.

SUMMARY: This project is investigating formal models that can support automated methods supporting software development. We have focused on automation support for requirements elicitation, particularly for prototyping, and on automation support for software evolution, particularly for automatically detecting the need for software maintenance actions using nonmonotonic logic, for capturing requirements dependencies and justifications using the REMAP extension of the IBIS model, for combining several modifications to a system, for coordinating parallel efforts of several designers, and automating the associated configuration management tasks.

PUBLICATIONS:

Dampier, D., Luqi, and Berzins, V., "Automated Merging of Software Prototypes," Journal of Systems Integration, Vol. 4, No. 1, pp. 33-49, February 1994.

Luqi and Shing, M., "Teaching Hard Real-Time Software Development via Prototyping," Proceedings of the International Workshop on Software Engineering Education at the International Conference on Software Engineering, Sorrento, Italy, pp. 199-211, 21 May 1994.

Luqi and Goguen, J., "Suggestions for Progress in Software Analysis, Synthesis and Certification," Proceedings of the 6th International Conference on Software Engineering and Knowledge Engineering, Jurmala, Latvia, pp. 501-507, 20-23 June 1994.

Badr, S. and Luqi, "Automation Support for Concurrent Software Engineering," Proceedings of the 6th International Conference on Software Engineering and Knowledge Engineering, Jurmala, Latvia, pp. 46-53, 20-23 June 1994.

Luqi, "Monterey Workshop 94: Software Evolution - Increasing the Practical Impact of Formal Methods in Computer Aided Software Development," Proceedings of Monterey Workshop 94, Monterey, CA, pp. 1-9, 7-9 September 1994.

Luqi, Goguen, J., and Berzins, V., "Formal Support for Software Evolution," Proceedings of Monterey Workshop 94, Monterey, CA, pp. 10-21, 7-9 September 1994.

Luqi, Yang, H., and Zhang, X., "Constructing an Automated Testing Oracle: An Effort to Produce Reliable Software," Proceedings of COMPSAC 94, Taipei, Taiwan, pp. 228-233, 7-9 November 1994.

Goguen, J., "Categorical Approaches to Merging Software Changes," research report, 1994.

Goguen, J. and Meseguer, J., "Software Component Search," research report, 1994.

DOD KEY TECHNOLOGY AREA: Software

KEYWORDS: Software Engineering, Formal Methods, Automation

REAL-TIME PROTOTYPE FOR EVALUATING GPS MISSILE CONTROL

Luqi, Associate Professor
V. Berzins, Professor
Department of Computer Science
Sponsor: Naval Surface Warfare Center

OBJECTIVE: The objective of the proposed research was to develop a prototype of a Tomahawk Land Attack Missile and its control system, to evaluate the benefits of replacing the current control system with one that uses the Global Positioning System (GPS) for navigation. The proposed work included a requirements analysis effort supported by the Computer-Aided Prototyping System (CAPS) and its associated Prototype Description Language (PSDL) to aid in modeling and determining the hard real-time constraints of the system and to evaluate the feasibility and effectiveness of this approach. The result was to be an executable model of the system that can be used to simulate its performance under a variety of scenarios.

SUMMARY: We initiated the work on requirements engineering of a GPS equipped TLAM Missile using CAPS. The sponsor requested us to emphasize integration of CAPS with other software tools, and we did an initial evaluation of the relation between CAPS and the IDAS system developed by JRS Labs, Inc. Our conclusion is that IDAS could be used for measuring maximum execution times for reusable software components to be installed in the CAPS software base.

OTHER:

Proposal: Real-Time Prototype for Evaluating GPS Missile Control, Demo of computer-aided prototyping system and meeting with JRS staff on integration of software tools, Software and missile prototype document, Models of Dynamic Systems, project analysis and tasks.

DOD KEY TECHNOLOGY AREAS: Software

KEYWORDS: Software Engineering, Prototyping, Automation

SYSTEMATIC DEVELOPMENT OF HARD REAL-TIME SYSTEMS

Luqi, Associate Professor
Department of Computer Science
Sponsor: Naval Research Laboratory

OBJECTIVE: The proposed research involved designing suitable methodology for building hard real-time systems, writing documentation for technology transfer, and providing hands on training for the software engineers at NRL to practice the methodology and tools.

SUMMARY: The major work on the project was completed in FY93. In FY94, we provided NRL with a copy of the CAPS system, together with installation manual and tutorial, and served as technical consultants in hard real-time system development.

OTHER:

Software: CAPS Release 1 (70,000 lines of code) CAPS Tutorial, CAPS Installation Manual, Patriot missile software prototype, C3I software prototype, Tomahawk missile software prototype, Autopilot prototype, Temperature control prototype

DOD KEY TECHNOLOGY AREA: Software

KEYWORDS: Hard Real-Time Embedded Systems, Computer-Aided Rapid Prototyping

NSF PRESIDENTIAL YOUNG INVESTIGATOR

Luqi, Associate Professor
Department of Computer Science
Sponsor: National Science Foundation

OBJECTIVE: The goal of this research is to enable rapid prototyping of hard real-time systems via a computer aided prototyping system (CAPS). CAPS is based on a prototyping language with module specifications for modeling real-time systems and combining reusable software. These tools make it possible for prototypes to be designed quickly and to be executed for validating the requirements. The research focuses on automated methods for retrieving, adapting, and combining reusable components based on normalized module specifications; establishing feasibility of real-time constraints via scheduling algorithms; simulating unavailable components via algebraic specifications; automatically generating translators and real-time schedules for supporting execution; constructing a prototyping project database using derived mathematical models; providing automated design completion and error checking facilities in a designer inter-face; and establishing a convenient graphical interface for design and debugging. This is a continuing project.

SUMMARY: The main research problems we have are developing abstract models and implementation techniques based on formalized specifications. Progress during this year has been mainly in the areas of automated support for software evolution, multiprocessor models for real-time systems, software transformation and software reuse. In FY94, we have completed the development and integration of many tools to support the abstract models for hard real-time system specifications, schedulability analysis, software evolution control, compute-aided software reuse and retrieval. These tools together forms an integrated software environment CAPS aimed at rapidly prototyping hard real-time embedded software system to support software evolution as well as initial development. In order to evaluate the benefits derived from the practice of computer-aided prototyping within the software acquisition process, we conducted a case study in which we compared the cost that is required to perform requirements analysis and feasibility study for an automated C3I system using the 2167A process in which the software is coded manually, and the rapid prototyping process where part of the code is automatically

generated via CAPS. We found that using the CAPS method resulted in a cost reduction of $56,300, a 27% cost saving. Projecting the results of this comparison to a mission control software system, the command and control segment (CCS), we estimated a cost saving of 12 million dollars.

PUBLICATIONS:

Dampier, D., Luqi, and Berzins, V., "Automated Merging of Software Prototypes," Journal of Systems Integration, Vol. 4, No. 1, pp. 33-49, February 1994.

Luqi and Shing, M., "Teaching Hard Real-Time Software Development via Prototyping," Proceedings of the International Workshop on Software Engineering Education at the International Conference on Software Engineering, Sorrento, Italy, pp. 199-211, 21 May 1994.

Luqi and Goguen, J., "Suggestions for Progress in Software Analysis, Synthesis and Certification," Proceedings of the 6th International Conference on Software Engineering and Knowledge Engineering, Jurmala, Latvia, pp. 501-507, 20-23 June 1994.

Badr, S. and Luqi, "Automation Support for Concurrent Software Engineering," Proceedings of the 6th International Conference on Software Engineering and Knowledge Engineering, Jurmala, Latvia, pp. 46-53, 20-23 June 1994.

Luqi, "Monterey Workshop 94: Software Evolution - Increasing the Practical Impact of Formal Methods in Computer Aided Software Development," Proceedings of Monterey Workshop 94, Monterey, CA, pp. 1-9, 7-9 September 1994.

Luqi, Goguen, J., and Berzins, V., "Formal Support for Software Evolution," Proceedings of Monterey Workshop 94, Monterey, CA, pp. 10-21, 7-9 September 1994.

Luqi, Yang, H., and Zhang, X., "Constructing an Automated Testing Oracle: An Effort to Produce Reliable Software," Proceedings of COMPSAC 94, Taipei, Taiwan, pp. 228-233, 7-9 November 1994.

DOD KEY TECHNOLOGY AREA: Software

KEYWORDS: Software Engineering, Formal Methods, Automation

RAPID PROTOTYPING FOR DISTRIBUTED APPLICATIONS

Luqi, Associate Professor
Department of Computer Science
Sponsor: National Science Foundation

OBJECTIVE: The objective of the proposed research is to extend the rapid prototyping language PSDL, which applies to hard real-time systems, to include specification concepts and implementation techniques suitable for distributed applications. We will provide a formal semantics which makes PSDL specifications amenable to formal analysis and reasoning, and will redesign its associated execution support system accordingly. Major emphasis research will be on development of a semantic model supporting both prototyping and available verification techniques for distributed programs, scheduling and resource allocation issues related to prototype execution on multiple processors in the presence of resource contention, and a two level approach to prototype execution which uses both executable specifications and reusable software components.

SUMMARY: The redesign and formal definition of the prototyping language aims at exploiting partly complementary skills in language and tool design, experimentation, and theoretical analysis of the cooperating parties to reduce the use of resources in solving problems of common concern. This joint effort has contributed to the research efforts of both parties by enabling them to extend the functionality and range of applications of their technical results with less effort than separate projects would require, promoting knowledge transfer among the US and Europe, and making research results mutually known and available for exploitation. This is a continuing project.

OTHER:

Final report, Analysis of Technology for Supporting Rapid Prototyping of Distributed Applications.

DOD KEY TECHNOLOGY AREA: Software

KEYWORDS: Software Engineering, Prototyping, Distributed Systems

INCREASING THE PRACTICAL IMPACT OF FORMAL METHODS FOR SOFTWARE DEVELOPMENT

Luqi, Associate Professor
Department of Computer Science
Sponsor: Army Research Office

OBJECTIVE: DoD and industry have an urgent need for software systems that can meet user needs effectively and reliably, and software quality is emerging as one of the main problems for the 1990's. Formal methods that can be partially or completely automated provide a promising approach to solving this problem. The objective of this project is to hold a four-day workshop entitled "Formal Methods for Computer Aided Software Development" at NPS. The purpose of the workshop is to assess current research efforts in this area, to identify results and directions that can increase the degree of automation that is feasible, to aid tool integration by building a common understanding, and to help bring formal methods into practical use.

SUMMARY: The workshop was held in Monterey on Sept. 7-9, 1994. The focus of the workshop was dynamic aspects of controlling software evolution and environments for supporting software development and evolution. A result of the workshop was recognition of a trend in recent research efforts to emphasize the application of formal methods to support automated and computer-aided synthesis of software systems.

PUBLICATION:

Luqi and Brockett, J. (Ed.), "Software Evolution," Proceedings of Increasing the Practical Impact of Formal Methods in Computer-Aided Software Development, Proceedings of the Monterey Workshop 94, September 1994.

CONFERENCE PRESENTATION:

Luqi, "Monterey Workshop 94: Software Evolution - Increasing the Practical Impact of Formal Methods in Computer Aided Software Development," presented at the Monterey Workshop 94, Monterey, CA, 7-9 September 1994.

OTHER:

Demonstration of the CAPS system, Demonstration of a C3I prototype, Demonstration of a Patriot Missile prototype, Demonstration of an autopilot system prototype, Demonstration of a fish farm control prototype.

DOD KEY TECHNOLOGY AREA: Software

KEYWORDS: Software Engineering, Software Evolution, Automation

AN EXPERIMENTAL STUDY OF SOFTWARE ARCHITECTURES AND SOFTWARE REUSE FOR CONTROL OF UNMANNED UNDERWATER VEHICLES

R.B. McGhee, Professor
A.J. Healey, Professor
S.H. Kwak, Research Assistant Professor
Department of Computer Science
Sponsor: National Science Foundation

OBJECTIVE: The goal of this project is to investigate alternative software architectures for control of unmanned underwater vehicles, and to find effective means for archiving and retrieving software modules used to implement such software systems. The research is being conducted in cooperation with the Monterey Bay Aquarium Research Institute (MBARI), and with INRIA, a French Government Research Institute.

SUMMARY: This is a three-year project which began in January, 1994. During the first year, much of our work was focused on further development of the "Rational Behavior Model" (RBM) architecture, and its testing in the NPS "Phoenix" autonomous underwater vehicle (AUV). This work was successful, and is reported in [1,2]. We also succeeded in creating a virtual world for Phoenix, using advanced graphics workstations to simulate in real-time both the vehicle dynamics and its ocean environment. This simulation includes a physical copy of the Phoenix control computer, thereby enabling laboratory testing and evaluation of control software running in the target computer, without the expense and hazards associated with in-water experiments [4]. Finally, we cooperated with MBARI in research on automated stationkeeping by an AUV using either sonar or visual target tracking [3]. Results obtained were encouraging, and we intend to pursue further software development and open water testing in CY95.

PUBLICATIONS:

Healey, A.J., McGhee, R.B., Papoulias, F.A., Cristi, R., Brutzman, D.P., Marco, D.B., and Kwak, S.H., "Search and Find Mission Control and Execution Using the NPS AUV II Autonomous Underwater Vehicle," Proceedings of Second IARP Workshop on Mobile Robots for Subsea Environments, Pacific Grove, CA, May 1994.

Byrnes, R.B., Healey, A.J., McGhee, R.B., Nelson, M.L., and Kwak, S.H., "A Software Architecture for Intelligent Ships: An Approach to Motion and Mission Control," Proceedings Intelligent Ships Symposium, American Society of Naval Engineers, Philadelphia, PA, 1-2 June 1994.

Marks, R.L., Rock, S.M., Lee, M.J., and Wang, H.H., "Automatic Visual Station Keeping of an Underwater Robot," Proceedings of Oceans '94 Conference, Brest, France, September 1994.

THESIS DIRECTED:

Brutzman, D.P., "A Virtual World for an Autonomous Underwater Vehicle," Doctoral Dissertation, Naval Postgraduate School, December 1994.

DOD KEY TECHNOLOGY AREA: Other (Battlefield Robotics)

KEYWORDS: Robotics, Minehunting, Autonomous Underwater Vehicles (AUV)

DEVELOPMENT AND EVALUATION OF A PROTOTYPE SMALL AUV NAVIGATION SYSTEM (SANS)

R.B. McGhee, Professor
J.R. Clynch, Research Associate Professor
S.H. Kwak, Research Assistant Professor
Department of Computer Science
Sponsor: NRaD Hawaii

OBJECTIVE: The goal of this project was to demonstrate the feasibility of using integrated GPS/INS navigation in a small Autonomous Underwater Vehicle (AUV), such as the NPS "Phoenix" AUV, in a shallow-water mine-hunting mission. Toward this end, at sea testing was undertaken using a small tow-body to simulate the Phoenix vehicle. Results obtained are to be used in adding a GPS/INS navigation capability to Phoenix in CY95.

SUMMARY: The SANS package is a self-contained unit suitable for accurately determining the location of a small AUV using a combination of GPS, inertial, depth, and magnetic sensors. It also incorporates a computer to provide navigation commands (heading, speed, and depth) to guide the AUV to a mission area, to record mission data, and to return the AUV to its recovery site. It is designed for either internal or external mounting on any AUV, or even for attachment to a human diver. The publications listed below support the conclusion that the location of objects detected by an AUV operating in depths up to 70 meters can be determined to an accuracy of approximately 10 meters rms, worldwide, by a SANS package occupying not more than 120 cu. in., and requiring less than 10 watts average power.

THESIS DIRECTED:

Norton, N.A., "Evaluation of Hardware and Software for a Small Autonomous Underwater Vehicle Navigation System (SANS)," Master's Thesis, September 1994.

OTHER:

McGhee, R.B., Clynch, J.R., Healey, A.J., Kwak, S.H., Brutzman, D.P., Norton, N.A., Whalen, R.H., Gay, D.L., and Bachmann, E.R., "At Sea Testing of an Integrated GPS/INS System for Shallow-Water AUV Navigation", submitted to 9th International Symposium on Unmanned Untethered Submersible Technology, Durham, NH, September 1995.

DOD KEY TECHNOLOGY AREA: Other (Battlefield Robotics)

KEYWORDS: Robotics, Minehunting, Autonomous Undersea Vehicles (AUV)

IMPROVEMENTS TO RECRUITING QUOTA ALLOCATION SYSTEM

T. Shimeall, Assistant Professor
Department of Computer Science
Sponsor: US Army Recruiting Command (USAREC)

OBJECTIVE: Allocating recruiting quota to field operating units is one of the essential tasks for the U.S. Army Recruiting Command. In particular, accurate and prompt analysis and execution for quota allocation can lead to competitive advantages over recruiters from the other services including other military branches. This research examined the existing recruiting quota operation and to improved it to meet the current and future needs. In order to achieve this objective, this research produced a totally new computer system for the U.S. Army Recruiting Command by utilizing Software Engineering methodologies.

SUMMARY: From July 1993 through September 1994, NPS researchers have examined the US Army Recruiting Command (USAREC) Recruiting Quota Allocation system. The results of this examination have been used in the acquisition of substantially improved hardware and the implementation of core software functionality on that hardware.

The initial phase of this research was a study of current USAREC operations, specifically the existing source code and file formats. The results of this study were used to develop specifications for the acquisition of hardware and for prioritizing of software conversion. This study (conducted by Dr. Sehung Kwak) involved extensive interviews with USAREC personnel.

The second phase of the research was the acquisition of needed hardware and support software to meet USAREC's current and projected quota allocation and mission planning needs. The acquired equipment (since installed at USAREC headquarters) includes a sun SPARCstation 10-30 with 32 megabytes of main memory, 10 gigabytes of disk, external tape backup, CD-ROM, and 8 9600- baud serial modems. The support software includes language processing for C++ (the selected development language) and extended operating system support.

The third phase of this research was the conversion and initial testing of the quota allocation software from the existing Fortran UNIVAC implementation to a more maintainable C++ Sun implementation. In addition to the quota allocation (MKTSHR) software described in the initial proposal, NPS personnel (Dr. Shimeall, and Dr. Carlos Borges of the NPS Department of Mathematics) were able to provide conversion of additional mission planning software, the testing of which is ongoing by USAREC personnel. The results of the MKTSHR testing revealed problems with both the converted and original software, and initial corrections in the converted software have been installed at USAREC.

PUBLICATION:

Shimeall, T., "MKTSHR - Computer Software for Recruiting Quota Allocation," US Army Recruiting Command, 1994.

DOD KEY TECHNOLOGY AREA: Software

KEYWORDS: Manpower planning, Optimization, Translation

VALIDATION OF VIRTUAL REALITY SOFTWARE

T. Shimeall, Assistant Professor
Department of Computer Science
Sponsor: Naval Postgraduate School Research Council

OBJECTIVE: The research facilitated the development of interactive real-time visual simulation software by introducing a software methodology to systematically review the concurrent and sequential aspects of the software for valid behavior.

SUMMARY: This research involved analysis of the testing needs of an advanced virtual reality development project, the NPSNet project at NPS. On the basis of that analysis, a review methodology was developed and applied to portions of the NPSnet software, demonstrating its practicality and effectiveness. A number of software problems were identified in this sample application, and the review methodology was revised to provide more information with greater ease-of-use to virtual reality developers.

OTHER:

Adams, C., "A Review Methodology for NPSNet Research Software," Master's Thesis forthcoming in March 1995.

DOD KEY TECHNOLOGY AREA: Software

KEYWORDS: Software Validation, Virtual Reality Software, Concurrent Software

ON-LINE POLYMORPHIC TYPE INFERENCE IN AN IMPERATIVE LANGUAGE

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Sponsor: National Science Foundation

OBJECTIVE: The goal of this project was to investigate type inference for an imperative language with higher-order functions, polymorphism and first-class references. Another goal is to examine the complexity of type inference for overloading and subtyping in this context.

SUMMARY: A weak lower bound was established for satisfiability of constraint sets in the context of the kind of overloading allowed in the programming language Haskell. It was shown that satisfiability is NP hard. A tighter lower bound was obtained shortly thereafter when it was shown that satisfiability is EXPTIME-complete. Independently, a prototype system was built to perform incremental type inference in an on-line setting. It was generated automatically from an attribute grammar.

THESES DIRECTED:

Bull, B., LT, USN, "Type Inference with Overloading Using an Attribute Grammar," Master's Thesis, March 1994.

Robinson, T., LT, USN, "Incremental On-line Type Inference," Master's Thesis, March 1994.

OTHER:

Two journal papers were submitted as part of this project. One entitled "On the Complexity of Constraint-Based Overloading" and was submitted to ACM Transactions of Programming Languages and Systems. The other titled "Type Checking Coherent Overloading" was submitted to Software Concepts and Tools. A conference paper titled "How Letvar Can Be Better Than Let and Ref" was submitted to the Conference on Functional Programming Languages and Computer Architecture.

DOD KEY TECHNOLOGY AREA: Software

KEYWORDS: Imparative Language, Type Inference, Polymorphism

EFFICIENT EXECUTION OF PERIODIC TASK GRAPHS ON DISTRIBUTED MEMORY MULTIPROCESSORS

A. Zaky, Assistant Professor
Department of Computer Science
Sponsor: SPAWAR

OBJECTIVE: To develop a framework and its associated mechanisms for efficient mapping and scheduling of real-time compute-intensive applications on distributed-memory multiprocessors.

SUMMARY: Quite a few compute-bound applications are naturally expressible in the form of task graphs. Signal processing, image processing, flight control are examples of these applications. These applications are real-time applications which can potentially be executed in environments imposing critical requirements on sampling rates, deadline constraints, and availability in the presence of hardware failures. Physical constraints imposed by the environment on the weight, volume, and power consumption of the underlying hardware preclude the use of expensive massively-parallel processors. More so is the case because of the nature of the available parallelism (large task granularity) and the potential need for hybrid processing requirements.

We introduced a framework to support the efficient execution of applications expressed as task graphs on multicomputers. The one basic feature that sets this work apart from other mapping and partitioning techniques of task graphs is our interest in improving the performance parameters related to the repetitive execution of task graphs rather than that of one graph instance. This approach is specifically useful for real time applications. The main performance parameter we seek to optimize is the graph execution throughput. Secondary parameters that can be optimized are resource utilization and output regularity (having outputs produced at almost regular intervals). Our initial results are algorithms that perform the functions of {restructuring, mapping, scheduling} on a task graph, and other algorithms which employ the mechanisms of {node fission, node fusion} operations on a real time task graph to optimize one or more of graph execution throughput. Preliminary results indicate that our scheduling and mapping algorithm- Periodic Scheduler(PS)- increases the application throughput over the traditional techniques for scheduling LGDF graphs. Also, our granularity adjustment algorithm (GSM) produce reasonable improvement in the throughput on shared-memory multiprocessors.

Currently, our efforts are directed at combining the PS and GSM in a common framework. The developed framework will be embodied in a software tool: the input to a tool will be a task graph and a multiprocessor configuration description. The description will include the processor performance, the interconnection topology, and the communication model characteristics. Along with the graph description, rules can be entered that describe how to fuse nodes or to break them into smaller nodes. The output of the tool will be a restructured task graph and its mapping and schedule on the given multicomputer.

THESIS DIRECTED:

Kasinger, C., "A Periodic Scheduling Heuristic for Mapping Iterative Task Graphs onto Distribute-Memory Multiprocessors," Master's Thesis, September 1994.

Negelspach, G., "Grain Size Management in Repetitive Task Graphs for Multiprocessor Compute Scheduling," Master's Thesis, September 1994.

OTHER:

Zaky, A. and Negelspach, G., "Granularity Management for a Large-Grain Data Flow Multiprocessor," Seventh SIAM Conference on Parallel Processing for Scientific Computing, San Francisco, CA, forthcoming in February 1995.

DOD KEY TECHNOLOGY AREA: Computers, Software

KEYWORDS: Distributed Memory, Task Graphs, Real-time Computer System

DEPARTMENT
OF
COMPUTER SCIENCE

1994
Faculty Publications
and Presentations

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DEPARTMENT
OF
ELECTRICAL AND COMPUTER
ENGINEERING



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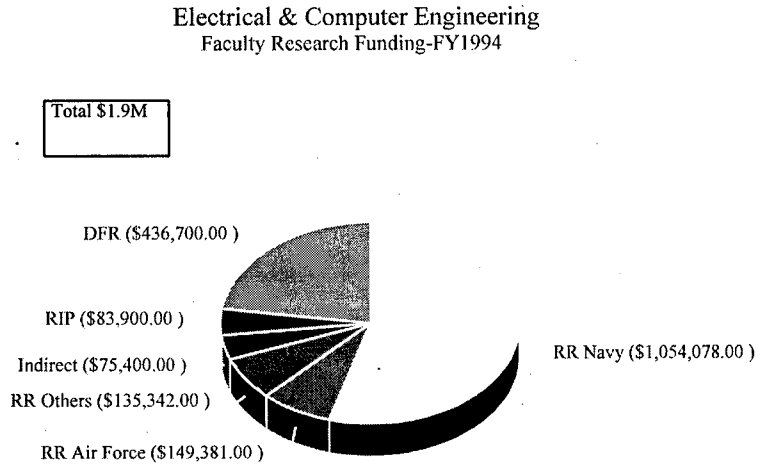
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Department of Electrical and Computer Engineering

Introduction

The research program of the Department of Electrical and Computer Engineering is very broad, reflecting the variety of skills and interests of the faculty in providing technical advances and solutions to important problems for the Department of Defense. DoD Research in ECE is strongly coupled to instruction, both in bringing the most recent advances into the classroom and in providing highly relevant and unique thesis topics for officer students to investigate with faculty guidance.

Research in the Department of Electrical and Computer Engineering is supported by an internal research program called Direct Funded Research (DFR) and the Research Initiation Program (RIP), for new faculty members, and by externally funded Reimbursable Research (RR) projects supported by various government agencies and by private industry through Cooperative Research And Development Agreements. The total of departmental research support in Fiscal Year 1994 was 1.9 Million dollars. The breakdown of that support is shown in the following figure.



Research topics span the following areas: Communications, Computer Engineering, Electromagnetics, Electro-Optics, Electronic Systems, Power Systems, Radar and Electronic Warfare, Signal Processing, Systems and Controls, and Underwater Acoustics. The following compendium categorizes each research project into one of the above areas and presents the investigator's name, project title. Some research projects involve one or more of these areas, although they are listed here in only one category. Following the listing, is a complete presentation of the projects, giving the objective, summary, and publications.

There is a strong interaction between the department's teaching and research programs, both by the incorporation of the latest research into courses and by the involvement of graduate students in the projects, as indicated by the numbers of theses completed.

Communications

SIGNAL-TO-NOISE ENHANCEMENT PROGRAM (SNEP) RESEARCH AND SUPPORT
R.W. Adler, Senior Lecturer, and W.R. Vincent, Senior Researcher

COMMUNICATION SYSTEM PERFORMANCE EVALUATION AND HIGH LATITUDE PROPAGATION RESEARCH
R.W. Adler, Senior Lecturer and W.R. Vincent, Senior Researcher

FIELD STATION RESEARCH AND SUPPORT
R.W. Adler, Senior Lecturer and W.R. Vincent, Senior Researcher

OFFSET ERRORS ESTIMATION FOR THE EXTREMELY HIGH FREQUENCY ANTENNA
R. Cristi, Associate Professor

ANALYSIS OF DENSE WDM OPTICAL FIBER NETWORKS
T.T. Ha, Professor and J.P. Powers, Professor

WAVELETS TIME-FREQUENCY ANALYSIS OF SIGNALS AND SYSTEMS
A.W. Lam, Associate Professor

SEQUENTIAL ACQUISITION SCHEMES FOR SSMA SYSTEMS WITH GENERALIZED SIGNATURE SEQUENCES
A.W. Lam, Associate Professor

PERSONAL COMMUNICATION SERVICES AND NETWORKS TECHNOLOGY FOR COMMAND, CONTROL, AND COMMUNICATION
C.-H. Lee, Professor

ULTRA-WIDEBAND IMPULSE ANTENNA DESIGN
M.A. Morgan, Professor and Chairman and R.C. Robertson, Associate Professor

RESEARCH IN DATA COMPRESSION TECHNIQUES
M. Tummala, Associate Professor

Computer Engineering

APLICATION OF MULTIPLE-VALUES TO LOGIC DESIGN
J.T. Butler, Professor

RADIATION TOLERANT, HIGH-SPEED, LOW-POWER, GALLIUM ARSENIDE DYNAMIC LOGIC
D.J. Fouts, Assistant Professor

CACHE MEMORY MISS LATENCY REDUCTION
D.J. Fouts, Assistant Professor

SOFTWARE ANALYSIS AND ELECTRICAL TESTING
C.-H. Lee, Professor

PROJECT GUSTY ORIOLE
(Computer Algorithms and Architectures for Space Applications)

H.H. Loomis, Jr., Professor
R.F. Bernstein, Jr., Visiting Instructor

DESIGN AND PERFORMANCE CHARACTERIZATION OF A MULTIPURPOSE DECENTRALIZED GROUP MEMBERSHIP SERVICE
S.B. Shukla, Assistant Professor

COMMON DATA LINK'S (CDL) INTERFACE TO THE GLOBAL NETWORK ARCHITECTURE
S.B. Shukla, Assistant Professor
P.H. Moose, Associate Professor
G.M. Lundy, Associate Professor

Electromagnetics

COMPUTER MODEL FOR PROPAGATION OVER IRREGULAR TERRAIN
R. Janaswamy, Associate Professor

COMPUTATIONAL ELECTROMAGNETIC METHODS FOR LARGE BODIES
R. Janaswamy, Associate Professor

EFFICIENT METHODS FOR PREDICTING RADIOWAVE PROPAGATION OVER IRREGULAR TERRAIN
R. Janaswamy, Associate Professor

NEED TO CALIBRATE INDICATOR FOR SHIPBOARD HFDF SYSTEMS
D.C. Jenn, Associate Professor

COMPUTER MODELING OF PROPAGATION OVER IRREGULAR TERRAIN
J.E. Lebaric, Visiting Associate Professor

MULTI-SENSOR INTEGRATION FOR LOW ALTITUDE DETECTION
H.-M. Lee, Associate Professor

EM SCATTERING FROM A TUBULAR CYLINDER OF ANISOTROPIC SURFACE IMPEDANCES
H.-M. Lee, Associate Professor

FIELD CANCELLATION USING A COUNTER-EMF APPROACH
M.A. Morgan, Professor and Chairman

EMP WAVEFORM ANALYSIS FOR AIRCRAFT TESTING
M. Tummala, Associate Professor

Electronic Systems

RADIATION HARDENED SPACE BASED SOLAR CELLS AND ELECTRONIC DEVICES
S. Michael, Associate Professor

ADVANCED ANALOG VLSI DESIGN FOR IC's AND NEURAL NETWORKS IMPLEMENTATIONS
S. Michael, Associate Professor

HIGH RESOLUTION DIRECT DIGITIZATION AND OPTICAL TELEMETRY OF ANTENNA SIGNALS
P.E. Pace, Assistant Professor

SOFTWARE FOR FLOW DISTRIBUTION IN ELECTRONIC RACK STRUCTURES
R.J. Pieper, Associate Professor

Electro-Optics

PROPAGATION OF TRANSIENT WAVES
J. Powers, Professor

Power Systems

CONVERTER DESIGN, ANALYSIS, AND PROTOTYPE FOR FUTURE NAVY SURFACE SHIPS
R.W. Ashton, Assistant Professor

A LIBRARY OF DETAILED AND REDUCED-ORDER POWER SYSTEM COMPUTER-BASED COMPONENT MODELS
J.G. Ciezki, Assistant Professor

SPACE POWER AND RADIATION EFFECTS
S. Michael, Associate Professor

Radar and Electronic Warfare

WIDEBAND RADAR SIGNAL PROCESSING
G.S. Gill, Visiting Associate Professor

COMPUTER MODELLING OF AERODYNAMIC RADAR AND EW RADOMES
D.C. Jenn, Associate Professor

ELECTRONIC SURVEILLANCE SYSTEM STUDIES
J.B. Knorr, Professor

HARDKILL-SOFTKILL COMBINATIONS FOR OPTIMUM PROBABILITY OF KILL FOR SURFACE SHIPS
F. Levien, Senior Lecturer

VERIFICATION OF THE RADAR RANGE EQUATION IN THE AFIWC IMOM COMPUTER MODEL
F. Levien, Senior Lecturer

OBSERVED EFFECTS OF AN ULTRA-WIDEBAND IMPULSE GENERATOR ON THE SLQ-32 AND OTHER MICROWAVE SYSTEMS
F. Levien, Senior Lecturer

PERFORMANCE EVALUATION OF GROUND BASED RADAR SYSTEMS USING THE AN/UPS-1 AT THE NAVAL POSTGRADUATE SCHOOL AS A MODEL
F. Levien, Senior Lecturer

ALGORITHMS FOR ASSESSING THE EFFECTIVENESS OF SHIPBOARD COUNTERMEASURES AGAINST ANTI-SHIPPING MISSILE PLATFORMS
P.E. Pace, Assistant Professor

SURFACE MODE PROCESSING FOR TARGET DETECTION AND DECLARATION
P.E. Pace, Assistant Professor

COMMUNICATIONS VULNERABILITY TO JAMMING
D.v.Z. Wadsworth, Senior Lecturer

AIRBORNE EW vs SPACE-BASED C3I SYSTEMS
D.v.Z. Wadsworth, Senior Lecturer

Signal Processing

MODELING AND CLASSIFICATION OF UNDERWATER BIOLOGICAL TRANSIENT SIGNALS
M.P. Fargues, Assistant Professor

FEATURE EXTRACTION FROM DIGITAL COMMUNICATION SIGNALS USING WAVELET TRANSFORMS
R. Hippenstiel, Associate Professor
M. Fargues, Assistant Professor

FEATURE EXTRACTION FROM DIGITAL COMMUNICATION SIGNALS
R. Hippenstiel, Associate Professor

ADVANCED SIGNAL PROCESSING TECHNIQUES
H.H. Loomis, Jr., Professor
R.F. Bernstein, Jr., Visiting Instructor

Systems and Control

SENSOR BASED NAVIGATION FOR THE AUTONOMOUS UNDERWATER VEHICLE
R. Cristi, Associate Professor

SENSOR FUSION, ESTIMATION, AND CONTROL OF NONLINEAR SYSTEMS THAT EXHIBIT ABRUPT DISCONTINUITIES IN THEIR BEHAVIOR
R.G. Hutchins, Associate Professor

SPACE RESEARCH
H.A. Titus, Professor

MULTI-SENSOR DATA FUSION USING FUZZY LOGIC AND NEURAL NETWORKS TECHNIQUES
M. Tummala, Associate Professor

COORDINATION OF MOBILE MANIPULATORS
X. Yun, Associate Professor

Underwater Acoustics

TRANSIENT LOCALIZATION
J.H. Miller, Associate Professor
C.-S. Chiu, Associate Professor

SONAR SIGNAL MODELING
C.W. Therrien, Professor

RECURSIVE RAY ACOUSTICS FOR THREE-DIMENSIONAL SPEEDS OF SOUND
L.J. Ziomek, Associate Professor

SIGNAL-TO-NOISE ENHANCEMENT PROGRAM (SNEP) RESEARCH AND SUPPORT

R.W. Adler, Senior Lecturer
W.R. Vincent, Senior Researcher
Department of Electrical and Computer Engineering
Sponsor: COMMNAVSECGRU

OBJECTIVE: Continued research and development in techniques to improve the signal-to-noise ratio at Navy receiving sites worldwide.

SUMMARY: Development of techniques and methodology for identifying and locating radio noise sources at NSG sites worldwide continued. The Automated Performance Evaluation Technique for HF receiving sites was simplified and improved. Support was provided to NGS via review of pre-survey planning documentation, mitigation plans and authoring "Quick-Look" and final site-survey reports. Students and NSG site personnel were trained as part of the NSG support. A standard was proposed for limits on the EMI/RFI current allowed in Navy SIGINT sites. Mitigation studies for eliminating interference to receiving equipment from electronic switching systems were successful. Two examples of this were presented in student theses. A 2 1/2 day HF Technical Review of Factors that Affect Performance of Naval Receiving Sites was hosted for CNSG.

PUBLICATIONS:

Vincent, W.R. and Adler, R.W., "Performance Comparison of AN/FRD-10 vs. PUSHER," Naval Postgraduate School Technical Report, NPS-EC-94-002, February 1994.

Vincent, W.R., "SNEP Team Survey," NSGA Edzell, Quick-Look Report, NSG Technical Report, April 1994.

Vincent, W.R., "Mitigation of Power Line Noise at the Morioka Quarry," NSG Technical Report, May 1994.

Vincent, W.R., "Radio Interference from Sources on Power Lines," Quick-Look Report, NSG Technical Report, July 1994.

Vincent, W.R., "The Mitigation of Radio Interference from Power Lines at Rota," Mitigation Plan, NSG Technical Report, November 1994.

Vincent, W.R., "Power Line Interference at NSGA Hanza," Test Plan, NSG Technical Report, November 1994.

CONFERENCE PRESENTATIONS:

Adler, R.W., "Mitigation of Noise from Uninterruptable Power Supplies (UPS)," presented at the Workshop on Factors Affecting the Performance of Naval Receiving Sites, Naval Postgraduate School, February 1994.

Adler, R.W., "Mitigation of Noise from a Small Telephone Switching System," presented at the Workshop on Factors Affecting the Performance of Naval Receiving Sites, Naval Postgraduate School, February 1994.

Adler, R.W., "EMI Software Recommendation for Use in SIGINT Receiving Site Encroachment Studies," presented at the Workshop on Factors Affecting the Performance of Naval Receiving Sites, Naval Postgraduate School, February 1994.

Adler, R.W., "Proposed Noise Current Injection Tests," presented at the Workshop on Factors Affecting the Performance of Naval Receiving Sites, Naval Postgraduate School, February 1994.

Vincent, W.R., "Power Line Noise Mitigation -- Test Plan Production," presented at the Workshop on Factors Affecting the Performance of Naval Receiving Sites, Naval Postgraduate School, February 1994.

Vincent, W.R., "Performance Evaluation Technique (PET) Improvements," presented at the Workshop on Factors Affecting the Performance of Naval Receiving Sites, Naval Postgraduate School, February 1994.

Vincent, W.R., "EMI from Grounds and Other Conductors," presented at the Workshop on Factors Affecting the Performance of Naval Receiving Sites, Naval Postgraduate School, February 1994.

Vincent, W.R., "Ground Problems: Myths and Solutions," presented at the Workshop on Factors Affecting the Performance of Naval Receiving Sites, Naval Postgraduate School, February 1994.

THESES DIRECTED:

Stelioudakis, E., LTJG, Hellenic Navy, "Elimination of Electromagnetic Interference to Receivers and Sensitive Equipment Generated by Switching Systems," Master's Thesis, March 1994.

Gehrki, T.D., MAJ, USMC, "An Analysis of the Effects of Feedline and Ground Screen Noise Currents on a Conical Monopole Receiving Antenna," Master's Thesis, June 1994.

DOD KEY TECHNOLOGY AREA: Sensors, Environmental Effects

KEYWORDS: Electromagnetic environmental effects, communication systems, man-made noise, antennas

COMMUNICATION SYSTEM PERFORMANCE EVALUATION AND HIGH LATITUDE PROPAGATION RESEARCH

R.W. Adler, Senior Lecturer
W.R. Vincent, Senior Researcher
Department of Electrical and Computer Engineering
Sponsor: COMMNAVSECGRU

OBJECTIVE: The goal of this seventh year of a continuing project was to conduct numerical analysis and experimental research in support of the Navy's requirement to site VLF through UHF communication antenna systems and support equipment in non-ideal locations such as polar and equatorial regions containing rugged terrain. A program of support for investigating the radiowave propagation characteristics of the polar (high-latitude) and the equatorial ionosphere was initiated in 1990 and continued in 1994.

SUMMARY: Numerical models of commercial and NPS-built HF receiving antennas were developed and used to provide gain values for ionospheric field strength models. Selected HF ionospheric propagation prediction codes were evaluated and compared to measured data for polar regions. A Doppler shift and spread study was initiated to establish parameters needed to characterize the Polar ionospheric regions.

PUBLICATIONS:

Vincent, W.R., "Field Testing of Engineering Models of High-Dynamic Range Amplifiers," NSG Technical Report, January 1994.

Vincent, W.R., "Preliminary Investigation into the Impact of Atmospheric Noise on the Reception of PENEX Signals," NSG Technical Report, May 1994.

Vincent, W.R., "Reception of PENEX CW & TTY Signals at PSU," NSG Technical Report, October 1994.

CONFERENCE PRESENTATIONS:

Vincent, W.R., Lott, G.K., and Jauregui, S., "HF Signal Amplitude Distributions and Total Power Spectrum Measurements," presented at the IEE HF Conference, York University, York, U.K., July 1994.

Lorrie, J.H., Colburn, D.C., Lott, G.K., and Vincent, W.R., "HF Pre-amplifier with a Third Order Intercept Point Greater than +75 dBm for Use with High Dynamic Range HF Digital Receivers," presented at the IEE HF Conference, York University, York, U.K., July 1994.

Vincent, W.R. and Lott, G.K., "Measurements of Extensive HF Industrial, Scientific and Medical (ISM) Interference Far Removed from the ITU Allocated Bands," presented at the IEE HF Conference, York University, York, U.K., July 1994.

THESIS DIRECTED:

Malachias, N., LTJG, Hellenic Navy, "Doppler Shift and Spread Study for Ionospherically Propagated Signals," Master's Thesis, June 1994.

DOD KEY TECHNOLOGY AREA: Sensors, Environmental Effects

KEYWORDS: Electromagnetic Environmental Effects, Communication Systems, Man-made Noise, Antennas, Radiowave Propagation

FIELD STATION RESEARCH AND SUPPORT

R.W. Adler, Senior Lecturer
W.R. Vincent, Senior Researcher
Department of Electrical and Computer Engineering
Sponsor: US ARMY INSCOM

OBJECTIVE: The Army's SIGINT Sites in Korea and Ft Gordon, GA were subjected to excessive amounts of interference from internal and external noise sources. The NPS Signal Enhancement Lab staff and students were tasked to identify and begin mitigation of the sources.

SUMMARY: The Army's Field Station KOREA Tactical SIGINT sites at the three DMZ detachments required a thorough site performance investigation. A new site being developed at Fort Gordon was suspect in terms of its suitability as a SIGINT operation center. NPS used techniques developed for the Naval Security Group HFDF sites to assess the state of performance and identify factors that degraded performance. Recommendations for mitigation of noise sources which were located was made.

PUBLICATIONS:

Vincent, W.R., "EMI Investigation at Luketina Hall," Fort Gordon, GA, INSCOM Technical Report, January 1994.

Vincent, W.R. and Adler, R.W., "RFI/EMI Survey, Detachment L," Quick-Look Report, INSCOM Technical Report, September 1994.

Vincent, W.R. and Adler, R.W., "RFI/EMI Survey, Detachment K," Quick-Look Report, INSCOM Technical Report, September 1994.

Vincent, W.R. and Adler, R.W., "EMI Survey, Detachments J,K and L," Technical Report MSA9409 (SECRET), USA INSCOM MSAV, December 1994.

THESIS DIRECTED:

Van Wiltenburg, P.E., CAPT, USA, "Mitigation of EMI Generated by a Variable-Frequency-Drive Controller for an AC Induction Motor," Master's Thesis, September 1994.

DOD KEY TECHNOLOGY AREA: Sensors, Environmental Effects

KEYWORDS: Electromagnetic Environmental Effects, Communication Systems, Man-made Noise

CONVERTER DESIGN, ANALYSIS, AND PROTOTYPE FOR FUTURE NAVY SURFACE SHIPS

R.W. Ashton, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Surface Warfare Center

OBJECTIVE: Due to the advancements in power electronics which includes greater device current densities and reliability, increased efficiency, and reduction in cost per watt, DC distribution is now a viable alternative to conventional AC systems. Evaluation of such a system by the Navy has shown that fight through capability is increased while real part count and cost are both decreased. An integral part of the Navy's proposed DC distribution system is the Ship Service Converter Module (SSCM) which acts as a buffer between the main DC bus and a specific zone in the ship. (The main bus is powered from a rectified multiphase alternator which provides the benefit of decoupling source and load frequency requirements.) The object of this research is to make available six 50 kW SSCMs for use at NSWC, Annapolis. This will be done as a cooperative effort with PPI of Anaheim, CA. A concurrent goal is to build an in house 50 kW SSCM prototype for testing and analysis purposes in order that PPI's engineering effort is minimized. Different closed-loop control strategies will be analyzed by utilizing a computer controller which mainly consists of a DAC card and software. Other issues to be considered while prototyping are stability and fault analysis.

SUMMARY: Up to this point, several important steps have been taken to assure successful design of an optimum performing SSCM. The first was a four week venture at NSWC, Annapolis which produced an updated 10 kW buck chopper using a multiloop control scheme. Being unsatisfied with the time necessary to hand build individual controllers for testing the same buck chopper, the second step was taken. Namely, a total digital controller was assembled at NPS which allows the user in software to develop a controller using Simulink and down load a compiled C code version to a dSpace DAC card which acts as a controller for the SSCM. This method has improved efforts to obtain good results rapidly without damaging equipment. The software controller can first be tested using a simulated SSCM and then implemented with existing hardware. At present only a 10 kW system has been implemented using the available materials in the Power Systems Lab located at NPS. Although this setup was adequate for testing the software implemented controller, it is insufficient for real use. The 10 kW buck chopper in the Power Lab is much smaller than the 50 kW requirement for the prototype and due to mechanical limitations stray inductance exists requiring the use of very large and inefficient snubbers.

OTHER: The investigator is working on two papers concerning the full development system using the Space DAC card and Simulink. A paper which incorporates the flexibility of a software controller implemented in a commonly used graphical language, and another on the system simulation and hardware.

Williams, S.M., Kline, D.B., and Ashton, R.W., "A New Approach for Teaching Electric Machinery: Object-Oriented Electric Machinery Simulation," to appear in Computers in Education Journal.

Blalock, H.G., LCDR, USN, "Comparative Assessment of a Competitive Design Pulse Width Modulated Three Phase Inverter Module in a Static Electronic Reversible Power Supply for Shipboard Power Distribution Systems," Master's Thesis, due in March 1995.

DOD KEY TECHNOLOGY AREA: Other (Power System Enhancement), Software

KEYWORDS: Power System, DC Distribution, Zonal Architecture, Stability

APPLICATION OF MULTIPLE-VALUES TO LOGIC DESIGN

J.T. Butler, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: The goal of this project is to develop improved circuits and improved circuit design techniques for use in advanced computer systems.

SUMMARY: Because it results in compact circuits, multiple-values has significant promise for high-speed, high-density logic. Under this project, we continued our work in this important area. During this reporting period, we devoted significant energy to the multiple-decision diagram, a compact means of representing combinational circuits. In a collaborative effort with Professor David S. Herscovici, Department of Mathematics, NPS and Professor Tsutomu Sasao, Department of Computer Science and Electronics of Kyushu Institute of Technology, Iizuka, Japan, we characterized the decision diagrams of certain well-known classes of functions, threshold functions and symmetric functions. We also made progress in the area of reduced representations for decision diagrams. This work continues.

PUBLICATIONS:

Butler, J.T. and Sasao, T., "Multiple-Valued Combinational Circuits with Feedback," Proceedings of the 24th International Symposium on Multiple-Valued Logic, pp. 342-347, May 1994.

Sasao, T. and Butler, J.T., "A Decision Method for Look-Up Table Type FPGA by Pseudo-Kronecker Expansion," Proceedings of the 24th International Symposium on Multiple-Valued Logic, pp. 97-106, May 1994.

Dueck, G. and Butler, J.T., "Multiple-Valued Operations with Universal Literals," Proceedings of the 24th International Symposium on Multiple-Valued Logic, pp. 73-79, May 1994.

CONFERENCE PRESENTATIONS:

Butler, J.T., "Multiple-Valued Combinational Circuits with Feedback," presented at the 24th International Symposium on Multiple-Valued Logic, Boston, MA, May 1994.

Butler, J.T., "Multiple-Valued Logic in VLSI," presented at Analog Devices, Inc., Wilmington, MA, May 1994.

OTHER:

During this time period, research was conducted under a Tateishi Science and Engineering Foundation Grant at the Kyushu Institute of Technology, Iizuka, Japan (July 1994 -- September 1994).

Two papers were written and submitted during this reporting period:

Sasao, T. and Butler, J.T., "Planar Multiple-Valued Decision Diagrams," Proceedings of the 25th International Symposium on Multiple-Valued Logic, May 1995, (accepted).

Butler, J.T., "Multiple-Valued Logic in Ultra-High Speed Computation," IEEE Potentials (invited paper - accepted).

DOD KEY TECHNOLOGY AREA: Computers, Electronic Devices, Design Automation

KEYWORDS: Ultra-compact Logic Circuits, Computer-aided Design, Multiple-valued Logic

A LIBRARY OF DETAILED AND REDUCED-ORDER POWER SYSTEM COMPUTER-BASED COMPONENT MODELS

J.G. Ciezki, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: The goal of this research is to implement a comprehensive library of digital computer models of the components and topologies common to electromechanical drives, power electronic converters, and power distribution networks. The detailed and reduced-order modeling and simulation of these systems is an important and developing area of research utilized in both defense and civilian endeavors. In particular, the Naval Surface Warfare Center is presently developing an Integrated Power System based on DC Zonal Electric Distribution for the surface ship of the next century. In this effort, it is vital to have design issues thoroughly investigated with accurate digital models prior to intensive hardware investment. With this requirement considered, research efforts at NPS have concentrated on establishing a set of analysis tools which may be readily applied to studies such as fault analysis, system stability, power quality, control integrity, system reconfiguration, and control synthesis. Implicit to this effort is the development and validation of a set of reduced-order models which may be conveniently used in-house by interested customers who are seeking alternatives to time-intensive detailed simulations.

SUMMARY: As originally intended, the simulation library (a collection of model definitions written in the Advanced Continuous Simulation Language) contains a range of standard and non-standard component representations which are commonly used in power system configurations. The library has been organized into thirteen principle categories to date including AC to DC conversion devices, DC to AC conversion devices, Current Source Inverters, Induction Machines, Synchronous Machines, DC Machines, Brushless DC Machines, Stepper Motors, Transformers, Electric Loads, Electric Sources, Mechanical Loads, and Magnetic Relays. Within each category are detailed, reduced-order, and specialty models. For instance, in the simulation of stiffly-connected power systems where tie-lines are largely inductive, component interconnection results in an algebraic loop which must be resolved by the programmer. The library contains several alternative component models to facilitate the solution of this problem. The next phase of development in the library is to include inverter controllers and DC-DC converters which are of particular interest to potential sponsors at NSWC.

OTHER: The investigator is actively preparing three journal papers. The first paper entails the reduced-order modeling of a parallel-output resonant converter. The second paper focuses on the comparison of three methods of simulating stiffly-connected power systems. The third paper details the integration of system simulation into the power system program at NPS.

DOD KEY TECHNOLOGY AREA: Electronic Devices, Propulsion and Energy Conversion

KEYWORDS: Electromechanical Drives, Electronic Converters, Simulation, Reduced Modeling

SENSOR BASED NAVIGATION FOR THE AUTONOMOUS UNDERWATER VEHICLE

R. Cristi, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Office of Naval Research (ONR)

OBJECTIVE: The aim of this research is to develop a low cost, sonar based navigation system for the Autonomous Underwater Vehicle (AUV), capable of localizing and guiding the vehicle within a partially known environment.

SUMMARY: A typical AUV mission is to navigate within an area where it has to perform a given task. A very important aspect is the determination of the location of the vehicle itself within the working environment and the identification of objects which are not present in its own memory. Typical example is the vehicle moving in a harbor which has known landmarks (walls, buoys, batts, moored, etc.) and uncharted objects (such as mines).

In this research we are currently developing an idea of navigation and localization based on *potential functions* which enables a) to describe the known topology of the environment and b) to identify objects which have not previously charted.

By this approach the vehicle can identify its own position and velocity relative to the environment using range and bearing of a pencil beam sonar operating at high frequency (around 1 MHz). The algorithm is currently being implemented in the vehicle NPS PHOENIX, operating in the NPS test tank.

PUBLICATION:

Cristi, R., "Navigation and Localization in a Partially Known Environment," Proceedings of AUV 94, Cambridge, MA, 19-20 July 1994.

THESIS DIRECTED:

Kayiirhan, A., LTJG, Turkish Navy, "Sonar Based Navigation of an Autonomous Underwater Vehicle," Master's Thesis, June 1994.

DOD KEY TECHNOLOGY AREA: Other (Robotics)

KEYWORDS: Autonomous Underwater Vehicle, Robotics

OFFSET ERRORS ESTIMATION FOR THE EXTREMELY HIGH FREQUENCY ANTENNA

R. Cristi, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: NISE West, Vallejo, California

OBJECTIVE: This research aims at designing an on line estimator to compensate for offset errors in the pointing system of the Extremely High Frequency (EHF) antenna. The offsets are due to tolerances on the mountings of the pedestal and biases in the synchros, and they can contribute to a total pointing error which exceeds the maximum tolerance.

SUMMARY: The mechanical pointing pedestal of the ship mounted EHF antenna has been modeled as a

sequence of successive rotations, each one affected by an error. The use of *quaternions* allows the model to be implemented as product of matrices, each associated to elements of the mechanical system. Also, this technique has the advantage that no singularity points exist, and it works for any possible configuration of the angles of rotation.

Since the individual errors are small, their effects on the rotations can be easily linearized and estimated using standard linear estimation techniques with rapid convergence such as recursive least squares. Also, any *a priori* information on some of the errors can be included in the algorithm.

This research identifies a class of maneuvers the ship has to perform in order to avoid ill conditioning of the data and thus obtain the most reliable estimation. Data collected from tests at sea on the USS Coronado and pierside calibration data on the USS T. Roosevelt show the effectiveness of the technique.

PUBLICATION:

Cristi, R. and Riling, W.D., "Offsets Errors Estimation for the EHF Antenna," in preparation, to be submitted to the American Society of Naval Engineers.

DOD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: EHF Antenna

MODELING AND CLASSIFICATION OF UNDERWATER BIOLOGICAL TRANSIENT SIGNALS

M.P. Fargues, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Office of Naval Research, Arlington, VA, Code 1114
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project was to investigate various classification schemes applied to underwater biological and seismic data.

SUMMARY: This research is part of an-going project studying various classification schemes. The project is divided into two main phases; the first phase was conducted during FY94 and investigated the application of the Principal Component method to model different types of underwater signals using parametric modeling techniques. In the second phase of the project, initiated during FY94 and still under investigation in FY95, we investigate the application of wavelet-based schemes to the classification problem.

The first phase investigated the application of the ARMA Iterative Prefiltering (IP) method to compute a non-minimum phase representations of the underwater data. The original IP minimization procedure is an ill-conditioned problem which has classically been solved using a least-squares approach. This work presents a modification of the classical IP technique in which the least-squares iteration step is replaced by a Total Least Squares (TLS) step to take advantage of the statistical properties of the TLS method. Results show that improvements in the modeling performances may be obtained by using the TLS-based IP method when modeling signals distorted by white Gaussian noise. The resulting model parameters can then be used as inputs to a neural network classifier to classify the various signals under study.

The second phase of the project considers the application of orthogonal and non-orthogonal wavelet-based schemes to the classification procedure. Results show that better performance may be obtained using a non

orthogonal decomposition.

PUBLICATION:

Fargues, M.P., "TLS-Based Prefiltering Technique for Time-Domain ARMA Modeling," NPS Technical Report, NPS-EC-94-009, November 1994.

OTHER:

Bennett, R.C., LT, USN, "Classification of Underwater Signals Using a Backpropagation Neural Network," Master's Thesis in progress.

DOD KEY TECHNOLOGY AREA: Electronic Devices, Other (Signal Processing, Classification)

KEYWORDS: Biological Signals Analysis, Neural Networks

RADIATION TOLERANT, HIGH-SPEED, LOW-POWER, GALLIUM ARSENIDE DYNAMIC LOGIC

D.J. Fouts, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: SPAWAR

OBJECTIVE: Gallium Arsenide (GaAs) digital logic is now the technology of choice for high-performance, terrestrial-based computers and digital systems. Furthermore, research has shown that GaAs ICs are inherently hard against long-term exposure to high levels of ionizing radiation. This tends to make GaAs logic ideal for use in high-performance, space-based computers and digital systems. However, GaAs logic suffers from single event upset (SEU) problems in high radiation environments. The purpose of this three-year project is to study and quantify the SEU problem in GaAs logic, and to develop SEU-tolerant logic circuits. The effort is concentrating on dynamic logic, because of its lower power consumption compared to static logic.

SUMMARY: New types of gallium arsenide, high-speed, low-power, logic circuits have been designed, fabricated, and tested. These new logic circuits have been shown to have approximately a one order of magnitude greater tolerance to ionizing radiation than other forms of high-speed logic. Furthermore, the new logic circuits do not require any changes to the fabrication process, which are usually very expensive to implement. The results of this research will allow high-speed, low-power logic circuits to be used on a spacecraft with significantly less shielding than previously required. Using less shielding is desirable because it saves weight and space inside the spacecraft. This research is continuing with the further development and characterization of the new logic circuits.

PUBLICATIONS:

Fouts, D.J., Weatherford, T., McMorrow, D., Melinger, J.S., and Campbell, A.B., "Single Event Upsets in Gallium Arsenide Dynamic Logic," IEEE Transactions on Nuclear Science, Vol. 41, No. 6, pp. 2244-2251, December 1994.

Fouts, D.J., Weatherford, T.R., McMorrow, D., Wolfe, K., VanDyk, S., and Campbell, A.B., "Single Event Upsets in Gallium Arsenide Pseudo-Complementary MESFET Logic," IEEE Transactions on Nuclear Science, Vol. 42, No. 6, December 1994, (submitted).

THESIS DIRECTED:

Wolf, K.A., LT, USN, "Single Event Upsets in Gallium Arsenide Two-Phase Dynamic FET Logic," Master's Thesis, December 1993.

OTHER: The primary research output from this project has been custom hardware for conducting radiation-induced single event upset testing of GaAs dynamic logic. Also, in addition to the journal publication and the related thesis, bimonthly progress reports have been written and forwarded to the contract monitor.

DOD KEY TECHNOLOGY AREA: Computers

KEYWORDS: Radiation Hard Electronics, Space Electronics, High-speed Computing

CACHE MEMORY MISS LATENCY REDUCTION

D.J. Fouts, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: Modern, high-performance microprocessors, of the type used in new designs of military embedded microprocessor systems, have extremely high memory bandwidths and very short memory latency requirements. Therefore, most new designs for military embedded microprocessor systems utilize DRAM implemented main memories together with a processor chip that contains an on-board cache memory. The use of a high-performance processor chip with an on-board cache memory leads to the problem of cache-miss latency. Second-level, off-chip, cache memories are the usual technique for reducing the cache-memory latency of high-performance workstations, servers, and main frames. However, second-level cache memories require an array of power consuming, heat generating, space and weight wasting, and expensive static RAMs. This research is developing a single IC that can predict in advance what the next miss will be in the on-board cache and prefetch the required data from the main memory so that the data is ready to load into the cache as soon as the miss occurs.

SUMMARY: Research is concentrating on data cache read misses. Predicting instruction reads in advance do not provide any significant performance improvement because most modern high-performance microprocessors prefetch instructions before they are needed. Predicting data write addresses in advance would also not provide any significant performance improvement because the write would not be able to complete until the write data is made available. A simulation study of the effectiveness of several different data cache read miss prediction algorithms was conducted. Based on these results, an algorithm was selected and the first version of a read prediction buffer chip was designed. The chip has now been fabricated and tested. The chip is 100% functional and proves the feasibility of the basic idea. A more comprehensive simulation study is currently being performed to improve the prediction algorithm and the performance of the chip. The design of a new version of the chip is in progress.

PUBLICATIONS:

Fouts, D.J. and Billingsley, A.B., "Predictive Read Caches: An Alternative to On-Chip Second-Level Cache Memories," Journal of Microelectronic Systems Integration, Vol. 2, No. 2, pp. 109-121, June 1994.

Fouts, D.J., Nowicki, G.J., and Aguilar, M., "A CMOS Read Prediction Buffer IC for Embedded Microprocessor Systems," IEEE Journal of Solid State Circuits, (in preparation).

THESIS DIRECTED:

Smith, W.G., "SACS: A Cache Simulator Incorporating Timing Analysis with Buffer and Memory Management," Master's Thesis, March 1994.

OTHER: The microprocessor division of Advanced Micro Devices in Dallas, Texas has expressed a keen interest in this research. Copies of theses and papers have been supplied to AMD, and a regular correspondence has developed. AMD may wish to pursue a Cooperative Research and Development Agreement in the near future.

Four quarterly research progress reports were submitted to the research sponsor.

DOD KEY TECHNOLOGY AREA: Computers

KEYWORDS: High-performance Computing, Computer architecture, Embedded Computing, Military Computing

WIDEBAND RADAR SIGNAL PROCESSING

G.S. Gill, Visiting Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Office of Naval Research

OBJECTIVE: Step frequency radars have been used for detailed RCS measurements either in anechoic chambers or in open ranges which involved two-dimensional imaging of rotating targets. The application of step frequency has been mainly for diagnostic RCS measurements and not for operational use. As a result there is little theory and design information available for detection of moving targets for operational use with the step frequency radar. The objective of this research is to rectify this situation in general and to develop necessary mathematics for system and waveform design including signal processing concepts for detection of low flying, low RCS, high speed anti-ship missile threat in lattoral environment.

SUMMARY: Step frequency offers special advantage for detection of moving targets embedded in clutter as it can achieve a large effective bandwidth (to reduce clutter) without increasing the sampling rate. The bandwidth is achieved sequentially instead of instantaneously and thus easing the requirements on radar hardware including analog to digital converter. Target return from a moving target due to step frequency transmission was accurately modeled. The resulting equation brought out the special properties and the problems associated with the step frequency waveform. When a return from moving target is processed in a conventional manner, target spreads and shifts in range. As a result there is loss of target magnitude, range accuracy and range resolution. To solve this problem exact compensation terms are calculated and signal processing technique to counteract the spreading of target return and cancellation of clutter was devised. Also the equations which are special to the waveform design of step frequency were developed. Although this work is oriented to the Navy's problem of timely detection of low flying, low RCS, high speed anti-ship missile but equations and techniques developed are applicable to moving target detection in any situation.

PUBLICATIONS:

Gill, G.W., "Waveform Generation and Signal Processing in Ultra Wideband Radar, Proceedings of Signal and Data Processing of Small Targets," SPIE's International Symposium on Optical Engineering and Photonics, Orlando, FL, April 1994.

Gill, G.S., Chang, H.F., and Hall, J., "Waveform Synthesis for Ultra Wideband Radar," Proceedings of the 1994 IEEE National Radar Conference, Atlanta, GA, March 1994.

Gill, G.S., "Detection of Targets Embedded in Clutter Using Frequency Step Waveform," Proceedings of the 1994 International Symposium on Noise and Clutter Rejection in Radar and Imaging Sensors, Kawasaki, Japan, November 1994.

THESES DIRECTED:

Paulose, A.T., LT, USN, "High Radar Range Resolution With the Step Frequency Waveform," Master's Thesis, June 1994.

Huang, J.-C., Major, Taiwan Army, "The Ambiguity Function of the Stepped Frequency Radar," Master's Thesis, September 1994.

OTHER:

Gill, G.S., "Step Frequency Waveform Design and Processing for Detection of Moving Targets in Clutter," accepted for IEEE International Radar Conference, Washington D.C., to be held in May 1995.

Gill, G.S. and Huang, J.-C., "The Ambiguity Function of the Step Frequency Radar Signal Processor," submitted to IEEE Transactions on Aerospace and Electronic Systems.

Gill, G.S., "Moving Target Indication (MTI) with Step Frequency," (in preparation).

DOD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Wideband Radar, Radar Signal Processing

ANALYSIS OF DENSE WDM OPTICAL FIBER NETWORKS

T.T. Ha, Professor
J.P. Powers, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: The goal of this project was to investigate efficient techniques to analyze dense wavelength division multiplexing optical fiber networks.

SUMMARY: Two techniques were employed to analyze WDM optical fiber networks. The first technique used a continuous time approach. The second technique employed a discrete time approach. Identical results were obtained by both techniques. The WDM networks employed OOK modulation with direct detection. The Fabry-Perot filter was used at the receiver. Bit error probability and power penalty were obtained.

THESES DIRECTED:

Chou, T.C., LCDR, Taiwan Navy, "A Simple Analytical Model for Dense WDM/OOK Systems," Master's Thesis, June 1994.

Huang, Y.Y., LTCOL, Taiwan Air Force, "A Simple Analytical Model for Asynchronous Dense WDM/OOK Systems," Master's Thesis, June 1994.

DOD KEY TECHNOLOGY AREA: Communications Networking

KEYWORDS: Optical Fiber Systems, WDM, Direct Detection

FEATURE EXTRACTION FROM DIGITAL COMMUNICATION SIGNALS USING WAVELET TRANSFORMS

R. Hippenstiel, Associate Professor
M. Fargues, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: SPAWAR

OBJECTIVE: The goal of this project was to investigate Wavelet based processing techniques as applied to digital Communication signal detection and classification and to recommend potentially useful basis functions.

SUMMARY: Research was conducted to evaluate the feasibility of applying wavelet transforms and methods based on proportional bandwidth processing to transient feature extraction. Classical wavelets and signal related basis functions were used to extract the switching instants from BPSK, QPSK, FSK, ASK and AMQPSK signals in the presence of additive Gaussian white noise. Results show that using the magnitude of one output scale, the transient times can be detected above a certain signal to noise ratio level. This level depends on the type of signal and wavelet, as well as on the acceptable number of mistakes. Additional work, using several scales and a properly trained neural network, should demonstrate automated selection of the modulation type.

PUBLICATION:

Hippenstiel, R. and Fargues, M., "Feature Extraction from Digital Communication Signals using Wavelet Transforms," Naval Postgraduate School Technical Report, in progress.

DOD KEY TECHNOLOGY AREA: Electronic Devices

KEYWORDS: Communication Intercept, Wavelets, Detection, Demodulation, Parameter Identification

FEATURE EXTRACTION FROM DIGITAL COMMUNICATION SIGNALS

R. Hippenstiel, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: The goal of this project was to investigate time-frequency representation based processing techniques as they pertain to digital Communication signal detection and classification.

SUMMARY: Research was conducted to evaluate the feasibility of using a variation of the spectrogram, bi-spectrum, 1.5-D spectrum, and dyadic spectrum to obtain transient feature extraction. These techniques were used to extract the switching instants from BPSK, QPSK, FSK, ASK and AMQPSK signals in the presence of additive Gaussian white noise or to obtain information regarding the modulation type. Results show that the spectrogram and the 1.5-D spectrum can be used to obtain the transition or switching times of the modulated carrier. The bispectrum and the dyadic spectrum provide no time information but allow the observation of some of the characteristics of the modulation type. Future work should be focused on the dyadic spectrum to demonstrate automated determination of the modulation type.

THESIS DIRECTED:

Yayci, C., LTJG, Turkish Navy, Master's Thesis, December 1994.

DOD KEY TECHNOLOGY AREA: Electronic Devices

KEYWORDS: Communication Intercept, Spectrogram, Instantaneous Spectrum, Bi-spectrum, Dyadic Spectrum, Detection, Demodulation, Parameter Identification

SENSOR FUSION, ESTIMATION, AND CONTROL OF NONLINEAR SYSTEMS THAT EXHIBIT ABRUPT DISCONTINUITIES IN THEIR BEHAVIOR

R.G. Hutchins, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: The purpose of this research is to examine data fusion, estimation and control algorithms in the contest of military systems. Specifically, algorithms capable of combining both parametric and attribute data from a suite of dissimilar sensors for tracking and control in military discontinuities, such as abrupt maneuvers by hostile targets, on these tracking and control algorithms. The methodology is built upon the previous research of the principal investigator in the area of sensor fusion for maneuvering target tracking by investigating both analytic and heuristic solutions to the tracking and control problem. The heuristic approach will be an augmented neural net, and various net architectures, as well as training algorithms, are being examined. Computer simulations to demonstrate the feasibility of alternative algorithms is ongoing.

SUMMARY: Several simulation models and algorithms are being investigated. With student assistance, I have completed a three dimensional model of an automated ship self-defense system that permits the test and evaluation of a variety of filtering algorithms in the target tracking module, as well as different control algorithms for target engagement. Nonlinear and adaptive filtering algorithms have been examined for the tracking module, and various control algorithms have been tested in the control module. Results in this area have been submitted for presentation at the 4th IEEE Conference on Control Applications to held in Albany, NY on 28-29 September 1995. Neural net research on filtering and system identification with respect to this research has resulted in a presentation at the Asilomar Conference last November and a submission for presentation at the IEEE International Conference on Systems, Man and Cybernetics to be held in Vancouver, BC, Canada, on 22-25 October 1995.

In addition to this ship self-defense model, I am collaborating with a student on a simulation project involving autonomous underwater vehicles. We are exploring two problems here: the anti-torpedo intercept problem and the autonomous docking problem. The torpedo intercept problem is examining different sensors, filters, and control algorithms to intercept a maneuvering underwater target. The docking problem examines more elaborate vehicle dynamics and focuses on control algorithms. Current results from this research have also been submitted for presentation at the 4th IEEE Conference on Control Applications to be held in Albany, NY on 28-29 September 1995.

OTHER: I am also supervising research being funded in part by the Air Force Information Warfare Center (AFIWC), San Antonio for classified EW research. This research constitutes Ms. Pam Sexton's thesis entitled "Operational Vulnerabilities in the Tracking Algorithms of an Exploited Integrated Air Defense System."

DOD KEY TECHNOLOGY AREA: Sensors, Software, Other (autonomous vehicles)

KEYWORDS: Sensor Fusion, Data Association, Target Tracking, Adapt Control

COMPUTER MODEL FOR PROPAGATION OVER IRREGULAR TERRAIN

R. Janaswamy, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Security Group Support Activity

OBJECTIVE: To develop a computer model for predicting HF wave propagation over two and three dimensional terrain for citing antenna systems under varying terrain situations.

SUMMARY: In the second year of this two-year project, we have developed a computer model of electromagnetic wave propagation over lousy, irregular terrain. Finite differences together with near-field radiation conditions were used to result in a rapid model whose execution time is of order 0(N) and whose storage requirement is of order 0(N^2). Half-space Green's function is used to further reduce the computational domain. The code computes the ground wave attenuation as well as sky wave patterns for an arbitrarily polarized, two-dimensional current element in the presence of irregular and inhomogeneous terrain. The code is capable of handling huge terrain irregularities extending a few hundred wavelengths where other methods tend to be inefficient.

PUBLICATION:

Janaswamy, R., "A Fast Finite Difference Method for Propagation Predictions Over Irregular, Inhomogeneous Terrain," IEEE Transactions on Antennas and Propagation, Vol. 42, No. 9, pp. 1257-1267, September 1994.

CONFERENCE PRESENTATION:

Janaswamy, R., "Application of the MEI Method to Wave Propagation Over Irregular Terrain," presented at 1994 Joint IEEE AP-S International Symposium and URSI Meeting, Seattle, WA.

DOD KEY TECHNOLOGY AREA: Design Automation, Environmental Effects

KEYWORDS: Radiowave Propagation, Finite Differences, Irregular Terrain

COMPUTATIONAL ELECTROMAGNETIC METHODS FOR LARGE BODIES

R. Janaswamy, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: To explore novel computational methods for handling large electromagnetic problems.

SUMMARY: It is well known that the computational requirements (CPU time and memory) for solving practical electromagnetic problems scale up in proportion to the size of the object. Generally, the number of unknowns required along any direction increases with the dimension of the object in that direction. For monochromatic waves, a typical choice is 10-15 unknowns per wavelength. For an object extending over 1 wavelength cube, one may then have at least 1,000 unknowns. The size of an object amenable to numerical study is necessarily limited because of the limitations of computer resources. There is an ever growing need to devise efficient numerical schemes for handling large objects. We are currently developing numerical schemes that would need only 4-5 points per wavelength. We plan to accomplish this by developing new finite difference schemes whose difference coefficients are determined by minimizing the numerical dispersion over all wavelengths and Courant numbers of interest. In the initial phase, we are focussing on the 2D problems.

OTHER:

Janaswamy, R. and Liu, Y., "An Unstaggered Colocated Scheme for Solving MAxwell's Equations in Curvilinear Coordinates," submitted for presentation at the 1995 Joint IEEE/URSI International Meeting, Newport Beach, CA.

Janaswamy, R. and Liu, Y., "An Optimized Finite Difference Scheme for Time Domain Maxwell's Equations," submitted for presentation at the 1995 Joint IEEE/URSI International Meeting, Newport Beach, CA.

DOD KEY TECHNOLOGY AREA: Design Automation

KEYWORDS: Computational Electromagnetics, Finite Differences, Curvilinaer Coordinates

EFFICIENT METHODS FOR PREDICTING RADIOWAVE PROPAGATION OVER IRREGULAR TERRAIN

R. Janaswamy, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Unfunded

OBJECTIVE: To develop an efficient algorithm for predicting propagation over irregular terrain.

SUMMARY: Radiowave propagation over irregular terrain is formulated and solved using the standard parabolic equation. The parabolic equation treats electromagnetic waves as propagating in the forward direction and enables the use of marching-in-range techniques for predicting field. The ground is characterized by means of an impedance boundary condition. A tropospheric boundary condition is derived to truncate the computational domain above the irregular terrain. The novelty of our approach is in the use of a curvilinear coordinate system. The curvilinear coordinate system is generated by the specification of the ground profile alone. The equations are solved by the Crank-Nicolson implicit scheme. Numerical results are presented to demonstrate the validity and limitations of our approach.

PUBLICATION:

Janaswamy, R., "Efficient Parabolic Equation Solution of Radiowave Propagation Over Irregular and Inhomogeneous Terrain: Formulation," Naval Postgraduate School Technical Report, NPS-EC-94-004, June 1994.

OTHER:

Lee, J.K., Major, Singapore Air Force, "Radiowave Propagation Over an Irregular Terrain Using Parabolic Equation in a Curvilinear Coordinate System," Master's Thesis, in progress.

DOD KEY TECHNOLOGY AREA: Environmental Effects, Design Automation

KEYWORDS: Radiowave Propagation, Finite Differences, Irregular Terrain

NEED TO CALIBRATE INDICATOR FOR SHIPBOARD HFDF SYSTEMS

D.C. Jenn, Associate Professor
Department of Electrical and Computer Engineering
Sponsor and Funding: SPAWAR

OBJECTIVE: The objective of this research is to investigate possible methods of calibrating shipboard high frequency direction finding (HFDF) systems, or at least developing a means of determining whether a need to calibrate exists. The present method involves circling the ship about an anchored buoy while monitoring signals from a shore site. A complete calibration requires days of at-sea time and, furthermore, there is currently no firm indicator of whether there is a need to calibrate after a topside configuration change.

SUMMARY: Several concepts have been examined in the first phase of this study. One was based on the standard antenna near-field measurement technique, and it was found to be of no use for the present purpose. The most promising approach is based on measuring the system response to multiple onboard near-field sources. The test is performed along with the usual system calibration, and the antenna responses to the near-field source are stored in a reference data base. When a modification is made to the topside, the test is repeated and the new results compared to the reference data base. A significant difference may indicate a need to perform a full calibration.

A first-cut simulation of the near-field test procedure was performed using a numerical electromagnetic model of a ship. Topside changes were simulated and the change in the HFDF system response computed. Preliminary results verify that the test procedure is capable of indicating whether there is a need to calibrate.

PUBLICATION:

Jenn, D., "Onboard Calibration," Proceedings of the Ship Calibration Workshop, NCCOSC RDT&E Division, San Diego, CA, March 1994.

THESIS DIRECTED:

Partsalidis, I., LTJG, Hellenic Navy, "A Need to Calibrate Indicator for High Frequency Direction Finding Systems," Master's Thesis, September 1994.

DOD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Shipboard HFDF, Test and Calibration

COMPUTER MODELLING OF AERODYNAMIC RADAR AND EW RADOMES

D.C. Jenn, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: NAWC
Funding: Naval Postgraduate School

OBJECTIVE: All airborne high-performance radar, EW and communication systems require a radome to protect the antenna from a severe operational environment. Predicting the effect of the radome on the antenna performance is crucial during the early stages of the design process. The objective of this research is to add further capability to a computer code developed on a previous direct funded program, and currently used by several Navy organizations. In addition, new models of antenna scattering are investigated.

SUMMARY: Several improvements to the radome code have been incorporated. They include multilayer

radome materials, allowing for arbitrary antenna excitation functions, and computing the ohmic loss and its effect on gain. HARM radome scattering was measured in the remodeled NPS anechoic chamber and the data compared to the code results. Two new antenna scattering models were developed for arrays: one for series feeds and the other for parallel feeds.

PRESENTATION:

Jenn, D. and Flokas, V., "Inband Scattering from Arrays with Parallel Feed Networks," 1994 AP-S/URSI Symposium, June 1994.

THESES DIRECTED:

Flokas, V., LTJG, Hellenic Navy, "Inband Radar Cross Section of Arrays with Parallel Feed Networks," Master's Thesis, June 1994.

Lee, S., Capt., Korean Army, "Inband Scattering from Arrays with Series Feed Networks," Master's Thesis, September 1994.

DOD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Radome Modeling, Antenna Scattering

ELECTRONIC SURVEILLANCE SYSTEM STUDIES

J.B. Knorr, Professor
Department of Electrical and Computer Engineering
Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: The objective of this project is to demonstrate the feasibility of predicting the performance of a shipboard HF direction finding system using computer simulation.

SUMMARY: A simulation is being created using computational electromagnetic software, signal processing software, and display software for visualization and interpretation of results. This project was initiated during the third quarter of FY 94 and there are no results to report at this time.

DOD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Shipboard HFDF

WAVELETS TIME-FREQUENCY ANALYSIS OF SIGNALS AND SYSTEMS

A.W. Lam, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Research Laboratory

OBJECTIVE: The goal of this project was to apply the theory of wavelets in time-frequency analysis of signals and systems.

SUMMARY: We investigated wavelet-based time-frequency analytical techniques for transient signals and digitally modulated signals. Problems of particular interests were the detection and classification of damped

sinusoidal signals and chirped waveforms in additive noise. The time-frequency decompositions of BPSK and QPSK signals, as well as spread-spectrum signals were obtained using a multiresolutional approach. Recursive generations of compactly supported wavelet time functions were synthesized to analyze phase shifts in signals with noise.

PUBLICATION:

Lam, A.W., "Wavelet Time-Frequency Analysis of Phase-Shift-Key Modulation Signals," Naval Postgraduate School Technical Report, NPS-EC-94-013, September 1994.

DOD KEY TECHNOLOGY AREA: Communications Networking

KEYWORDS: Wavelets, Time-frequency Analysis, Digital Modulations, Spread-spectrum

SEQUENTIAL ACQUISITION SCHEMES FOR SSMA SYSTEMS WITH GENERALIZED SIGNATURE SEQUENCES

A.W. Lam, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Army Research Office

OBJECTIVE: The goal of this project was to investigate fast sequential acquisition schemes and system performance of spreadspectrum systems with complex signature sequences.

SUMMARY: This research was to investigate sequential code sequence acquisition schemes for spread-spectrum multiple-access communication systems with generalized signature sequences. Fast, robust sequential code sequence acquisition schemes were developed and analyzed for systems with or without the presence of data modulation. Parametric and nonparametric schemes were proposed. Noncoherent and M-ary digital modulations were employed together with the generalized (nonbinary and polyphase) sequences. Product sequences that were efficient for rapid multiple-level sequential and/or parallel detections were proposed. The results were essential to the understanding of the system efficiency and reliability.

PUBLICATIONS:

Lam, A.W. and Tantaratana, S., "Theory and Applications of Spread Spectrum," IEEE Press, September 1994.

Tantaratana, S., Lam, A.W., and Vincent, P., "Noncoherent Sequential Acquisition of PN sequences for DS/SS Communications with/without Fading," to appear in IEEE Transactions on Communications, March 1995.

Ozluturk, F.M., Tantaratana, S., and Lam, A.W., "Probability of Bit Error for DS/SSMA Systems with MPSK Signaling and Complex Sequences," to appear in IEEE Transactions on Communications, April 1995.

THESIS DIRECTED:

Chang, E.K., Major, Singapore Air Force, "ECCM Networking Research," Master's Thesis, December 1994.

DOD KEY TECHNOLOGY AREA: Communications Networking

KEYWORDS: Spread Spectrum, Sequential, Sequence Acquisition, CDMA, Digital Communications

COMPUTER MODELING OF PROPAGATION OVER IRREGULAR TERRAIN

J.E. Lebaric, Visiting Associate Professor
Department of Electrical and Computer Engineering
Sponsor: COMMNAVSECGRU

OBJECTIVE: To model terrain irregularities in the vicinity of HF transmitting and receiving sites in order to assess the terrain influence on antenna radiation patterns.

SUMMARY: 1993-94 was the initial phase of the study of numerically exact solutions of Maxwell's equations in time domain for the HF frequency region. The particular problems addressed were the termination of the computational grid and the dispersion effects due to media conductivity and permitivity. The research continues in the 1994-95 fiscal year with one thesis student.

DOD KEY TECHNOLOGY AREA: Other (HF Communication Systems)

KEYWORDS: HF Communications, Electromagnetic Wave Propagation

PERSONAL COMMUNICATION SERVICES AND NETWORKS TECHNOLOGY FOR COMMAND, CONTROL, AND COMMUNICATION

C.-H. Lee, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: The objective of this research is to monitor PCS/PCN development and promote technology spin-on path to DoD applications. The goal is to promote and facilitate open architecture and standard development for low cost competition in PCS/PCN.

SUMMARY: There are many different views on exactly what is PCS. But, the majority agree that "integrated access," "personalized identification," and "mobile roaming" are the themes of PCS. Personalized services means that identification is not based on a terminal but instead on a person. PCS will use digital technology, standard procedures, and air interface for universal roaming. This means a tetherless connection through all the infrastructure for voice, data, image, and video services. The intensive development can be divided into the following four areas: Digital cellular or digital PCS, wireless data network services (WWAN, WLAN, WPBX), land mobile radio (LMR), and mobile satellite services (MSS). These areas characterize wireless technology in their own perspectives, possible DoD applications was investigated in this report. With some orientation of traditional DoD concept and doctrine benefits of using commercial technology (COTS) can be great.

PUBLICATIONS:

Lee, C.-H., "Capacity and Variable Data Rate for Wireless Communications," Proceedings of the 28th Asilomar Conference on Signals, Systems, and Computers, November 1994.

Lee, C.-H., "Wireless Technology for Command, Control, and Communication," Naval Postgraduate School Technical Report, NPS-EC-94-007, September 1994.

CONFERENCE PRESENTATIONS:

Lee, C.-H., "Capacity and Variable Data Rate for Wireless Communication," presented at the 28th Asilomar Conference on Signals, Systems, and Computers, November 1994.

Lee, C.-H., "Personal Communication Services (PCS) and Wireless Technology," presented as a tutorial at the 1994 International Computer Symposium, December 1994.

Lee, C.-H., "Introduction to VHDL," presented as a tutorial at the VHDL International User's Forum (VIUF), May 1994.

THESIS DIRECTED:

Schnelgrove, A.H., NAWC Civilian, "The Design of a Programmable Convolution Encoder Using VHDL and an FPGA," Master's Thesis, December 1994.

DOD KEY TECHNOLOGY AREA: Communications Networking

KEYWORDS: Wireless Technology, Personal Communication Services, Mobile Satellite Services

SOFTWARE ANALYSIS AND ELECTRICAL TESTING

C.-H. Lee, Professor
Department of Electrical and Computer Engineering
Sponsor: Office of Naval Intelligence

OBJECTIVE: This research will develop a design methodology for unknown device testing. Initial attention is concentrated on modification of the Genrad 125 software and use LEARN function.

SUMMARY: Continue writing/modification of GENRAD 125 VLSI tester software and document all procedures. Continue use of tester's LEARN function for device exploitation/program modification. Provide a complete report documenting all procedures and for device exploitation a complete technical report to be used as the basis of an ONI FMEMR.

PUBLICATIONS:

Choinsky, T.C. and Lee, C.-H., "Massively Parallel System Design for Real-Time Embedded Applications," Proceedings of the 4th Reengineering Technology Workshop, 8-10 February 1994.

Choinsky, T.C. and Lee, C.-H., "Massively Parallel System Design for Real-Time Embedded Applications," NUWC-NPT Reprint Report 10,591, Naval Underwater Weapons Center, February 1994.

DOD KEY TECHNOLOGY AREA: Sensors, Software

KEYWORDS: VLSI Testing, Automatic Testing, VHDL Language

MULTI-SENSOR INTEGRATION FOR LOW ALTITUDE DETECTION

H.-M. Lee, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Program Executive Office, Theater Air Defense

OBJECTIVE: Examine the short range, low altitude detection mechanism of each sensor integrated under the Ship Self Defense System. Determine the performance of the integrated system against low altitude targets in the littoral region.

SUMMARY: The first goal of this research project is to identify the specific information carried by the data from the sensors being integrated, merge them together for detection and tracking. Some sensors may provide doppler data, some may give an extremely accurate bearing of the target. Furthermore, there maybe data kept within an individual system which should and could easily be made available for the complete integrated system. This is the first topic to be investigated. At different ranges or under different operating environments, some data may not be available or reliable. To evaluate the probability of detection and the firm track time of the integrated system under such circumstances is the second task to be undertaken.

DOD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Ship Self Defense System, Multi-Sensor System

EM SCATTERING FROM A TUBULAR CYLINDER OF ANISOTROPIC SURFACE IMPEDANCES

H.-M. Lee, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Sandia National Laboratories

OBJECTIVE: To investigate the effects of impedance coating on the scattering of electromagnetic waves by a body in the resonant region. To develop accurate computer codes as a reference standard. This is a continuation of work initiated in FY93.

SUMMARY: The electromagnetic scattering from a zero-thickness, perfectly conducting, circular, tubular cylinder of finite length with different anisotropic coatings on its inside and outside surfaces is investigated. The induced electric and magnetic surface current densities and the far field are obtained. Analytical expressions of the double series expansion coefficients of the kernels of the integral-differential equations of this problem are found and utilized in the computation to assure that extremely accurate numerical results can be obtained. These results will be used as a standard for validating numerical electromagnetic computation codes.

PUBLICATIONS:

Lee, H.-M., "An Absolute Standard for Validating General Numerical Codes for Scattering from an Object Coated with Anisotropic Surface Impedance, Program and Abstracts," National Radio Science Meeting, Boulder, CO, pg. 277, January 1994.

Lee, H.-M., "Scattering of an Impedance Coated Tubular Cylinder of Finite Length," Proceedings of the Progress in Electromagnetics Research Symposium (in CD-ROM), Noordwijk, Netherlands, July 1994.

Lee, H.-M., "Scattering of an Anisotropic Tubular Cylinder: Axial Incidence," Proceedings of 1994 Asia-Pacific Microwave Conference, pp. 495-496, Tokyo, Japan, December 1994.

DOD KEY TECHNOLOGY AREA: Other (Electromagnetics)

KEYWORDS: EM Scattering

HARDKILL-SOFTKILL COMBINATIONS FOR OPTIMUM PROBABILITY OF KILL FOR SURFACE SHIPS

F. Levien, Senior Lecturer
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: To determine the optimum procedure for achieving the maximum probability of kill when using both hardkill and softkill weapons in defense of a typical Navy surface platform.

SUMMARY: Using the USS Arleigh Burke as a representative platform, the characteristics primarily of the SLQ-32 for softkill and the SM-2 medium range missile for hardkill are combined with other last ditch defense systems such as the 5"/54 MK 45 gun system and the CIWS as well as other techniques available on board, to determine which combinations of a coordinated ship's defense offer a Commanding Officer the optimal approach to defend his ship. A computer simulation algorithm is incorporated into the study which yields a final probability of kill for various combinations of defense.

THESIS DIRECTED:

Footman, D.A., LT, USN, "Hardkill-Softkill Combinations for Optimum Probability of Kill for Surface Ships (U)," Master's Thesis, (SECRET), September 1994.

DOD KEY TECHNOLOGY AREA: Computers, Sensors, Human Systems Interface

KEYWORDS: Ship Self-defense, Missiles, ESM, Softkill

VERIFICATION OF THE RADAR RANGE EQUATION IN THE AFIWC IMOM COMPUTER MODEL

F. Levien, Senior Lecturer
Department of Electrical and Computer Engineering
Sponsor and Funding: USAF Information Warfare Center

OBJECTIVE: The AFIWC IMOM (Improved Many [jammers] -On-Many [radars]) is presently in use by the U.S. Air Force to model the electronic EOB for pilots on operational missions. The thesis verified the IMOM results against the basic Radar Range Equation. Particular attention was paid to the method of modeling coherent pulse and CW radar.

SUMMARY: It was demonstrated that simulation results using the basic IMOM radar range equation adaptations agreed with radar theory. In addition, the manner in which the radar range equation was modified by IMOM to account for stand-off jamming effects was also reviewed. Typical operational values were substituted into these equations and results compared to those calculated by IMOM.

THESIS DIRECTED:

Morton, J.W., LT, USN, "Verification of the Radar Range Equation and its Variants in the AFIC IMOM Computer Model and Recommendations for Modeling CW and Coherent Pulse Radar in the Current AFIC IMOM Computer Model (U)," Master's Thesis, September 1994.

DOD KEY TECHNOLOGY AREA: Computers

KEYWORDS: Radar, Jamming, Electronic Warfare

OBSERVED EFFECTS OF AN ULTRA-WIDEBAND IMPULSE GENERATOR ON THE SLQ-32 AND OTHER MICROWAVE SYSTEMS

F. Levien, Senior Lecturer
Department of Electrical and Computer Engineering
Sponsor: Joint Chiefs, Washington D.C.

OBJECTIVE: To determine if UWB devices could disrupt the operation of the SLQ-32, and if so, whether the technique could be developed into a useful weapon system. A secondary goal was to assess the compatibility of UWBs and the SLQ-32 if both were operated simultaneously.

SUMMARY: Tests were performed using Gallium Arsenide bulk devices as impulse sources on an operating SLQ-32 and three operating radar systems: SPS-12, SPS-58A, and SPS-65. Additional exposure to three other EW systems was also conducted.

THESIS DIRECTED:

Elliot, R., LCDR, USN, "Observed Effects of an Ultra-Wideband Impulse Generator on the SLQ-32 (U)," Master's Thesis, (SECRET), September 1994.

DOD KEY TECHNOLOGY AREA: Computers, Sensors, Human Systems Interface

KEYWORDS: Ultra-wideband, Jamming, Electronic Warfare, Ships Self-defense, ESM

PERFORMANCE EVALUATION OF GROUND BASED RADAR SYSTEMS USING THE AN/UPS-1 AT THE NAVAL POSTGRADUATE SCHOOL AS A MODEL

F. Levien, Senior Lecturer
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: To provide an approach for use in the evaluation of radar systems by establishing two measurable performance standards; the baseline and theoretical, and then using the NPS AN/UPS-1 radar as a model, demonstrating how to use this evaluation method.

SUMMARY: Ground based radar systems are a critical resource to C3I system performance. The thesis provides the tools and methods for a better understanding of the actual performance of a ground based radar system. A multipath study was performed and coverage diagrams were generated and discussed in detail. Atmospheric data collected in 1991 was used with IREPS and EREPS software to illustrate the impact of atmosphere on the radar systems performance. The key variables used to construct the multipath study and coverage diagrams are discussed in detail.

THESIS DIRECTED:

Grant, S. E., Capt, USAF, "Performance Evaluation of Ground Based Radar Systems," Master's Thesis, June 1994.

DOD KEY TECHNOLOGY AREA: Computers, Sensors, Environmental Effects, Human System Interface, Software

KEYWORDS: Radar, Propagation

ADVANCED SIGNAL PROCESSING TECHNIQUES

H.H. Loomis, Jr., Professor
R.F. Bernstein, Jr., Visiting Instructor
Department of Electrical and Computer Engineering
Sponsor and Funding: Secretary of the Air Force

OBJECTIVE: To investigate advanced signal processing algorithms and architectures for the detection and characterization of broadband communications signals in noise and interference.

SUMMARY: My principal accomplishment this year has been in the development, realization, and experimental verification of algorithms for the detection and characterization and emitter location of cyclostationary signals, such as Phase Shift Keyed (PSK) signals. This work has resulted in one book chapter, three conference papers, one presentation and two theses. I also organized and conducted a classified workshop on DoD Applications of Cyclostationarity.

PUBLICATIONS:

Bernstein, R.F., Jr. and Loomis, H.H., Jr., "Cyclostationary Processing Using Butterfly Machines," Proceedings of the 1994 Conference on Information Science and Systems, Princeton, NJ, March 1994.

Loomis, H,H., Jr. and Bernstein, R.F., Jr., "High Speed Pipeline Processor and Memory Architectures for Cyclostationary Processing," Proceedings of the 1994 Workshop on Cyclostationary Signals, Monterey, CA, pp 4.1-4.5, August 1994.

Roberts, R.S. and Loomis, H.H., Jr., "Computational Balance in Real-time Cyclic Spectral Analysis," Proceedings, 1994 International Conference on Acoustics, Speech and Signal Processing, Adelaide, South Australia, pp IV-161 - IV-164, April 1994.

Roberts, R.S., Brown, W.A., and Loomis, H.H., Jr., "A Review of Digital Spectral Correlation Analysis: Theory and Implementation," Article 6 in Cyclostationarity in Communications and Signal Processing, (W.A. Gardner, Ed.), IEEE Press, New York, pp. 455-479, January 1994.

PRESENTATION:

Loomis, H.H., Jr., "High Speed Pipeline Processor and Memory Architectures for Cyclostationary Processing," presented to the 1994 Workshop on Cyclostationary Signals, Monterey, CA, August 1994.

THESES DIRECTED:

Jackson, K.L., LCDR USN, "A CMOS VLSI Implementation of a Near Real Time FFT," Master's Thesis, September 1994.

Lipscomb, M.P., LCDR USN, "A Hybrid Enhancement To Precision Geolocation Capabilities," Master's Thesis, September 1994.

Radcliffe, R.M., LCDR USN, "Detection of Spread Spectrum Signals Using Cyclic Spectral Analysis Techniques," Master's Thesis, December 1994.

OTHER:

Classified Adjunct to 1994 Workshop on Cyclostationary Signals, DoD Applications of Cyclostationarity, Naval Postgraduate School, Monterey California, August 1994.

DOD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Cyclostationarity, PSK Signal Detection

PROJECT GUSTY ORIOLE

H.H. Loomis, Jr., Professor
R.F. Bernstein, Jr., Visiting Instructor
Department of Electrical and Computer Engineering
Sponsor and Funding: Secretary of the Air Force

OBJECTIVE: To conduct research into computer algorithms and architectures for the processing of tactical information. To provide support for the course Space Systems 3001, Military Applications of Space.

SUMMARY: Investigated Algorithms and architectures of systems for the production, distribution and analysis of tactical information. Investigated architectures of spaceborne computer systems. Investigated operational problems concerned with the employment of tactical information for decision making and targeting. Continued research into chokepoint shipping analysis. Visited several military satellite facilities to gather information in support of SS3001.

THESES DIRECTED:

Lamb, J.H., LT USN, "Exploitation of Cellular Communications," Master's Thesis, September 1994.

Lindsay, R.W., LT USN, "Satellite Support to Sea-Based Theater Ballistic Missile Defense," Master's Thesis, September 1994.

Lipscomb, M.P., LCDR USN, "A Hybrid Enhancement To Precision Geolocation Capabilities," Master's Thesis, September 1994.

DOD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Military Space Systems

RADIATION HARDENED SPACE BASED SOLAR CELLS AND ELECTRONIC DEVICES

S. Michael, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: SPAWAR, Space and Naval Warfare Command

OBJECTIVE: Investigate radiation effects on different electronic devices and the possibility of on-orbit annealing of satellite's InP and GaAs Solar Cells using the new Minority Carriers Annealing Techniques.

SUMMARY: This is a continuation of the ongoing research on Photovoltaic Power Technology. Research tasks include the development and testing of a microprocessor based experiment suitable for small satellites. The tasks also include investigation of Photovoltaic current annealing processes and other related topics of radiation effects on GaAs, InP and Si devices. Another task is to investigate a novel technique for reducing active device sensitivity to radiation. The new designs are based on Composite Amplifiers, previously introduced by the investigator. The technique is applicable to both hard and soft devices. Preliminary data demonstrates the

impressive results when device parameters were measured during irradiation using NPS LINAC. Further study is needed to fully address all the advantages of these designs in different network topologies, and under various radiation conditions. This research also has direct application in the investigation of current satellite hardware survivability in space.

PUBLICATION:

Michael, S., "Stray Insensitive Implementation of Programmable Switched Capacitor Amplifiers," Proceedings of the 1994 International Symposium on Circuits and Systems, London, U.K., May 1994.

THESES DIRECTED:

Baczuk, R., LT, USN, "PSPICE Simulation of Total Dose Effects on Composite and Single Operational Amplifiers," Master's Thesis, September 1994.

Kramer, R.D., LCDR, USN, "Annealing of Radiation Damaged Gallium Arsenide Solar Cells by Laser Illumination," Master's Thesis, September 1994.

DOD KEY TECHNOLOGY AREA: Electronic Devices

KEYWORDS: Radiation Hardening, Solar Cells

SPACE POWER AND RADIATION EFFECTS

S. Michael, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: U.S. Department of Energy

OBJECTIVE: To perform research studies related to the development and use of Space Nuclear Power. This would support teaching courses in Space Power and Radiation Effects, projects and thesis work in the integration of nuclear power and propulsion systems with the spacecraft bus and payload.

SUMMARY: This research investigates of different radiation and nuclear effects topics, as well as other power system research projects. Some of these projects are listed below:

GPS Life Extension
Tethered Power Generation
Space Thermo-Acoustic Generator(STAG)
Fuel Cells for Space Applications
Solar Array Design Alternatives for Geosynch. Spacecraft
Nuclear Reactor System for Manned Mission to Mars
To the Moon From a B-52
Solar Concentrator Array for P91-1 Spacecraft
Power System for the Mars Rover Sample Return
Comparison of Alternative Energy Storage Systems for the United States Space Station Freedom
Deep Space Probe RTG Power System Design(Galileo Mission)
LEO Communication Satellite Power System Design
Space Station Alternate Power System using Nuclear Power and Brayton Cycle
Photovoltaic vs Solar Dynamic For Space Station Power Requirements
USAF/NASA Combined Release & Radiation Effects Satellite
(CRRES) Power Requirements using Alternate Power Source

SP-100 Nuclear Space Power for Space Station Freedom
Lunar Orbiter Power System
Spacecraft Energy Storage Using Fly Wheel

THESIS DIRECTED:

Garcia, R.E., CAPT, USMC, "Design and Test of an Uninterruptible Power Supply for the AN/MRC-142 UHF Radio," Master's Thesis, December 1994.

DOD KEY TECHNOLOGY AREA: Electronic Devices, Energy Storage

KEYWORDS: Space Power System

ADVANCED ANALOG VLSI DESIGN FOR IC's AND NEURAL NETWORKS IMPLEMENTATIONS

S. Michael, Associate Professor
Department of Electrical and Computer Engineering
Sponsor and Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project is to investigate the design and developments of low-sensitivity Analog Building Blocks to be utilized in Switched-Capacitor Networks implementations.

SUMMARY: In this research a novel technique for designing high performance, low sensitivity analog VLSI building blocks is investigated. The new designs are based on the Composite Amplifiers, previously introduced by the investigator. The Research goal is to develop Stray-Insensitive Switched-Capacitor analog building blocks that would be instrumental in the design of high performance analog VLSI circuits. The availability of such novel designs would play a key role in the practical implementations of Neural Networks.

PUBLICATIONS:

Michael, S., "A VLSI Implementation of a Stray Insensitive Programmable Switched Capacitor Amplifiers," Proceedings of the 37th Midwest Symposium on Circuits and Systems, Lafayette, LA, August 1994.

Michael, S., "A VLSI Implementation of High Performance Switched-Capacitor Analog Building Blocks," Proceedings of the 1st International Conference on Electronics, Circuits and Systems, ICECS '94, Cairo, Egypt, December 1994.

CONFERENCE PRESENTATIONS:

Michael, S., "A VLSI Implementation of a Stray Insensitive Programmable Switched Capacitor Amplifiers," presented at the 37th Midwest Symposium on Circuits and Systems, Lafayette, LA, August 1994.

Michael, S., "A VLSI Implementation of High Performance Switched-Capacitor Analog Building Blocks," presented at the 1st International Conference on Electronics, Circuits and Systems, ICECS '94, Cairo, Egypt, December 1994.

THESES DIRECTED:

Anestis, R., LTJG, Greek Navy, "Theory and Implementation of a VLSI Stray Insensitive Switched Capacitor Composite Operational Amplifiers," Engineer's Thesis, June 1994.

Serbinski, J., LT, USN, "Design of Electronic Experiments Using Computer Generated Virtual Instruments," Master's Thesis, March 1994.

DOD KEY TECHNOLOGY AREA: Electronic Devices

KEYWORDS: Switched Capacitor Amplifiers

TRANSIENT LOCALIZATION

J.H. Miller, Associate Professor
Department of Electrical and Computer Engineering
C.-S. Chiu, Associate Professor
Department of Oceanography
Sponsor: Naval Undersea Warfare Center, New London

OBJECTIVE: The objective of this project is the development and application of an efficient algorithm for the localization of short duration acoustic events in shallow water.

SUMMARY: One of the difficulties facing implementation of a transient localization technique is the large computational burden of a) the generation of the ocean transfer function using a propagation code and b) the correlation function matching. While the propagation modeling issue is outstanding, the time required for the correlation function matching has been reduced by a factor of 50 by keeping the replica signal correlation function calculation in the time domain, i.e., using the ray-traced arrival times to ''sift'' out the measured usable in real-time during sea tests and eventually may enable the implementation in an operational system.

PUBLICATIONS:

Chiu, C.S., Semtner, A.J., Ort, J.H., and Miller, J.H., "A Ray Variability Analysis of Sound Transmission from Heard Island to California," Journal of the Acoustical Society of America, Vol. 96, No. 4, pp. 2380-2388, 1994.

Chiu, C.-S., "Downslope Modal Energy Conversion," Journal of the Acoustical Society of America, Vol. 95, No. 3, pp. 1654-1657, 1994.

Baggeroer, A.B., Sperry, B., Lashkari, K., Chiu, C.-S., Miller, J.H., Mikhalevsky, P.N., and Von Der Heydt, K., "Vertical Array Receptions of the Heard Island Feasibility Transmissions," Journal of the Acoustical Society of America, Vol. 96, No. 4, pp. 2395-2413, 1994.

Miller, J.H., Kresge, J., Chiu, C.-S., and Barnikel, P., "Localization of Submarine Transients in Shallow Water (U)," Naval Postgraduate School Technical Report, NPS-UW-94-001, (S-NF), January 1994.

THESIS DIRECTED:

Kresge, J. K., LT, USN, "Localization of Submarine Transients in Shallow Water (U)," Master's Thesis, April 1994.

DOD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Acoustics, Modeling, Transients

FIELD CANCELLATION USING A COUNTER-EMF APPROACH

M.A. Morgan, Professor and Chairman
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: A distributed, active cancellation approach has been investigated for reduction of bistatic radar cross section.

SUMMARY: The counter-EMF technique appears most promising at lower radar frequencies where passive measures such as shaping and absorbing materials become inefficient. By combining active and passive techniques, ultra-wideband RCS reduction can be provided for protection against future radar designs, including impulse radars. Analytical studies and numerical simulations were conducted during this project to consider tradeoffs of RCS reduction vs. frequency range for number and placement of canceler modules using wire models of aircraft structures. Typical bistatic RCS reductions of 30-40 dB were observed at very low frequencies, decreasing to no less than 20 dB over all aspects near frequencies corresponding to canceler spacings of one-fourth wavelength. Gradual degradation in performance continued as frequency was increased until the canceler spacing approached one-half wavelength; at this point the system failed dramatically in all cases tested. Practical implementation of an active system requires nearly real-time sensing of the incident field waveform but no global knowledge of the platform's scattering is required, since each module acts to cancel the incident signal in a local region. This accumulated cancellation of the incident field suppresses the globally scattered field and reduces the RCS in all directions.

PUBLICATION:

Morgan, M.A., "Counter-EMF Active Reduction of Bistatic Radar Scattering," in preparation for IEEE Transactions on Antennas and Propagation.

DOD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Active Cancellation, RCS Reduction, Low Observables

ULTRA-WIDEBAND IMPULSE ANTENNA DESIGN

M.A. Morgan, Professor and Chairman
R.C. Robertson, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: U.S. Army CECOM Signals Warfare Directorate

OBJECTIVE: Goals of this project are to perform engineering designs, develop validation procedures, and to construct and test highly efficient, small-sized prototypical ultra-wideband impulse receiving antennas.

SUMMARY: Impulse antennas are intended to either transmit or receive very short pulses of electromagnetic energy. Not only is an extremely wide bandwidth necessary, but in order to maintain high signal fidelity, impulse receiving antennas must also display a nearly linear phase characteristic in their frequency domain transfer functions. A resistively-loaded TEM horn antenna for receiving impulse signals having a measured passband of 80MHz--6GHz was designed, constructed, tested and delivered in 1993. Continuation of the effort in 1994 has centered about creating optimal designs for increasing the antenna sensitivity and bandwidth, while also reducing the physical size of the structure to meet the sponsor's requirements.

CONFERENCE PRESENTATIONS:

Morgan, M.A. and Robertson, R.C., "Ultra-Wideband Impulse Receiving Antenna Design and Evaluation," 1994 International Conference on Ultra-Wideband, Short-Pulse Electromagnetics, Brooklyn, NY, 5-7 April 1994.

Robertson, R.C. and Morgan, M.A., "Loaded TEM Horn Antenna for Ultra-Wideband Signal Reception," 1994 URSI National Radio Science Meeting, Seattle, WA, June 1994.

DOD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Ultra-wideband, Impulse Antennas, TEM Horns

ALGORITHMS FOR ASSESSING THE EFFECTIVENESS OF SHIPBOARD COUNTERMEASURES AGAINST ANTI-SHIPPING MISSILE PLATFORMS

P.E. Pace, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Tactical Electronic Warfare Division,
Naval Research Laboratory

OBJECTIVE: The objective of this research is to improve the process for evaluating hardware-in-the-loop and field test performance results. As part of this objective, new algorithms to measure the overall EW systems utility and effectiveness were robe developed. (CONTINUING PROJECT)

SUMMARY: Hardware-in-the loop data from NRL's Central Targeting Simulator facility was obtained. This data demonstrates the response of various anti-shipping missile simulators (open-loop/closed-loop) in an electronic countermeasures environment. Using these response periods, models of various anti-ship cruise missile threat simulators were constructed within a Simulator Correlation Environment (SCE). To incorporate the P-3 captive carry experimental test results into the SCE, a Transition Preprocessor was developed. This preprocessor predicts the closed-loop dynamics of the ASCM simulator from the open-loop results.

PUBLICATION:

Pace, P.E. and Cooper, C.R., "Correlation Environment for Determining the Effectiveness of Shipboard Electronic Countermeasures Against Anti-Ship Cruise Missile Simulators (U)," Naval Postgraduate School Technical Report (Secret) NPS-EC-95-002, to be published in February 1995.

THESES DIRECTED:

McGinnis, R., LCDR, USN, "HIL Closed Loop Correlation Model for the CHARLIE Simulator vs. Swept Square Wave ECM Modulation (U)," Master's Thesis (Secret), June 1994.

Lynch, C.B., LT, USN, "Incorporation of Captive Carry Open Loop Seeker Parameters into a HIL Closed Loop Model (U), Master's Thesis (Secret), September 1994.

OTHER:

Pace, P.E., Nishimura, B., Cooper, C.R., and Surratt, R.B., "Correlation of Anti-Ship Cruise Missile Simulator ECM Experiments," to be presented at the Association of Old Crows Joint Western-Mountain Region EW Technical Symposium '95, April 1995.

Pace, P.E. and Moreno, M.S., "Optimization of Shipboard Self-Protection ECM Systems Using SCE Techniques," to be presented at the 63rd Military Operations Research Society Symposium, June 1995.

DOD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Anti-ship Cruise Missile Simulators, Electronic Countermeasures, Captive Carry

HIGH RESOLUTION DIRECT DIGITIZATION AND OPTICAL TELEMETRY OF ANTENNA SIGNALS

P.E. Pace, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: The objective of this research was to investigate the feasibility of directly digitizing, wideband antenna signals using high-resolution symmetrical number system (SNS) techniques to achieve 14-bits resolution at a sampling rate of 5 MHz. (CONTINUING PROJECT)

SUMMARY: A prototype 8-bit electro-optical SNS ADC has been constructed in the NPS Optical Electronics Laboratory. The digital processor portion of the device has been tested and verified. The optical processor front-end has also been constructed. The three optical interferometers used in the 8-bit prototype were borrowed from the National Security Agency. The interferometers for the 14-bit device were purchased from United Technologies Photonics. These interferometers were a reflective design resulting in a Vpi = 0.35 volts. The design for the printed circuit boards for the 14-bit device has been completed.

PUBLICATIONS:

Pace, P.E., Ramamoorthy, P.A., and Styer, D., "A Preprocessing Architecture For Resolution Enhancement in High-Speed ADC's," IEEE Transactions on Circuits and Systems-II: Analog and Digital Signal Processing, Vol. 41 pp. 373-379, 1994.

Pace, P.E. and Styer, D., "High-Resolution Encoding Process For an Integrated Optical Analog-To-Digital Converter," Optical Engineering, Vol. 33, pp. 2638-2645, 1994.

Pace, P.E. and Foster, C.C., "Beam Propagation Analysis of a Parallel Configuration of Mach-Zehnder Interferometers," Optical Engineering, Vol. 33, pp. 2911-2921, 1994.

Foster, C.C. and Pace, P.E., "Numerical Modeling of Opto-Electronic Integrated Circuits," Scientific Computing, pp. 19-22, October 1994.

Pace, P.E., Pieper, R.J., and Powers, J.P., "High-Resolution Direct Digitization and Optical Telemetry of Shipboard Antenna Signals," Naval Postgraduate School Technical Report, NPS-EC-94-016, December 1994.

CONFERENCE PRESENTATION:

Pieper, R.J., Pace, P.E., Powers, J.P., Van de Veire, R., and Foster, C.C., "Feasibility Demonstration of a High-Resolution Integrated Optical Analog-To-Digital Converter," presented at the 4th Annual Darpa Symposium on Photonic Systems for Antenna Applications, January 1994.

THESES DIRECTED:

Foster, C.C., Capt, USMC, "Numerical Modeling of Opto-Electronic Integrated Circuits," Master's Thesis, December 1994.

Carr, R.D., LCDR, USN, "Analog Preprocessing in a SNS 2umLow-Noise CMOS Folding ADC," Master's Thesis, December 1994.

PATENT APPLICATIONS:

Pace, P.E., "High Resolution Encoding Circuit and Process for Analog-to-Digital Conversion," Attorney Docket No. 76,164.

OTHER:

Pace, P.E. and Schafer, J.L., "Decimation of Encoding Errors in an Optimum SNS Folding ADC," to be presented at the 1995 IEEE International Symposium on Circuits and Systems, May 1995.

Pace, P.E. and Styer, D., "Resolution of Undersampling Ambiguities Using Symmetrical Residues," to be presented at the 38th Midwest Symposium on Circuits and Systems, August 1995.

Pace, P.E., Schafer, J.L., and Styer, D., "Optimum Preprocessing For Folding ADCs," IEEE Transactions on Circuits and Systems-II: Analog and Digital Signal Processing, submitted September 1994.

Pace, P.E., Powers, J.P., Pieper, R.J., Walley, R., Yamakoschi, H., and Crowe, C., "8-Bit Integrated Optical SNS ADC," to be presented at the 27th IEEE Southeastern Symposium on System Theory, March 1995.

Pace, P.E., Carr, R.D., and Schafer, J.L., "Analysis of a 2um Low-Noise CMOS Folding Circuit," Journal of Analog Integrated Circuits and Signal Processing, submitted December 1994.

DOD KEY TECHNOLOGY AREA: Sensors, Electronic Devices

KEYWORDS: Symmetrical Number System, Analog-to-digital Conversion, Preprocessing

SURFACE MODE PROCESSING FOR TARGET DETECTION AND DECLARATION

P.E. Pace, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Hughes Missile Systems Company

OBJECTIVE: The objective of this research was to experimentally evaluate the trade-offs between an inverse MTI filtering approach and a DFT filter bank approach to detect surface targets in actual recorded sea clutter.

SUMMARY: Trade-offs in performance versus hardware complexity were evaluated for two search processor configurations for several slow moving targets of various size buried in recorded sea clutter data. Several variations were investigated for each approach. A retrofit of the current Phalanx hardware to perform this search/detection processing was studied and an optimal inverse filter was constructed that could easily be implemented in the currently configured hardware. Overflow effects and truncationnoise levels were numerically evaluated.

PUBLICATION:

Pace, P.E. and Taylor, L.L., "False Alarm Analysis of the Envelope and Envelope Approximation GO CFAR Processor," IEEE Transactions on Aerospace and Electronic Systems, Vol. 30, pp. 848-864, July 1994.

THESES DIRECTED:

Brewer, D.B., LT, USN, "PHALANX Surface-Mode Signal Processing For Target Detection and Declaration," Master's Thesis, June 1994.

Roberts, B.C., LT, USN, "Scan-to-Scan Correlation for PHALANX Surface-Mode Using Modified Optimal Gating," Master's Thesis, September 1994.

Hache, J.J.P., CAPT, Canadian AF, "Probability of Detection For a GO-CFAR Radar Processor Using Envelope Detection Approximation," Master's Thesis, September 1994.

Tanaka, C., LT, USN, "Closed-Form Expressions for the Probability of Detection for an Envelope Detection Approximation GO-CFAR Processor," Master's Thesis, December 1994.

OTHER:

Pace, P.E., Brewer, D.B., Taylor, L.L., Laulusa, G., and Butt, E., "Harbor Control Search Processing for Detection of Slow Moving Ships in Adverse Conditions," to be presented at the IEEE International Radar Conference '95, May 1995.

DOD KEY TECHNOLOGY AREA: Sensors, Software

KEYWORDS: PHALANX, Close-in-weapon-system, Surface-mode Signal Processing, Sea Clutter

SOFTWARE FOR FLOW DISTRIBUTION IN ELECTRONIC RACK STRUCTURES

R.J. Pieper, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: To develop a Fortran code which predicts flow rates in multipath structures in which regimes associated with laminar and turbulent flow are covered.

SUMMARY: A Fortran Code has been developed which predicts pressures and flow rates in a piping network for the regimes of laminar, transition, and turbulent flow. A novel and effective scheme for modeling the transition region between laminar and turbulent flow is demonstrated. A proposed linear indicator for the deviation from larninar behavior is introduced into the analysis in order to facilitate the computational task. Although the turbulent flow problem is inherently nonlinear, the method of analysis described herein, typically employed with linear electrical networks, is found to converge rapidly to art approximate solution without user-specified a priori guesses.

PUBLICATION:

Pieper, R., "Software for Flow Distribution in Electronic Rack Structures," Naval Postgraduate School Technical Report, NPS-EC-94-010, September 1994.

DOD KEY TECHNOLOGY AREA: Electronic Devices

KEYWORDS: Laminar and Turbulent Flow

PROPAGATION OF TRANSIENT WAVES

J. Powers, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: To study the predicted propagation properties of transient acoustic and optical waves in an effort to under-stand the propagation of very short duration waves and to use such waves in imaging applications.

SUMMARY: With the ability to generate short-duration sound and light pulses comes the requirement to be able to model and understand the propagation of these waves. Unlike most line-integral techniques presently available, these models should be computationally efficient.

We have developed a method of simulating acoustic propagation in linear homogeneous media based on Fourier transform techniques. The propagation transfer function represents a time-varying spatial filter that increasingly attenuates the higher spatial frequencies of the wave as time increases.

We constructed a computer-controlled, experimental data collection system to measure experimental acoustic data fields to confirm the technique. Using GBIB-controlled instruments and LabView software for instrument control, stepper motor control, data collection, and data recording, we successfully recorded an acoustic field from a pulsed source and compared it with the theoretical predictions from our model. The results compared favorably, with some discrepancies due to misalignments of the source and receiving aperture.

PUBLICATION:

Powers, J.P., Reid, W., Upton, J.G., and Van de Veire, R., "A Comparison of the Transient Propagation Properties of Gaussian and Bessel Waves," to be published in Acoustical Imaging, Vol. 21, J.P. Jones, Ed., Plenum Press, 1994.

CONFERENCE PRESENTATION:

Powers, J.P., Reid, W., Upton, J.G., and Van de Veire, R., "A Comparison of the Transient Propagation Properties of Gaussian and Bessel Waves," presented at the 21st International Symposium on Acoustical Imaging, Laguna Beach, CA, March 1994.

THESES DIRECTED:

Gatcheil, P., LTJG, USN, "Experimental Measurement of Acoustic Wave Propagation," Master's Thesis, June, 1994.

OTHER:

Baylosis, B., LT, USN, "Acoustic Imaging of Ultrasonic Wave Propagation," Master's Thesis, in progress.

Powers, J.P., Baylosis, B., Gatcheil, P., and Reid, W., "Experimental Comparison of Measured Ultrasound Pressure Fields with Theoretical Prediction," submitted to the 22nd International Symposium on Acoustical Imaging, Florence, Italy, September 1995.

DOD KEY TECHNOLOGY AREA: Other (Wave Propagation)

KEYWORDS: Transient Waves, Optical Waves, Acoustic Field

ULTRA-WIDEBAND IMPULSE ANTENNA DESIGN

R.C. Robertson, Associate Professor
M.A. Morgan, Professor and Chairman
Department of Electrical and Computer Engineering
Sponsor: US Army CECOM Signals Warfare Directorate

OBJECTIVE: The goal of this project is to develop an ultra-wideband impulse receiving antenna with greater sensitivity and lower frequency response than a previously designed prototype ultra-wideband impulse receiving antenna.

SUMMARY: Impulse antennas are intended to either transmit or receive very short pulses of electromagnetic energy. Previously, a resistively loaded, TEM horn was designed, built, and tested. Experimental results indicate that the prototype TEM horn is capable of receiving an incident impulsive electric field having a time duration of less than 100 ps with virtually no distortion. Numerical modeling of various resistively loaded, TEM horn designs was done with the goal of increasing sensitivity and lowering the frequency response given strict limitations in maximum antenna dimensions. A novel design approach was developed that consists of increasing the antenna impedance as distance from the feed point increases rather than maintaining a constant impedance as is usually done. This approach allows antenna sensitivity to be maximized for given maximum dimensions while maintaining a 50 S\OmegaS input impedance. Numerical modeling predicts a roughly 5 dB increase in sensitivity for an antenna having the same maximum physical dimensions as the prototype.

PUBLICATIONS:

Morgan, M.A. and Robertson, R.C., "Loaded TEM Horn Antenna for Ultra-Wideband Signal Reception," Abstracts of URSI Radio Science Meeting, p. 490, 1994.

Robertson, R.C. and Morgan, M.A., "Ultra-Wideband Impulse Receiving Antenna Design and Evaluation," to be published in Ultra-Wideband, Short-Pulse Electromagnetics 2, (H.L. Bertoni, L. Carin, L.B. Felsen, and S.U. Pillai, Eds.), Plenum Press, New York.

CONFERENCE PRESENTATIONS:

Robertson, R.C. and Morgan, M.A., "Ultra-Wideband Impulse Antennas," Tri-service Ultra-wideband Antenna Design Workshop, U.S. Army Missile Command, Redstone Arsenal, Huntsville, AL, 1-2 December 1994.

Morgan, M.A. and Robertson, R.C., "Loaded TEM Horn Antenna for Ultra-Wideband Signal Reception," URSI Radio Science Meeting, University of Washington, Seattle, WA, 19-24 June 1994.

Robertson, R.C. and Morgan, M.A., "Ultra-Wideband Impulse Receiving Antenna Design and Evaluation," 2nd International Conference on Ultra-wideband, Short-pulse Electromagnetics, Polytechnic University, NY, 5-7 April 1994.

DOD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Ultra-wideband Antenna, Impulse Antenna, Antenna Transient Response

DESIGN AND PERFORMANCE CHARACTERIZATION OF A MULTIPURPOSE DECENTRALIZED GROUP MEMBERSHIP SERVICE

S.B. Shukla, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: The goal of this three year project ending in June 1996 is to develop and characterize a multipurpose and scalable group membership service.

SUMMARY: This project focuses on the structure of a group membership service, a basic building block for group-oriented distributed applications. The objectives of this project are development and performance characterization of a membership service with multiple classes of service. The emphasis is on categorical definition of service classes to support a wide spectrum of applications, adaptive status monitoring to minimize wrongly perceived status changes, a completely decentralized and hierarchical protocol requiring an overhead proportional to the quality of the service rendered, and support of a spectrum of membership semantics in spite of transient network partitioning. Techniques are being developed to support seamless distribution of large groups across a set of heterogeneous networks by exploiting the attributes of local communication environments and using topology-based optimizations. Formal techniques will be used for specification, verification and implementation of the protocol. A performance metric will be developed for characterization of the performance of membership protocols. Performance will be studied with simulations based on stochastic modeling of applications, membership protocols, and underlying networks. The simulations will be built using commercial network engineering tools. The main contributions expected from this research are a single multipurpose membership protocol instead of the current application-specific variety and quantitative performance characterization which is currently lacking.

THESIS DIRECTED:

Neely, D., LT, USN, "A Scaleable Decentralized Group Membership Service For An Asynchronous Environment," Master's Thesis, June 1994.

DOD KEY TECHNOLOGY AREA: Communications Networking, Software, Computers

KEYWORDS: Group Membership, Fault-tolerance, Decentralized Network Service

COMMON DATA LINK'S (CDL) INTERFACE TO THE GLOBAL NETWORK ARCHITECTURE

S.B. Shukla, Assistant Professor
P.H. Moose, Associate Professor
Department of Electrical and Computer Engineering
G.M. Lundy, Associate Professor
Department of Computer Science
Sponsor: Defense Airborne Reconnaissance Office, The Pentagon

OBJECTIVE: The goal of this project is to determine the attributes and protocols for interfacing the Common Data Link to the DoD global network architecture.

SUMMARY: CDL is a full-duplex, jam-resistant point-to-point microwave communication system developed by the US government that provides real-time connectivity and interoperability between multiple collection platforms and surface terminals. This two-year project ending in September 1995 is evaluating the emerging high-speed networking architectures and protocols for design of a seamless interface of the CDL to the global

broadband network. The expected outcome is a recommendation for an implementation plan to integrate CDL into the DoD global network architecture. This recommendation will include a verification of the concept along with substantiated discussions of protocol availability, interoperability, network management issues, and performance-related modeling and trade-offs.

PUBLICATION:

Shukla, S.B., "Design Requirements for the Common Data Link's Network Interface," Naval Postgraduate School Technical Report NPS-EC-94-011, October 1994.

THESES DIRECTED:

Eichelberger, J.W., LT, USN, "Design and Implementation of a Link Monitoring Mechanism for the Common Data Link," Master's Thesis, September 1994.

Karayakalar, S., LTJG, Turkish Navy, "Data Link Level Interconnection of Remote Fiber Distribute Data Interface Local Area Networks Through the Critical Data Link," Master's Thesis, June 1994.

Nix, E.G., Jr., LT, USN, "Modeling and Simulation of a Fiber Distributed Data Interface Local Area Network Using {OPNET} for Interfacing Through the Common Data Link," Master's Thesis, June 1994.

DOD KEY TECHNOLOGY AREA: Communications Networking

KEYWORDS: CDL, High-speed Network Interface, Global Network, FDDI, Internetworking

SONAR SIGNAL MODELING

C.W. Therrien, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Undersea Warfare Center (New London)

OBJECTIVE: This research involves the development of models for underwater signals received by a passive sonar, to support work in classification. The research is part of a continuing project begun in 1992.

SUMMARY: During FY1994 tests were completed on the sonar data noise background to test for Gaussianity. A new data synthesis method based on a time-varying autoregressive model was developed and tested. Results are reported in the technical report cited below.

PUBLICATIONS:

Therrien, C.W., Frack, K.L., and Kjono, O.E., "Summary Report on Sonar Signal Modeling for FY94," Naval Postgraduate School Technical Report, NPS-EC-94-018, December 1994.

Therrien, C.W., Victory, C.W., and Pfeifer, G.K., "Methods for Modeling Transient Sonar Data," U.S. Navy Journal of Underwater Acoustics, Vol. 44, No. 2, April 1994. [SECRET NOFORN]

CONFERENCE PRESENTATION:

Therrien, C.W., Cristi, R., and Allison, D.E., "Methods for Acoustic Data Synthesis," IEEE DSP Workshop, Yosemite National Park, CA, October 1994.

THESES DIRECTED:

Frack, K.L., LT, USN, "Improving Transient Signal Synthesis Through Noise Modeling and Noise Removal," Master's Thesis, March 1994.

Kjono, O.E., LT, USN, "Synthesis of Nonstationary Stochastic Signals," Master's Thesis, June 1994.

DOD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Sonar Signal, Passive Sonar, Autoregressive Model

SPACE RESEARCH

H.A. Titus, Professor
Department of Electrical and Computer Engineering
Sponsor: SPAWAR, NRL, Washington DC

OBJECTIVE: We wish to locate targets from space platforms and to develop optimal control techniques for attitude control and maneuver of spacecraft.

SUMMARY: Optimal control techniques have been applied in the general attitude control and spacecraft maneuver problem. Lt. Wolfe has been working on the attitude control of a sun pointing satellite. Lt Haefner has worked on the analysis of radar emitter signatures via FFT and time domain filtering. Capt Williamson and Lt Fallon are extending this work to include RPVs and other sensor platforms. Sensor fusion for locating threat radar and cellular phones are being addressed.

DOD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Attitude Control, Spacecraft

RESEARCH IN DATA COMPRESSION TECHNIQUES

M. Tummala, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: SPAWAR SYSCOM, Arlington, VA

OBJECTIVE: The goal of this work is to investigate modern data (image inparticular) compression techniques with emphasis on their application to DoD and commercial satellite imagery. Part of the work has been carried out during AY94 and the rest is undertaken during AY95.

SUMMARY: The work consists of a comprehensive survey of military data compression standards and an investigation of the image compression techniques based on wavelet transforms and the quad tree method. Several military standards examined appear to be lacking in both performance and technology when compared to commercial standards available. Commercial standards could support the objectives as well as the functionality of military systems such as the Global Command and Control System. Commercial standards could also provide better longterm inter-operability and information exchange capabilities than the currently available military standards.

A multiresolution image compression scheme has been developed using discrete wavelet transform with a nonstandard tiling method to decompose a given image into a number of sequences. These sequences are encoded

using a uniform quantizers and a new multiresolution coding scheme. The bit rates achieved are on the order of 0.5 bits per pixel, which corresponds to a compression ratio of 16:1. Lower bit rates are attainable with additional coding of these sequences. The scheme allows a user to choose from five different resolution levels, providing different image qualities at different bit rates. Because the scheme is scalable, it enables the user to upgrade the quality of a lower resolution transmission until sufficient detail is obtained. Near exact reconstruction of the original image is possible when all the resolution levels are available. Work on the quad tree algorithm is currently in progress.

PUBLICATIONS:

Erdemir, A., Carvalho, R.M., and Tummala, M., "Data Compressing Using Wavelet Transforms and Vector Quantization," in Proceedings of the 37th Midwest Symposium on Circuits and Systems, Lafayette, LA, August 1994.

Watkins, B.E. and Tummala, M., "Classification Vector Quantization of Image Data Using Competitive Learning," in Proceedings of the First IEEE International Conference on Image Processing, Austin, TX, November 1994.

THESES DIRECTED:

Carvalho, R.M., LT, USN, "Multiresolution Image Compression Using Subband Coding and Wavelet Decomposition," Engineer's Thesis, December 1994.

Pratt, E.S., LT, USN, "Data Compression Standards and Applications to Global Command and Control System," Master's Degree, December 1994.

DOD KEY TECHNOLOGY AREA: Sensors, Communications Networking

KEYWORDS: Data Compression, Image Coding, Text Compression, Wavelet Transform, Data Compression Standards, JPEG, MPEG

MULTI-SENSOR DATA FUSION USING FUZZY LOGIC AND NEURAL NETWORKS TECHNIQUES

M. Tummala, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Electronics Engineering Center, U.S. Coast Guard, Wildwood, NJ

OBJECTIVE: The goal of this project is to develop algorithms for fusion of data originating from a number of sensors. Two techniques have been explored: fuzzy membership and neural networks. The work reported here supports the Coast Guard's VTS system upgrade as well as their new system development; it is part of a multi-year effort.

SUMMARY: The USCG Electronics Engineering Center (EECEN) is in the process of developing a new vessel traffic system as well as modernizing the existing vessel traffic systems. In a typical VTS, the data is originated by radars, video cameras, ship's voice communication channel, and traffic operators' prospective lists. Effective use of these multi-sensor, multi-media data leads to improved harbor traffic monitoring and port safety. Here fuzzy membership and neural networks techniques are explored to develop multisensor data fusion algorithms that will be integrated into the VTS software.

The fuzzy membership function approach to multi-sensor data fusion has been thoroughly investigated. An algorithm based on this approach has been applied to a simulated harbor scenario (a section of the New York

harbor) with encouraging results. The algorithm consists of alignment of the received data, association of these data based on their degree of similarity, update of the track correlation matrix, and estimation of the features of the fused template. The features of the vessel that make up the template are position on the x--y plane, course, speed, epoch, remote site identification, and track identification. On the neural network approach, an algorithm for data fusion based on competitive learning and adaptive resonance theory ideas is currently under investigation.

OTHER:

Ruthenberg, T., LT, USN, "Multi-Sensor Data Fusion: The Fuzzy Membership Approach," Master's Thesis, in progress.

Koh, L., Singapore Civilian, "Multi-Sensor Data Fusion: The Neural Networks Approach," Master's Thesis, in progress.

DOD KEY TECHNOLOGY AREA: Sensors, Communications Networking

KEYWORDS: Data Fusion, Vessel Traffic Control, Fuzzy Logic, Neural Networks, Data Compression

EMP WAVEFORM ANALYSIS FOR AIRCRAFT TESTING

M. Tummala, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Air Warfare Center, Aircraft Division, Patuxent River, MD

OBJECTIVE: Develop signal processing algorithms for the analysis of electromagnetic pulse (EMP) waveforms measured in aircraft testing and synthesis of the measured waveforms to produce composite test signals for determining aircraft margin of survivability. This is a multi-year effort; the work reported here consists of the results obtained during the third year of this effort.

SUMMARY: The Naval Air Warfare Center (Code 5.1.7.2) conducts EMP testing of aircraft. In order to improve the effectiveness of their EMP testing techniques, a method for "bounding" the stress waveforms measured inside the aircraft from a series of tests is sought. At each test-point in an aircraft under test, four to eight stress waveforms (signals received at a test-point in response to a simulated EMP pulse) are measured. These signals are currently sampled at 1.3 GHz with the bandwidth of interest being from about 10 kHz to 100 MHz. Three specific tasks were identified to meet their needs: waveform compression for efficient storage, stress waveform bounding using time series modeling approach, and wideband EMP signal analysis to meet their near future bandwidth requirements (10 kHz to 200 MHz). The first task has been completed during AY1992; the second task has been completed during AY1993, and parts of the third task have been completed during AY1994.

Wideband signal analysis techniques have been employed to combine multiple (four in this case) measurements obtained at a test point. The algorithms developed used a combination of sinusoidal modeling and discrete wavelet transform techniques. This approach helped reduce a complex, broad frequency range problem to a more manageable set of narrowband analysis problems. The performance of the algorithms was measured using a set of metrics called "norm attributes." All the tests yielded composite waveforms with time domain representations and frequency responses that faithfully retained the key time and frequency domain features of the original signals. Further investigation using multirate filter banks is currently undertaken.

PUBLICATIONS:

Frazier, S., Parimuha, E., and Tummala, M., "Waveform Bounding and Combination Techniques for Direct Drive Testing," in Proceedings of the EUROEM-94 Symposium on Electromagnetic Environments and Consequences,

Bordeaux, France, June 1994.

Erdemir, A., Carvalho, R.M., and Tummala, M., "Data Compressing Using Wavelet Transforms and Vector Quantization," in Proceedings of the 37th Midwest Symposium on Circuits and Systems, Lafayette, LA, August 1994.

Tummala, M., "Wideband Analysis of EMP Data," Naval Postgraduate School Technical Report, in preparation.

CONFERENCE PRESENTATION:

Frazier, S., Parimuha, E., and Tummala, M., "EMP Waveform Analysis and Combination Techniques," presented at 1994 HEART Conference, NPS, Monterey, CA, February 1994.

THESIS DIRECTED:

Winnenberg, T.F., LT, USN, "Wide-band Signal Analysis Applied to EMP Stress Waveforms," Electrical Engineer Thesis, December 1993.

OTHER: Software developed in Matlab for EMP signal analysis was delivered to Code 5.1.7.2, NAWC; it has been tested by their personnel on their test database.

DOD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Data Compression, EMP Waveform, Discrete Wavelet Transform, Waveform Synthesis

COMMUNICATIONS VULNERABILITY TO JAMMING

D.v.Z. Wadsworth, Senior Lecturer
Department of Electrical and Computer Engineering
Sponsor: OPNAV N64E

OBJECTIVE: This is a continuing project by the same sponsor covering CY 1994 and 1995. The primary goals are to model the vulnerability of selected (blue) RF tactical communications links to both conventional and "smart" jamming and to incorporate these models into the "analytic engine" which drives the Navy's RF Mission Planning system (RFMP) which is part of JMCIS. A secondary goal is to improve the RFMP communications probability of success algorithms by refining the probability density models.

SUMMARY: The initial effort was directed toward collecting existing vulnerability analyses and engineering specifications for six high-priority communications systems: NTDS Links (4A, 11, 16), TADIXS B, TACINTEL, and SINCGARS. Organizations which supported this task included N6, NAVSECGRU, PD-50, Johns Hopkins APL, ARL/SLAD/EW, and Army RDEC/IEWD. During 1994, the groundwork was laid for developing and evaluating the vulnerability models at NPS by acquiring a TAC-3 platform complete with the necessary memory and C++ program development software. The JMCIS/RFMP software delivery is expected in early 1995.

OTHER: One related thesis will be completed in 1995. Also analyses and software will be documented as NPS technical reports in 1995. A conference presentation or journal publication is planned for 1995, tentatively entitled "Linear FM Signal Detection." The paper is 95% completed and applies to Navy Link 4C receivers, among others.

DOD KEY TECHNOLOGY AREA: Communications Networking, Other (Electronic Warfare)

KEYWORDS: Electronic Warfare, Command and Control Warfare, Communications, EW, C2W, C3I

AIRBORNE EW vs SPACE-BASED C3I SYSTEMS

D.v.Z. Wadsworth, Senior Lecturer
Department of Electrical and Computer Engineering
Sponsor: Joint Staff-J3/C2W Branch (Unfunded)

OBJECTIVE: The goal was to document a collateral version of previous research on existing capabilities and analyses regarding the use of airborne EW against space-based C3I systems.

SUMMARY: Previous research on the subject was performed at NPS under the direction of myself and CPT J.R. Powell. The collateral version of this research was prepared in 1994 and published as a classified NPS report.

PUBLICATION:

Wadsworth, D.v.Z., O'Reilly, T.C., and Powell, J.R., "Airborne EW vs Space-based C3 Systems (U)," Naval Postgraduate School Technical Report, NPS-EC-94-003, May 1994.

DOD KEY TECHNOLOGY AREA: Other (Electronic Warfare)

KEYWORDS: Electronic Warfare, Command and Control Warfare, EW, C2W

COORDINATION OF MOBILE MANIPULATORS

X. Yun, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: National Science Foundation

OBJECTIVE: The goal of this project is to investigate the coordination of a mobile manipulator consisting of a mobile platform and a multi-link manipulator.

SUMMARY: In the absence of obstacles, we have studied the coordination of locomotion and manipulation of mobile manipulators in the previous year. This phase of the project was focused on the obstacle avoidance of a mobile manipulator. In the presence of obstacles, one must simultaneously consider the obstacle avoidance problem and the coordination problem. We have developed a control method for mobile manipulators that integrates an obstacle avoidance scheme with the coordination scheme developed early. The obstacle avoidance scheme is based on superquadric potential functions. The coordination scheme is based on preferred operating regions. The controller allows a mobile manipulator to retain optimal or sub-optimal configurations while avoiding obstacles. The effectiveness of the control method has been validated by computer simulations.

OTHER:

Yamamoto, Y. and Yun, X., "Coordinated Obstacle Avoidance of a Mobile Manipulator," to be presented at the 1995 International Conference on Robotics and Automation, Nagoya, Japan, 21-27 May 1995.

Yun, X., "State Space Representation of Holonomic and Nonholonomic Constraints Resulting from Rolling Contacts," to be presented at the 1995 IEEE International Conference on Robotics and Automation, Nagoya, Japan, 21-27 May 1995.

DOD KEY TECHNOLOGY AREA: Other (Robotics)

KEYWORDS: Controller Design, Mobile Manipulator

RECURSIVE RAY ACOUSTICS FOR THREE-DIMENSIONAL SPEEDS OF SOUND

L.J. Ziomek, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Program Executive Office for Undersea Warfare, Advanced Systems and Technology

OBJECTIVE: Continue to generalize, test, and evaluate the Recursive Ray Acoustics (RRA) Algorithm. The RRA Algorithm is a simple, fast, and accurate algorithm that can be used to find eigenrays and to compute the position, angles of propagation, travel time, phase, and path length along a ray path and to draw ray trace plots for speeds of sound that are functions of all three spatial variables. In addition, the RRA Algorithm can calculate the sound-pressure level along individual ray paths for arbitrary, one-dimensional, depth-dependent speeds of sound.

SUMMARY: Computer code was written in FY94 to give the RRA algorithm the additional capability to calculate the phase along individual eigenrays in order to model pulse (transient) propagation. The phase calculations also take into account phase shifts due to ocean surface and bottom reflections. Since SPL and phase calculations can now be performed along individual eigenrays, a major new effort started in FY94 was to begin incorporating the further enhanced version of the RRA algorithm into the full-wave, pulse-propagation computer program LSVOCN (Linear Space-Variant Ocean) in order to ultimately perform target localization studies. Another new effort started in FY94 was to investigate the possibility of using two-dimensional orthogonal function expansions to fit surfaces to two-dimensional ocean bottom depth data, that is, bathymetry as a function of cross-range and down-range. Such ocean bottom surface fits would allow for the prediction of out-of-plane ray propagation due to bottom bounces.

PUBLICATION:

Ziomek, L.J., "Sound-Pressure Level Calculations Using the RRA Algorithm for Depth-Dependent Speeds of Sound Valid at Turning Points and Focal Points," IEEE Journal of Oceanic Engineering, Vol. 19, pp. 242-248, 1994.

CONFERENCE PRESENTATION:

Ziomek, L.J., "Recursive Ray Acoustics Algorithm," presented at the Surface ASW Advanced Development and Submarine Combat System Advanced Development Joint Program Review, Naval Undersea Warfare Center (NUWC), New London, CT, 31 January - 4 February 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Three-dimensional Ray Acoustics, Pulse (transient) Propagation Modeling, Underwater Acoustics, Undersea Warfare

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

1994
Faculty Publications and Presentations

JOURNAL PAPERS

Anderson, G.L., Robertson, R.C., Peterson, B.L., and Dillard, D.A., "Embedded Piezoelectric Sensors to Measure Peel Stresses in Adhesive Joints," Experimental Mechanics, Vol. 34, pp. 194-201, September 1994.

Baggeroer, A. B., Sperry, B., Lashkari, K., Chiu, C-S., Miller, J.H., Mikhalevsky, P.N., and Von Der Heydt, K., "Vertical Array Receptions of the Heard Island Feasibility Transmissions," Journal of the Acoustical Society of America, Vol. 96, No. 4, pp. 2395-2413, 1994.

Breakall, J.K., Adler, R.W., and Elliniadis, P.D., "An Investigation of Wird Grid and Surface Patch Modeling Using the Numerical Electromagnetics Code (NEC)," The Applied Computational Electromagnetics Society Journal, Vol. 9, No. 2, pp. 93-113, 1994.

Breakall, J.K., Young, J.S., Hagn, G., Adler, R.W., Faust, D.L., and Werner, D. H., "Modeling and Measurements of HF Antenna Skywave Radiation Patterns in Irregular Terrain," IEEE APS Transactions, Vol. 42, No. 7, pp. 936-945, July 1994.

Borchardt, R.L. and Ha, T.T., "Capture Aloha with Two Random Power Levels," Computer Communications, Vol. 17, No. 1, pp. 67-71, January 1994.

Chiu, C-S., Miller, J.H., and Lynch, J.F., "Inverse Techniques for Coastal Acoustic Tomography, Environmental Acoustics, (D. Lee and M. Schultz, Eds.), World Scientific, pp. 917-931, 1994.

Chiu, C.S., Semtner, A.J., Ort, J.H., and Miller, J.H., "A Ray Variability Analysis of Sound Transmission Form Heard Island to California," Journal of the Acoustical Society of America, Vol. 96, No. 4, pp. 2380-2388, 1994.

Cristi, R., Burl, Russo, N., "Adaptive Quaternion Feedback Regulation for Eigenaxis Rotations," AIAA Journal of Guidance, Control, and Dynamics, Vol. 17, No. 6, November-December 1994.

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Department of Mathematics

The research program of the Mathematics Department seeks to advance the state of knowledge in the areas important to the Department of the Navy and Department of Defense, such as scientific and parallel computing, fluid flow, orbital mechanics, graph theory and simulation and modeling.

The specific research areas of our faculty and their students are reported in detail, including sponsors, later in this book. Output in the form of student theses, technical reports, conference presentations, and refereed journal articles is listed here.

Scientific Computation

The area of scientific computation includes both numerical (on serial and parallel computers), and analytical (symbolic) solutions to a variety of problems of interest to the Department of the Navy and Department of Defense. Research has been conducted by Professors Danielson and Neta to develop parallel versions of the satellite orbit propagator and the differential correction process in current use by the Naval Space Command. The algorithms were tested on a cluster of networked workstations running Parallel Virtual Machines (PVM) software.

Professors Gragg and Borges has continued his research into parallel divide and conquer algorithm for solving large symmetric eigenproblems. Focus on techniques for deflation and extension to the specially structure case of the bi-diagonal singular value decomposition.

On scientific, non-parallel computing, Professor Canright is working on welding problems to determine the scaling and structure of the "cold-corner singularity" in thermocapillary flow in weld pools.

Professor Henson has applied multigrid and multilevel techniques to the image reconstruction problem. He has also finished a book (jointly with Professor Briggs at the University of Colorado, Denver) on the Discrete Fourier Transform, which is at the heart of Fast Fourier Transform (FFT).

Professor Danielson is contributing to the design of ship structures in his work with Professor Fahroo. The goal of their work is to obtain the maximum stresses in rectangular plates subjected to axial load and lateral pressure. The stresses are calculated using a computer code developed with the collaboration of Professor Charles Steele at Stanford University. Implications are made for the current Navy design for ship plating.

Professors Frenzen and Scandrett have initiated a study for the detection of buried mines. The acoustic model is based upon bio-theory of wave propagation in porous media.

Professor Kang has continued his work in nonlinear control theory (started in Washington University, St. Louis, MO). His work is applied to aircraft and spacecraft stabilization.

Simulation and Modeling

Professors Mansager and Neta have finished their work on audio detection algorithms, and modeling of the TUG-V (Tactical Unmanned Ground Vehicle). Professor Mansager is also continuing his work on evaluating the government's concept for flight testing for the Hellfire Longbow Missile System. He is also working on simulating environmental effects on weapon systems.

Professors Barr (USMA) and Neta are editors of a special issue of International Journal on Mathematical and Computer Modeling dedicated to combat modeling. This special issue will appear in 1995.

Discrete Mathematics

Professor Fredricksen has continued his work in graph theory applied to Joint Warfare activities. He has also initiated research in computer security concerning the downgrading of security of digital images. The images when displayed on good quality workstations may appear to be unclassified as to content but by embedding classified material into the image it may be possible for a saboteur, for example, to cause this material to be inadvertently release. Interest has been expressed in this project.

Professor Rasmussen has continued his work in graph theory, to identify classes of graphs whose competition graphs have good coloring properties. Such graphs would be of use in obtaining exact solutions to a variety of resource allocation problems. He is also working on graph completion sequences.

Professor Owen continues his research into game theory. He is working on multilinear extensions of games and applications.

PARALLEL AND DISTRIBUTED ALGORITHMS FOR LARGE SYMMETRIC EIGENPROBLEMS

C.F. Borges, Assistant Professor
Department of Mathematics
Sponsor: Naval Postgraduate School

OBJECTIVE: Continued research into parallel divide and conquer algorithm for solving large symmetric eigenproblems. Focus on techniques for deflation and extension to the specially structure case of the Bi-diagonal Singular Value Decomposition. Research on numerical techniques for the computation of tristimulus values from spectral information.

SUMMARY: A substantial effort was directed to the study and development of the parallel divide and conquer algorithm for generalized symmetric eigenproblems. This work has resulted in the publication of two papers with W.B. Gragg and a conference presentation. This work is already widely known and respected, and has received numerous citations in the literature over the past year. We have been pursuing other aspects of the algorithm this past year including an investigation of methods for implementing it in a distributed computing environment and the refinement of deflation techniques that are used to simplify the problem. I have some new results on deflation strategies including a one-pass deflation algorithm. I believe that these will lead to further publications and possibly to external funding for this research.

Work on the numerical computation of tristimulus values yielded two papers this year, one journal publication and a proceedings publication of work presented in an invited lecture at the First NSF Workshop on Visualization in Earthquake Engineering.

PUBLICATIONS:

Borges, C.F., "On a Class of Gauss-like Quadrature Rules," Numerische Mathematik, Vol. 67, No. 3, pp. 271-288, 1994.

Borges, C.F., "Physical Models, Color, and Perception," Proceedings of the First NSF Workshop on Visualization in Earthquake Engineering, Chico, CA, August 1994.

Borges, C.F., "Numerical Determination of Tristimulus Values," Journal of the Optical Society of America A, Vol. 11, No. 12, pp. 3152-3161, December 1994.

Borges, C.F., Frezza, R., and Gragg, W.B., "Some Inverse Eigenproblems for Jacobi and Aarow Matrices," to appear in Journal of Numerical Linear Algebra Applications.

CONFERENCE PRESENTATION:

Borges, C.F., "Physical Models, Color, and Perception," First NSF Workshop on Visualization in Earthquake Engineering, Chico, CA, August 1994.

OTHER:

Borges, C.F. and Frezza, R., "On Model Identification of Gaussian Reciprocal Processes from the Eigenstructure of their Covariances," Journal of Mathematical Systems, Estimation and Control, under revision.

I have been invited to be a featured speaker at the Fourth International Colloquium on Numerical Analysis where I will talk about parallel divide-and-conquer algorithms for the symmetric eigenproblem.

DOD KEY TECHNOLOGY AREA: Other (Scientific Computation)

KEYWORDS: Inverse Problems, Color Perception, Eigenproblems, Reciprocal Stochastic Processes

ANALYSIS OF THERMOCAPILLARY CONVECTION IN WELDING

D.R. Canright, Associate Professor
Department of Mathematics
Sponsor: Naval Postgraduate School

OBJECTIVE: The goal of this project is to determine the scaling and structure of the "cold-corner singularity" in thermocapillary flow in weld pools. This is a continuing project.

SUMMARY: Recent work in modeling thermocapillary convection in materials processing, for example in the pool of liquid metal formed during welding, shows a region of rapid flow and intense heat transfer, concentrated in the "cold corner" region. A theoretical understanding of this region, currently lacking, is essential for accurate numerical models. The objective of this study is to analyze the coupled thermal and flow fields in this important region. The results should be useful in developing more complete numerical models of the welding process, to understand how to make welds more reliable.

In 1994, the results of work to date were published, including a detailed scaling analysis and extensive numerical simulations of the basic convective feedback mechanism. These results validated the asymptotic behaviors predicted by the scaling, and also showed the details of the transitions between regimes.

Work was begun on extending the model to include the curved interface due to phase change, in an axisymmetric stationary weld pool. The necessary resolution of widely different length scales required sophisticated numerical methods; the Fast Adaptive Composite Grid method using Finite Volume Element discretization was adopted. The programming is currently underway.

PUBLICATION:

Canright, D., "Thermocapillary Flow Near a Cold Wall," Physics of Fluids, Vol. 6, pp. 1415-1424, 1994.

CONFERENCE PRESENTATION:

Canright, D., Henson, V., and Litaker, E., "Thermocapillary Flow in a Weld Pool: A Finite Volume Element Approach," 47th Annual Meeting of the Division of Fluid Dynamics of the American Physical Society, Atlanta, GA, 20-22 November 1994. (Abstract published in 1994 Bulletin of the American Physical Society, Vol. 39, No. 9, p. 1977.)

OTHER:

A second paper, with former thesis student M. Huber, is under revision for publication.

DOD KEY TECHNOLOGY AREA: Materials and Processes

KEYWORDS: Thermocapillary, Solidification, Welding, Crystal Growth, Marangoni, Convection

DISTRIBUTED PARALLEL MULTILEVEL METHODS FOR SOLVING THE COMPRESSIBLE NAVIER-STOKES EQUATIONS AT HIGH REYNOLDS NUMBERS

D.R. Canright, Associate Professor
V.E. Henson, Assistant Professor
Department of Mathematics
Sponsor: Naval Postgraduate School

OBJECTIVE: Numerical simulation of high-speed flows is an extremely valuable tool in the design of vehicles and other engineering enterprises. Current methods are expensive in both computing time and requisite hardware (supercomputers). The objective of this research is to develop new, more efficient algorithms for solving these equations, combining multigrid methods for speed of convergence, multilevel grid-refinement methods for local high accuracy, and parallel implementation for distributed computing on heterogeneous networks for computational speed. This is an ongoing project.

SUMMARY: One of the primary fields of computational interest to the DoN and DoD is the accurate and efficient simulation of fluid flows. Typical applications include performance estimation of new designs for aircraft, submarines, missiles, and other vehicles (external flows) as well as design of turbines, SCRAM-jets, and other engines (internal flows). Currently, numerical modeling of such complicated problems requires significant programming effort and tremendous computing resources, often supercomputers.

In 1994 we began the development of efficient innovative methods for solving such flow problems, by combining multigrid techniques for fast convergence at each step with a parallelized implementation to take advantage of distributed computing over heterogeneous Unix networks. A suite of test problems was developed, and one particular problem was chosen as an initial focus because it combines fluid flow, heat transfer, and tracking of a moving surface of discontinuity. This problem was discretized using the Finite Volume Element method, using a Computer Algebra System to validate the stencils. The Fast Adaptive Grid algorithm will be used to resolve small local scales.

The thermal part of the problem was coded and extensive numerical experiments determined optimum parameters for the algorithm. The programming for the flow portion is underway.

CONFERENCE PRESENTATION:

Canright, D., Henson, V.E., and Litaker, E., "Thermocapillary Flow in a Weld Pool: A Finite Volume Element Approach," 47th Annual Meeting of the Division of Fluid Dynamics of the American Physical Society, Atlanta, GA, 20-22 November 1994. (Abstract published in 1994 Bulletin of the American Physical Society Vol. 39, no. 9, p. 1977.)

THESIS DIRECTED:

Litaker, E., MAJ, USMC, "Finite Volume Element (FVE) Discretization and Multilevel Solution of the Axisymmetric Heat Equation," Master's Thesis, December 1994.

OTHER:

Canright, D. and Henson, V.E., "An FAC-FVE Approach to Convection in Phase Change," scheduled for the Copper Mountain Conference on Multigrid Methods, Copper Mountain, CO, 4 April 1995.

DOD KEY TECHNOLOGY AREA: Software

KEYWORDS: Parallel Processing, Navier-Stokes, Multilevel Methods, Distributed Processing

MAXIMUM STRESSES IN CLAMPED RECTANGULAR PLATES UNDER AXIAL LOAD AND LATERAL PRESSURE

D.A. Danielson, Professor
F. Fahroo, Visiting Assistant Professor
Department of Mathematics
Sponsor: David Taylor Naval Ship R&D Center

OBJECTIVE: Improve structural design of ships.

SUMMARY: The goal of this work is to obtain the maximum stresses in rectangular plate subjected to axial load and lateral pressure. The stresses are calculated using a computer code developed with the collaboration of Professor Charles Steele at Stanford University. Implications are made for the current Navy design for ship plating.

PUBLICATION:

Danielson, D.A., "Analytical Tripping Loads for Stiffened Plates," Naval Postgraduate School Technical Report, NPS-MA-94-006, June 1994.

THESIS DIRECTED:

Meissel, J.E., LT, USN, "Acoustic Spectroscopic Determination of Dynamic Material Properties from a Free-Free Bar Resonant Based Technique," Master's Thesis, June 1994.

DOD KEY TECHNOLOGY AREA: Computers, Software

KEYWORDS: Plates, Stresses, Ship Structures

NATURAL FREQUENCIES OF VIBRATING BEAMS

D.A. Danielson, Professor
Department of Mathematics
D. Brown, Research Assistant Professor
Department of Physics
Sponsor: Naval Postgraduate School

OBJECTIVE: Develop formulas for prediction elastic module of hydrophone materials.

SUMMARY: Literature on the dynamic resonance method for measuring the elastic module of solids was reviewed. Formulas were extended to correct for the added mass and stiffness of the wires used in experiments being conducted at the Naval Postgraduate School Acoustics Laboratory.

OTHER:

The investigators and LT Mick Meissel are preparing a paper for submission to the Journal of the Acoustical Society of America. Completion expected in 1994.

DOD KEY TECHNOLOGY AREA: Materials and Processes

KEYWORDS: Acoustics, Hydrophones, Beams

SEMIANALYTIC SATELLITE THEORY: TRUNCATION ALGORITHMS

D. Danielson, Professor
Department of Mathematics
Sponsor: Naval Postgraduate School

OBJECTIVE: We (D. Danielson, and C.Sagovac) continue the development of software for using parallel computers and workstation clusters running PVM (Parallel Virtual Machine software) to predict the paths of Earth orbiting objects. We develop mathematical algorithms for the automatic truncation of series in SST (Semianalytic Satellite Theory). We are currently preparing a document to bridge the SST code and our mathematical algorithms document recently completed.

SUMMARY: We have finished our 100-page technical report detailing the algorithms in the semianalystic satellite theory. In this report, we have collected information that was scattered in the literature, unified the notation, rederived almost all the equations, and extended the theory.

PUBLICATIONS:

Danielson, D.A., "Semianalytic Satellite Theory," Proceedings of the U.S./Russian Orbit Determination and Prediction Workshop, U.S. Naval Observatory, Washington, DC, 1994.

Stone, L.C., Shukla, S.B., and Neta, B., "Parallel Orbit Prediction Using a Workstation Cluster," International Journal of Computer and Mathematics with Applications, Vol. 28, pp. 1-8, 1994.

Neta, B., Danielson, D.A., Ostrom, S., and Brewer, S.K., "Performance of Analytic Orbit Propagator on a Hypercube and a Workstation Cluster," Proceedings AIAA-AAS Astrodynamics Program, in Scottsdale, AZ, Paper Number 94-3706, 1994.

Danielson, D.A., Neta, B., and Early, L.W., "Semianalytic Satellite Theory (SST): Mathematical Algorithms," Naval Postgraduate School Technical Report, NPS-MA-94-001, 1994.

Danielson, D.A., "Analytical Tripping Loads for Stiffened Plates," Naval Postgraduate School Technical Report, NPS-MA-94-006, 1994.

CONFERENCE PRESENTATIONS:

Neta, B., Danielson, D.A., Ostrom, S., and Brewer, S.K., "Performance of Analytic Orbit Propagator on a Hypercube and a Workstation Cluster," AIAA-AAS Astrodynamics Program, in Scottsdale, AZ, 1-3 August 1994.

Danielson, D.A., "Semianalytic Satellite Theory," U.S./Russian Orbit Determination and Prediction Workshop, U.S. Naval Observatory, Washington, DC, 1994.

DOD KEY TECHNOLOGY AREA: Computers, Software, Design Automation

KEYWORDS: Artificial Satellites, Parallel Computers, Orbit Prediction

WAKE GENERATION OF INTERNAL WAVES

C. Frenzen, Associate Professor
C. Scandrett, Associate Professor
Department of Mathematics
Sponsor: Naval Postgraduate School

OBJECTIVE: The objective of this research shifted midway through the academic year to another topic. The new emphasis has been on the detection of buried mines. To this end, the principle investigators are developing an acoustic means of mine detection in porous media. The acoustic model is based upon Bio-theory of wave propagation in porous media. Ultimately, when the forward problem has been well enough developed, the inverse problem will be tackled.

SUMMARY: In this preliminary year of work, the investigators have set out a course of action for the methodology to be used in subsequent years. At present, the authors have developed a bi-orthogonality law for porous media, which will be invaluable in studying the behavior of Rayleigh surface waves propagating on and scattering from porous media with disparate material properties. The bi-orthogonality principle has been submitted for publication, and the authors are currently working on employing the principle to the two dimensional scattering of Rayleigh waves from two joined quarter planes.

OTHER:

Two thesis students (Jonah Shen and William Stewart) scheduled to graduate in September 1995 are currently working on experimental and numerical simulations of surface wave propagation in porous media.

"A bi-orthogonality relationship for porous media," paper submitted for publication to the Journal of the Acoustical Society of America.

DOD KEY TECHNOLOGY AREA: Sensors, Environmental Effects, Software

KEYWORDS: Acoustics, Porous Media, Scholte Waves, Scattering/radiation, Surface/interface Waves

MULTIGRID, MULTILEVEL, AND MULTILEVEL PROJECTION METHODS

V.E. Henson, Assistant Professor
Department of Mathematics
Sponsor: Unfunded

OBJECTIVE: To formulate theoretical foundations of the multigrid, multilevel, and multilevel projection method (PML), and apply them to several problems, specifically to the image reconstruction problem and to the solution of certain nonlinear PDEs.

SUMMARY: This work is the unfunded continuation of projects funded in 1990, 1991, and 1992 by the Naval Postgraduate School Research Council. Multigrid and multilevel methods are numerical computation methods that take advantage of all of the scales of a problem in order to accelerate the convergence to the solution. Design and implementation of the methods, however, is not simple, and many workers have resisted using them because of their complexity. Recently a new approach, called multilevel projection, was formulated by Stephen F. McCormick which greatly simplifies the design and implementation of multilevel methods. This project investigates the theoretical foundation and the application of these methods to several types of problems, including solution and grid refinement methods for PDEs, specifically certain semilinear elliptic equations that arise in non-Newtonian fluid flow, and multilevel methods for image reconstruction (the Radon Transform problem).

Output from this research in 1994 included one published refereed paper (accepted, to appear), two published conference proceedings papers, two conference presentations, and one completed PhD dissertation. Several further publications are expected to result, as well.

PUBLICATIONS:

Henson, V.E., Limber, M.A., McCormick, S.F., and Robinson, B.T., "Multilevel Image Reconstruction with Natural Pixels," to appear in SIAM Journal of Scientific and Statistical Computing.

Henson, V.E., Limber, M.A., McCormick, S.F., and Robinson, B.T., "Spotlight Computed Tomography with Natural Pixels," Proceedings of the SIAM conference on linear algebra, Snowbird, UT, 1994.

CONFERENCE PRESENTATION:

Henson, V.E., Limber, M.A., McCormick, S.F., and Robinson, B.T., "Multilevel Image Reconstruction with Natural Pixels," Colorado Conference on Iterative Methods, Breckenridge, CO, April 1994.

THESIS DIRECTED:

Robinson, B.T., "A Multilevel Approach to the Algebraic Image Reconstruction Problem," Doctoral Dissertation, June 1994.

OTHER:

Shaker, A.W. and Henson, V. E., "Multigrid Solution of a Singular Nonlinear BVP in Fluid Theory," the First Asian CFD Conference, Hong Kong, forthcoming 18 January 1995.

Henson, V.E. and Shaker, A.W., "Multigrid Solution of a Singular Nonlinear BVP in Fluid Theory," Proceedings of the First Asian CFD Conference, Vol. 2, pp. 791-796, Hong Kong University of Science and Technology, forthcoming in 1995.

This project is ongoing research. The conference paper by Henson and Shaker is being rewritten for submission to a refereed journal. A follow-up paper from that work, as well as an expanded paper on spotlight image reconstruction are expected.

DOD KEY TECHNOLOGY AREA: Other (Scientific Computation)

KEYWORDS: Multigrid, Numerical PDEs, Image Reconstruction

THE DFT: AN OWNER'S MANUAL FOR THE DISCRETE FOURIER TRANSFORM

V.E. Henson, Assistant Professor
Department of Mathematics
W.L. Briggs, University of Colorado, Denver
Sponsor: Unfunded

OBJECTIVE: To write a tutorial on the Discrete Fourier Transform (DFT), aimed at a broad audience of engineers, scientists, and mathematicians. Certain sections on error analysis of the DFT include new results.

SUMMARY: This unfunded work is the joint work of Professor Henson and his dissertation advisor, Professor

William L. Briggs (University of Colorado at Denver). It is designed to provide a tutorial level discussion of the DFT, which is at the heart of the Fast Fourier Transform (FFT), perhaps the most frequently used of all mathematical computer algorithms. Despite its enormous popularity and the many books written about the FFT, there are many aspects of the DFT which are not widely publicized, and yet which critically affect the use and performance of the FFT. This text is sufficiently rigorous to present the many faces of the DFT in detail, while remaining accessible to readers with only a moderate background in mathematics. It is to be published by the Society for Industrial and Applied Mathematics.

This ongoing project has been completed, with the final manuscript submitted to the publisher. Two other results of this work have been prepared: an article has been submitted to a refereed journal, and a technical report was published under the auspices of the University of Colorado Computational Mathematics Group.

PUBLICATIONS:

Briggs, W.L. and Henson, V. E., "The DFT: An owner's manual for the discrete Fourier transform," Society for Industrial and Applied Mathematics, 434 pages, in press, publication date scheduled for 29 March 1995.

Briggs, W.L. and Henson, V.E., "A Table of Analytical Discrete Fourier Transforms," Technical Report, Computational Mathematics Group, University of Colorado at Denver, forthcoming in 1995.

Henson, V.E., Limber, M.A., McCormick, S.F., and Robinson, B.T., "Multilevel Image Reconstruction with Natural Pixels," to appear in SIAM Journal of Scientific and Statistical Computing.

Henson, V.E., Limber, M.A., McCormick, S.F., and Robinson, B.T., "Spotlight Computed Tomography with Natural Pixels," Proceedings of the SIAM conference on linear algebra, Snowbird, UT, 1994.

Henson, V.E. and Shaker, A.W., "Multigrid Solution of a Singular Nonlinear BVP in Fluid Theory," "Proceedings of the First Asian CFD Conference, Vol. 2, pp. 791-796, Hong Kong University of Science and Technology, forthcoming 1995.

Briggs, W.L. and Henson, V.E., "The DFT: an owner's manual for the discrete Fourier transform," Society for Industrial and Applied Mathematics, Philadelphia, PA, in press (appears March 29, 1995).

CONFERENCE PRESENTATIONS:

Henson, V.E., Limber, M.A., McCormick, S.F., and Robinson, B.T., "Multilevel Image Reconstruction with Natural Pixels," Colorado Conference on Iterative Methods, Breckenridge, CO, April 1994.

Canright, D., Henson, V.E., and Litaker, E., "Thermocapillary Flow in a Weld Pool: A Finite Volume Element Approach," 47th Annual Meeting of the Division of Fluid Dynamics of the American Physical Society, Atlanta, GA, 20-22 November 1994. (Abstract published in 1994 Bulletin of the American Physical Society Vol. 39, no. 9, p. 1977.)

THESES DIRECTED:

Robinson, B.T., "A Multilevel Approach to the Algebraic Image Reconstruction Problem," Doctoral Dissertation, June, 1994.

Litaker, E., MAJ, USMC, "Finite Volume Element (FVE) Discretization and Multilevel Solution of the Axisymmetric Heat Equation," Master's Thesis, December 1994.

OTHER:

Briggs, W.L. and Henson, V.E., "A Table of Analytical Discrete Fourier Transforms," Technical Report, Computational Mathematics Group, University of Colorado at Denver, forthcoming in 1995.

Briggs, W.L. and Henson, V.E., "A Table of Analytical Discrete Fourier Transforms," submitted to the Journal of Fourier Analysis.

Briggs, W.L. and Henson, V.E., "A Table of Analytical Discrete Fourier Transforms," submitted to the Journal of Fourier Analysis.

Shaker, A.W. and Henson, V.E., "Multigrid Solution of a Singular Nonlinear BVP in Fluid Theory," The First Asian CFD Conference, Hong Kong, forthcoming in January 1995.

Canright, D. and Henson, V.E., "An FAC-FVE Approach to Convection in Phase Change," scheduled for the Copper Mountain Conference on Multigrid Methods, Copper Mountain, CO, April 1995.

DOD KEY TECHNOLOGY AREA: Other (Scientific Computing)

KEYWORDS: Fourier Analysis, Fourier Transforms, FFT, DFT

NONLINEAR H∞ CONTROL, DISTURBANCE DECOUPLING AND THEIR APPLICATIONS

W. Kang, Assistant Professor
Department of Mathematics
Sponsor: Naval Postgraduate School

OBJECTIVE: The goal of this project is to investigate the methodology of feedback design for the purpose of minimizing the influence of disturbances on the performance of nonlinear control systems. The theory is believed to be useful to problems such as aircraft control, under water vehicle control, helicopter control and spacecraft control etc.

SUMMARY: The Hamilton-Jacobi-Isaacs inequality for the problem of rigid body control via H∞ method was successfully solved on the Lie group SO(3). A robust stabilizing feedback was designed based on the solution. Computer simulations were also carried out to show the performance of the system under the designed feedback. Another related problem investigated was the domain of attraction of a nonlinear control system under a stabilizing feedback. Limit for attraction basin of some control systems was found. For homogeneous systems, local stabilizable by L2 feedback was proved to be equivalent to the property of semi-global stabilization.

PUBLICATIONS:

Kang, W., "Spacecraft stabilization via nonlinear H∞ method," Proceedings IEEE Conference on Decision and Control, Orlando, FL, 1994.

Isidori, A. and Kang. W., "H∞ control via measurement feedback for general nonlinear systems," IEEE Transactions on Automation Control, to appear in 1995.

Kang, W., "Nonlinear H∞ control and its application to rigid spacecraft," IEEE Transactions on Automation Control, to appear in 1995.

CONFERENCE PRESENTATION:

Kang, W., "Spacecraft stabilization via nonlinear H∞ method," IEEE Conference on Decision and Control, Orlando, FL, 1994.

OTHER:

Byrnes, C.I., Priscoli, F., Delli, Isidori, A., and Kang W., "New results on output regulation of nonlinear systems," submitted to IEEE Transactions on Automation Control.

Kang, W., "Some applications of Zubov's theorem to nonlinear control systems," submitted to Systems and Control Letters.

Kang, W. and Huang, J., "Calculation of the minimal dimension k^{th}-order robust servo-regulator," in preparation.

DOD KEY TECHNOLOGY AREA: Design Automation

KEYWORDS: Nonlinear H-infinity Control, Disturbance Decoupling

AUDIO DETECTION ALGORITHMS

B. Neta, Professor
Department of Mathematics
Sponsor: TRAC-Monterey

OBJECTIVE: The goal of this project was to investigate the benefit of audio cueing in detection algorithms used in Janus.

SUMMARY: Audio information concerning targets generally includes direction, frequencies and energy levels. One use of audio cueing is to use direction information to help determine where more sensitive visual detection and acquisition sensors should be directed. Generally, use of audio cueing will shorten times required for visual detection, although there could be circumstances where the audio information is misleading and degrades visual performance. Audio signatures can also be useful for helping classify the emanating platform, as well as to provide estimates of its velocity.

The Janus combat simulation is the premier high resolution model used by the Army and other agencies to conduct research. This model has a visual detection model which essentially incorporates algorithms as described by Hartman. The model in its current form does not have any sound cueing capabilities. We have modified Janus combat simulation model to include the Tactical Unmanned Ground Vehicle (TUGV) for sound acquisition. The new model also allows sound to be played by using a subroutine ACOUSDET2 developed by TRAC White Sands.

PUBLICATIONS:

Cersovsky, D., Kleinschmidt, E., Mansager, B., and Neta, B., "Audio Detection Algorithms in Combat Simulations," International Journal of Mathematical and Computer Modelling, 1994, accepted for publication.

Neta, B. and Mansager, B., "Benefit of Sound Cueing in Combat Simulation," Naval Postgraduate School Technical Report, NPS-MA-94-003, 1994.

DOD KEY TECHNOLOGY AREA: Computers, Software

KEYWORDS: Simulation, Janus, Combat modelling

PARALLEL ORBIT PROPAGATORS

B. Neta, Professor
Department of Mathematics
Sponsor: National Research Laboratory

OBJECTIVE: The goal of this project was to investigate the benefit of PVM (parallel Virtual Machines) software for prediction of orbits of objects.

SUMMARY: I have audited a class in ECE (EC4820) in which I learned to use the software PVM (Parallel Virtual Machine). This software allows a heterogeneous set of networked workstations (or computers) to appear as a parallel computer. The software is available (free of charge) from Oak Ridge National Laboratory. It is now residing on the LRC at ECE department.

A paper (with a former student, Leon C. Stone) [1] appeared in Computers and Mathematics with Applications and another [2] was presented at AIAA/AAS Astrodynamics meeting in Scottsdale, AZ, and appeared in the proceedings.

I have visited NRL, Washington, DC and have produced (jointly with Dr. Shannon Coffey) a parallel (PVM) version to update the catalog of objects as used by NAVSPACECOM. This software was given to NAVSPACECOM.

I have been active in the Parallel Processing Forum (a team of scientists who seek to develop highly accurate algorithms which exceed current system capabilities in all areas of orbit determination, estimation, and propagation). I have presented the research of our group to the forum.

PUBLICATIONS:

Stone, L.C., Shukla, S.B., and Neta, B., "Parallel Orbit Prediction Using a Workstation Cluster," International Journal of Computer and Mathematics with Applications, Vol. 28, pp. 1-8, 1994.

Neta, B., Danielson, D.A., Ostrom, S., and Brewer, S.K., "Performance of Analytic Orbit Propagator on a Hypercube and a Workstation Cluster," Proceedings AIAA-AAS Astrodynamics Program, in Scottsdale, AZ, Paper Number 94-3706, 1994.

CONFERENCE PRESENTATION:

Neta, B., Danielson, D.A., Ostrom, S., and Brewer, S.K., "Performance of Analytic Orbit Propagator on a Hypercube and a Workstation Cluster," AIAA-AAS Astrodynamics Program, in Scottsdale, AZ, 1-3 August 1994.

DOD KEY TECHNOLOGY AREA: Computers, Software, Design Automation

KEYWORDS: Artificial Satellites, Parallel Computers, Orbit Prediction

ORBIT PREDICTION USING SEMIANALYTIC SATELLITE THEORY AND PARALLEL COMPUTERS

B. Neta, Professor
D. Danielson, Professor
Department of Mathematics
Sponsor: NAVSPACECOM

OBJECTIVE: We (D. Danielson, B. Neta and C.Sagovac) continue the development of software for using parallel computers and workstation clusters running PVM (Parallel Virtual Machine software) to predict the paths of Earth orbiting objects. We develop mathematical algorithms for the automatic truncation of series in SST (Semianalytic Satellite Theory). We are currently preparing a document to bridge the SST code and our mathematical algorithms document recently completed.

SUMMARY: We have finished our 100-page technical report detailing the algorithms in the semianalystic satellite theory. In this report, we have collected information that was scattered in the literature, unified the notation, rederived almost all the equations, and extended the theory.

We have started the second document to bridge the theory with the R\&D GTDS code. This document will not be ready this year. In order to get more acquainted with the semianalytic satellite theory code, I have been experimenting with it, to correct the results of our former student (W. Dyar) and add other examples. We have optimized the code and added calls to measure the run time. Lt Dan Fonte (Phillips Lab) has visited me and together we continued to experiment with R\&D GTDS. The results of our experiments will be presented at AIAA/AAS conference this summer.

PUBLICATIONS:

Danielson, D.A., "Semianalytic Satellite Theory," Proceedings of the U.S./Russian Orbit Determination and Prediction Workshop, U.S. Naval Observatory, Washington, DC, 1994.

Stone, L.C., Shukla, S.B., and Neta, B., "Parallel Orbit Prediction Using a Workstation Cluster," International Journal of Computer and Mathematics with Applications, Vol. 28, pp. 1-8, 1994.

Neta, B., Danielson, D.A., Ostrom, S., and Brewer, S.K., "Performance of Analytic Orbit Propagator on a Hypercube and a Workstation Cluster," Proceedings AIAA-AAS Astrodynamics Program, in Scottsdale, AZ, Paper Number 94-3706, 1994.

Danielson, D.A., Neta, B., and Early, L.W., "Semianalytic Satellite Theory (SST): Mathematical Algorithms," Naval Postgraduate School Technical Report, NPS-MA-94-001, 1994.

CONFERENCE PRESENTATIONS:

Neta, B., Danielson, D.A., Ostrom, S., and Brewer, S.K., "Performance of Analytic Orbit Propagator on a Hypercube and a Workstation Cluster," AIAA-AAS Astrodynamics Program, in Scottsdale, AZ, 1-3 August 1994.

Danielson, D.A., "Semianalytic Satellite Theory," U.S. Russian Orbit Determination and Prediction Workshop, U.S. Naval Observatory, Washington, DC, 1994.

DOD KEY TECHNOLOGY AREA: Computers, Software, Design Automation

KEYWORDS: Artificial Satellites, Parallel Computers, Orbit Prediction

MULTILINEAR EXTENSIONS OF GAMES AND THEIR APPLICATIONS

G. Owen, Professor
Department of Mathematics
Sponsor: National Science Foundation

OBJECTIVE: The objective of this project is to generalize the theory of multilinear extensions of games and consider possible applications.

SUMMARY: Multilinear extensions were used to develop a model for non-equilibrium behavior in economic markets. In the special case of homogeneous production functions with two input goods, an efficient algorithm was developed to evaluate expected payoffs.

On a more abstract note, multilinear extensions were used, (a) to study symmetries of games, (b) to study the gains and benefits to be expected from prior commitments to form coalitions, and (c) to study the possible controls in corporations where there are interlocking boards of directors, or in situations where several corporations own shares in each other.

Finally, multilinear extensions were used to generalize Rubinstein's two-person sequential bargaining model to one-person bargaining situations.

PUBLICATIONS:

Carreras, F. and G. Owen, "Automorphisms and Weighted Values of Games," to appear in International Journal of Game Theory.

Owen, G., "The Not-Quite Non-Atomic Game," to appear in International Journal of Game Theory.

Amer, R., Carreras, F., Magañ a, A., and G. Owen, "Multilinear Extensions and Quotients of Simple Games," to appear in Naval Research Logistics.

OTHER:

Carreras, F. and G. Owen, "Separation of Games by Weighted Values," submitted.

Owen, G., "Multilinear Extensions and Rubinstein's Bargaining Model," submitted.

DOD KEY TECHNOLOGY AREA: Other (Multilinear Extensions)

KEYWORDS: Game Theory, Bargaining, Economic Markets

CLASSIFICATION OF GRAPHS WITH EFFICIENTLY COLORABLE COMPETITION GRAPHS

C.W. Rasmussen, Assistant Professor
Department of Mathematics
Sponsor: Naval Postgraduate School

OBJECTIVE: The goal of this project was to identify classes of graphs whose competition graphs have good coloring properties. Such graphs would be of use in obtaining exact solutions to a variety of resource allocation problems.

SUMMARY: This summary covers the final funded year of a project that was funded by the Research Initiation Program. The work yielded interesting results, and promises to continue to do so, predominantly in the more general areas of p-competition and tolerance competition graphs. The primary focus was on classification of undirected graphs whose competition graphs fall into the class of interval graphs. The characterization of undirected graphs with interval squares and interval two-step graphs is complete. Additionally, results were obtained placing tight bounds on the chromatic numbers of competition graphs of tournaments.

PUBLICATIONS:

Lundgren, J.R., Merz, S.K. and Rasmussen, C.W., "Chromatic Numbers of Competition Graphs," accepted and scheduled to appear March 1995 in Linear Algebra and Its Applications.

Lundgren, J.R., Maybee, J.S., Merz, S.K., and Rasmussen, C.W., "A Characterization of Graphs With Interval Two-step Graphs," accepted and scheduled to appear March 1995 in Linear Algebra and Its Applications.

CONFERENCE PRESENTATIONS:

Langley, L., Lundgren, J.R., McKenna, P.A., Merz, S.K., and Rasmussen, C.W., "p-Competition Graphs of Strongly Connected and Hamiltonian Digraphs," Twenty-fifth Southeastern International Conference on Combinatorics, Graph Theory, and Computing, Boca Raton, FL, March 1994.

Anderson, C., Langley, L., Lundgren, J.R., McKenna, P.A., Merz, S.K., and Rasmussen, C.W., "p-Competition Graphs and Tolerance Competition Graphs," Seventh SIAM Conference on Discrete Mathematics, Albuquerque, NM, June 1994.

OTHER:

Papers in progress in 1994, to be submitted in 1995:

Langley, L., Lundgren, J.R., McKenna, P.A., Merz, S.K., Rasmussen, C.W., "The p-Competition Graphs of Strongly Connected and Hamiltonian Digraphs."

Lundgren, J.R., McKenna, P.A., and Merz, S.K., "p-Competition Graphs of Symmetric Digraphs and p-Neighborhood Graphs."

Anderson, C., Langley, L., Lundgren, J.R., McKenna, P.A., Merz, S.K., and Rasmussen, C.W., "p-Competition Graphs and Tolerance Competition Graphs."

DOD KEY TECHNOLOGY AREA: Communications Networking, Other (Resource allocation)

KEYWORDS: Graph Coloring, Competition Graphs, Interval Graphs

GRAPH COMPLETION SEQUENCES

C.W. Rasmussen, Assistant Professor
Department of Mathematics
Sponsor: Unfunded

OBJECTIVE: The goals of this project are to (i) identify those classes of graphs that allow sequential inclusion of all missing edges without inducing the loss of the properties defining the respective classes, (ii) develop

efficient algorithms for generating such completion sequences, and (iii) to investigate potential applications for such sequences.

SUMMARY: This summary covers the early stages of a project that was unfunded in FY94 and which has been partially funded by the Naval Postgraduate School in FY95. The work has its roots in work done in the 1980s by Grone, Johnson, et al., which showed that for any chordal graph there exists a sequence of edge insertions with the property that each of the resulting graphs is chordal. This observation was the key to solving a problem in matrix analysis. Subsequent work by this investigator has shown that a number of other classes of graphs allow such completion sequences. Current work emphasizes the interplay between such sequences and elimination orders, and the development of good algorithms for generating such sequences.

PUBLICATIONS:

Rasmussen, C.W., "Conditional Graph Completions," Congressus Numerantium, Vol. 103, pp.183-192, 1994; Naval Postgraduate School Technical Report, NPS-MA-94-005, May 1994.

CONFERENCE PRESENTATION:

Rasmussen, C.W., "Conditional Graph Completions," Twenty-fifth Southeastern International Conference on Combinatorics, Graph Theory, and Computing, Boca Raton, FL, March 1994.

DOD KEY TECHNOLOGY AREA: Other (Applied Mathematics)

KEYWORDS: Perfect Graphs, Elimination Orders, Matrix Completions

DEPARTMENT OF MATHEMATICS

1994
Faculty Publications and Presentations

JOURNAL PAPERS

Borges, C.F., "On a Class of Gauss-like Quadrature Rules," Numerische Mathematik, Vol. 67, No. 3, pp. 271-288, 1994.

Borges, C.F., "Numerical Determination of Tristimulus Values," Journal of the Optical Society of America A, Vol. 11, No. 12, pp. 3152-3161, December 1994.

Canright, D., "Estimating the Spatial Extent of Attractors of Iterated Function Systems," Computers and Graphics, Vol. 18, pp. 231-238, 1994.

Canright, D., "Thermocapillary Flow Near a Cold Wall," Physics of Fluids, Vol. 6, pp. 1415-1424, 1994.

Franke, R., Hagen, H., and Nielson, G.M., "Least squares surface approximation to scattered data using multiquadric functions," Advances in Computational Mathematics, Vol. 2, pp. 81-99, 1994.

Kang, W., "Extended controller form and invariants of nonlinear control systems with a single input," Journal of Mathematical System, Estimation and Control, Vol. 4, pp. 253-256, 1994.

Kang, W., "Approximate Linearization of Nonlinear Control Systems," Systems and Control Letters, Vol. 23, No. 1, pp. 43-52, July 1994.

Owen, G., "The Non-consistency and Non-Uniqueness of the Consistent Value," Essays in Game Theory in Honor of Michael Maschler, N. Megiddo, ed., Berlin (Springer Verlag), pp. 15-162, 1994.

Owen, G. and Gambarelli, G., "Indirect Control of Corporations," International Journal of Game Theory, pp. 287-302, 1994.

Owen, G. and Gambarelli, G., "50 Years of Game Theory," Journal of European Business Education, 1994.

Rasmussen, C.W., "Conditional Graph Completions," Congressus Numerantium, Vol. 103, pp.183-192, 1994.

Scandrett, C.L. and Canright, D, "Low Frequency Active Array Calculations in a Shallow Channel," Journal of the Acoustical Society of America, Vol. 96, pp. 557-563, 1994.

Stone, L.C., Shukla, S.B., and Neta, B., "Parallel Orbit Prediction Using a Workstation Cluster," International Journal of Computer and Mathematics with Applications, Vol. 28, pp. 1-8, 1994.

CONFERENCE PAPERS

Borges, C.F., "Physical Models, Color, and Perception," Proceedings of the First NSF Workshop on Visualization in Earthquake Engineering, Chico, CA, August 1994.

Danielson, D.A., "Semianalytic Satellite Theory," Proceedings of the U.S./Russian Orbit Determination and Prediction Workshop, U.S. Naval Observatory, Washington, DC, 1994.

Henson, V.E., Limber, M.A., McCormick, S.F., and Robinson, B.T., "Spotlight Computed Tomography with Natural Pixels," Proceedings of the SIAM conference on Linear Algebra, Snowbird, UT, 1994.

Henson, V.E. and Shaker, A.W., "Multigrid Solution of a Singular Nonlinear BVP in Fluid Theory," forthcoming Proceedings of the First Asian CFD Conference, Vol. 2, pp. 791-796, Hong Kong University of Science and Technology, 1995.

Kang, W., "Spacecraft stabilization via nonlinear H∞ method," Proceedings IEEE Conference on Decision and Control, Orlando, FL, 1994.

Neta, B., Danielson, D.A., Ostrom, S., and Brewer, S.K., "Performance of Analytic Orbit Propagator on a Hypercube and a Workstation Cluster," Proceedings AIAA-AAS Astrodynamics Program, paper number 94-3706, Scottsdale, AZ, 1994.

CONFERENCE PRESENTATIONS

Anderson, C., Langley, L., Lundgren, J.R., McKenna, P.A., Merz, S.K., and Rasmussen, C.W., "p-Competition Graphs and Tolerance Competition Graphs," Seventh SIAM Conference on Discrete Mathematics, Albuquerque, NM, June 1994.

Borges, C.F., "Physical Models, Color, and Perception," presented at the First NSF Workshop on Visualization in Earthquake Engineering, Chico, CA, August 1994.

Canright, D., Henson, V., and Litaker, E., "Thermocapillary Flow in a Weld Pool: A Finite Volume Element Approach," 47th Annual Meeting of the Division of Fluid Dynamics of the American Physical Society, Atlanta, GA, 20-22 November 1994. (Abstract published in 1994 Bulletin of the American Physical Society, Vol. 39, No. 9, p. 1977.)

Henson, V.E., Limber, M.A., McCormick, S.F., and Robinson, B.T., "Multilevel Image Reconstruction with Natural Pixels," Colorado Conference on Iterative Methods, Breckenridge, CO, April 1994.

Kang, W., "Spacecraft stabilization via nonlinear H∞ method," IEEE Conference on Decision and Control, Orlando, FL, 1994.

Langley, L., Lundgren, J.R., McKenna, P.A., Merz, S.K., and Rasmussen, C.W., "p-Competition Graphs of Strongly Connected and Hamiltonian Digraphs," Twenty-fifth Southeastern International Conference on Combinatorics, Graph Theory, and Computing, Boca Raton, FL, March 1994.

Mansager, B., "Modeling Remotely Piloted Vehicles in Janus," presented at the Reconnaissance Symposium, Department of Systems Engineering, U.S. Military Academy, West Point, NY, 5-6 May 1994.

Mansager, B., "Pre-Test Modeling of the Javelin Antitank System," presented at the Military Operations Research Society Symposium, U.S. Air Force Academy, Colorado Springs, CO, 7-9 June 1994.

Mansager, B., "Supporting Acquisition Decisions Through Effective Experimental Design," presented at the Military Operations Research Society Symposium, U.S. Air Force Academy, Colorado Springs, CO, 7-9 June 1994.

Neta, B., Danielson, D.A., Ostrom, S., and Brewer, S.K., "Performance of Analytic Orbit Propagator on a Hypercube and a Workstation Cluster," AIAA-AAS Astrodynamics Program, Scottsdale, AZ, 1-3 August 1994.

Owen, G., "Multilinear Extensions and the Rubinstein Approach to Nash's Bargaining Problem," International Conference on 50 Years of Game Theory, Barcelona, Spain, 29 June 1994; Spanish National Conference on Game Theory, Bilbao, Spain, 16 September 1994.

Owen, G., Granot, D., Maschler, M., and Zhu, W.R., "The Kernel/Nucleolus of a Standard Tree Game," International Conference on Game Theory, Chicago, IL, 14 August 1994.

Owen, G., "Applications of Game Theory to Networks," Conference on Networks and Competition, Toulouse, France, 14 October 1994.

Rasmussen, C.W., "Conditional Graph Completions," Twenty-fifth Southeastern International Conference on Combinatorics, Graph Theory, and Computing, Boca Raton, FL, March 1994.

TECHNICAL REPORTS

Danielson, D.A., "Analytical Tripping Loads for Stiffened Plates," Naval Postgraduate School Technical Report, NPS-MA-94-006, June 1994.

Danielson, D.A., Neta, B., and Early, L.W., "Semianalytic Satellite Theory (SST): Mathematical Algorithms," Naval Postgraduate School Technical Report, NPS-MA-94-001, 1994.

Mansager, B., "Model Test Model," Naval Postgraduate School Technical Report, NPS-MA-94-007, September 1994.

Neta B. and Mansager, B., "Benefit of Sound Cuing in Combat Simulation," Naval Postgraduate School Technical Report, NPS-MA-94-003, 1994.

Rasmussen, C.W., "Conditional Graph Completions," Naval Postgraduate School Technical Report, NPS-MA-94-005, May 1994.

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Department of Mechanical Engineering

The Department of Mechanical Engineering's research program continues to advance the state of knowledge in areas important to the U.S. Navy, in particular, those areas involving solid mechanics and composite structures; underwater shock and vibration/noise; control of dynamic systems; applications to electronic cooling, welding, boiling and condensation, and applied thermodynamics; and materials science applied to metals and metal matrix composites. Results of research are published in student theses, NPS technical reports, and in papers presented both at, and appearing in, national conference proceedings, and published in scientific journals. The following is an overview of each area of research with individual faculty summaries.

Solid Mechanics, Shock and Vibration

Professor Shin has continued his investigation of "Response of Naval Structures to Underwater Explosions" under the sponsorship of the Defense Nuclear Agency (DNA), Naval Surface Warfare Center (NSWC) - Annapolis Detachment, and Naval Sea Systems Command (NAVSEA). For DNA project, the analytical and numerical studies of underwater explosion and its effect to the naval structures have been conducted. There are three basic features; (i) shock wave propagation through the surrounding hydro-acoustic medium and the behavior of explosive-gas bubble, (ii) structural dynamics problems with material and geometric nonlinearities, and (iii) fluid - structure interaction and explosive gas bubble - structure interaction. The scientific objective of NAVSEA project is to simulate the ship-shock environment and its effect to shipboard combat systems using Navy's mediumweight shock machine with tuned mounting fixture. The multi-DOF tuned deck simulator has been designed, fabricated, and shock testing was performed using U.S. Navy's mediumweight shock machine with designed tuned deck simulator and the analytical results were compared with those of tests. Addendum to MIL-S-901D was proposed to the mediumweight shock qualification procedures. NSWC-Annapolis has been developing Advanced Lightweight Influence Sweep System (ALISS). ALISS is an Advanced Technology Demonstration to validate the feasibility of superconducting technology to sweep magnetic influence mines in shallow water. Under the extremes of shock and vibration environment, the high magnetic field of the superconducting coil may collapse and jeopardize its mission. We developed operational shock and vibration criteria to be designed into ALISS and have been performed numerical simulation of dynamic response of superconductor magnet.

Professor Shin has also conducted an investigation of time-frequency domain distribution and its application to reciprocating machinery analysis from the standpoint of machinery condition monitoring and diagnostics. Pseudo Wigner-Ville distribution and wavelet transform were used to characterize the non-stationary signatures in time-frequency domain. The project was sponsored by NAVSEADET PERA (CV).

Professor Kwon worked on five major projects during this reporting period. One of them was biomechanics project studying the human knee to understand the motion of the posterior cruciate ligament deficient knee and to improve the reconstruction technique. This project was sponsored by Oakland Naval Hospital. The other project was to improve numerical modeling technique of stiffened shell structures subjected to underwater explosion. It was sponsored by the Naval Surface Warfare Center, Carderock Division. The objective of the third project was to develop a progress damage and failure model for laminated fibrous composite structures. The combined micro/macromechanics model was derived to this end. This project was supported by the Naval Postgraduate School. The next project, sponsored by the Defense Nuclear Agency, studied the effects of surface coating on a structure subjected to underwater shock as well as the shock induced dynamic response of composite cylinders. Finally the last unfunded project was a study of compressive failure of unbalanced sandwich composite structures subjected to impact loading.

Assistant Professor Joshua H. Gordis of the Department of Mechanical Engineering is conducting research in several areas in structural dynamics and vibration. In structural synthesis, a family of analytic methods have been developed which allow the direct calculation of modified dynamic response of structural dynamic system

computer models which have been arbitrarily modified and/or combined with other models. These methods are distinguished by their ability to treat modifications of arbitrary size, distribution and damping, and that the methods provide a highly efficient and exact solution in all cases.

Research is also being performed in structural system identification, where deficiencies in math models are identified through the use of measured dynamic response data. Recent results here include the identification of an non-standard set of eigenvalues which provide a additional, independent data with which to tackle the underdetermined system identification problem. The system identification methods are being applied in the area of structural damage detection, which seeks to uncover structural damage in components using measured dynamic response data. Additional areas of research include the optimization of shipboard topside equipment with respect to weapons effects.

Ship Systems

Professor Calvano has continued his close working relationship with the Naval Sea Systems Command, extending his areas of involvement to include simulation based design, warship design tools and assessment methods for evaluating warship effectiveness. His paper (co-authored with Prof. Ball of the Aero Department) "Establishing the Fundamentals of a Surface Ship Survivability Discipline", appearing in the American Society of Naval Engineers Journal, has been instrumental in standardizing and clarifying survivability concepts and terminology in the ship and ship systems design community. He is supporting the Office of Naval Research in its Advanced Technology Demonstration (ATD) project with Lockheed Missile and Space Company, to demonstrate the performance advantages of an innovative hull form called SLICE. Professor Calvano is providing design technical review support for ONR and is using this involvement to foster student thesis work in ship structures for the novel hull form.

In the area of ship design tools, Professor Calvano is performing research, including student thesis work, in development of a computer based tool for use by the ship designer in evaluating the vulnerability of a warship to progressive flooding after damage. In addition, he is exploring the vulnerability reduction potential of a novel trimaran concept (originally proposed by the Royal Navy) for a surface warship, through student thesis work in damaged stability considerations for such a ship. He has also provided review and input to the design team for the SC-21 (Surface Combatant, 21st Century), via their subcontractor, in the area of developing measures of effectiveness for that design.

Dynamic Systems, Controls and Robotics

During 1994, **Professor Anthony Healey** has continued his investigations into Control Systems and Software Architectures for Intelligent Control of Autonomous Systems. This year has seen the implementation of full control over the NPS AUV II hovering modes, and has incorporated the use of a high frequency profiling sonar in the direction of the motion of the vehicle. The results have presented at the IEEE AUV '94 conference and represent a major step toward the full implementation of tri-level intelligent control architectures in AUVs. In addition, Professor Healey was the Technical Program Chairman for that meeting which is the premier conference for AUV technology.

The work is funded by NSF and is complemented by work funded by ONR to investigate local area navigation using active imaging sonar. Another major step has been taken through implementing ethernet protocols for communications between the GESPAC OS-9 system in the AUV and a LAN consisting of a SUN and an IRIS workstation that enable experiments with the full tri-level software mission controller. The migration to inside the vehicle of the workstation environment for the higher levels of the controller architecture is underway through the acquisition of a VxWorks operating system running on a MVME 167 - a single board computer that in the future will be placed inside the vehicle.

In an additional study, Professor Healey, began the development of a Graphics Based Simulator for study of operational concepts in using small robotics for Munitions Clearance on land. This work is funded by the Navy Explosive Ordnance Disposal Technical Center at Indian Head, MD. and is helping to assess search strategy and control systems effectiveness in using small size machines under coordinated control of search strategies for removal of unexploded munitions.

A terrain data base has been acquired representing the 290 Palms facility of the US Marine Corps and small size walking machines have been simulated with full kinematic motion representation as they traverse the terrain. Sensors for the detection of metallic objects (i.e. magnetometers, or tactile sensors) are being installed in the simulation, and search strategies under different control schemes are being studied.

Professor Driels conducted his research on "Synthetic Environments for C3 Operations." The purpose of this work is to demonstrate how computer simulation modeling can improve the information available to decision makers, and in particular, how a three-dimensional visualization of a combat scenario provides insights that are not apparent from the traditional two dimensional, traditional, data displays.

Using an off the shelf software package called World Tool Kit, a virtual environment was prototypes to represent an engagement between two surface combatants with air forces involved. The engagement took place on a 300 mile by 300 mile grid and involved about twenty ships and thirty aircraft. The two forces could be controlled by the computer, or by the operator. In addition, the operator could move anywhere in the virtual environment and view any of the forces. By appropriate menu selection, a view from any of the ships, or any of the aircraft could be generated. Several views of the battle scenario were presented on the screen. It was concluded that the data formats presented were of considerable use in tactical planning, and also allowed several "what-if" scenarios to be examined. It was also noted that data generating the displays could be driven by real sensor systems, such as surface or air based radar.

Professor Papoulias conducted research on small waterplane twin hull (SWATH) resistance studies and submarine dynamics at periscope depth. Comparative calculations demonstrated that a certain variant of SWATH design, called SLICE, may offer decreased resistance. Several key parameters and their effects on resistance as well as downward force were identified. Research was also initiated in the area of submarine maneuvering in shallow and littoral waters. A comprehensive study of shallow water characterization was undertaken, and several operations and missions were defined. The steady state forces on the body were computed as a function of forward speed and depth. Parametric studies were conducted in order to assess the effects of body shape and size.

Assistant Professor Mukherjee, the Principal Investigator, is involved in two main projects. The first project is aimed at the development of a flexible, surgical, robotic arm to aid in minimally-invasive surgical procedures. Current instrumentation in minimally-invasive surgery is highly constrained with respect to the maneuvers available to the surgeon. This limitation can be overcome through the advancement of current technology and its integration geared towards the development of a controllable, flexible, robotic arm. A superelastic alloy tube element has been designed as the actuator of the flexible robotic arm, and an actuation system has been designed to activate the actuators using the minimum number of electrical connecting wires. The design problem has been considerably simplified by the use of the actuation system and currently we are working on the calibration of the actuators and the integration of the various components of the manipulator.

The second project is more theoretical in nature and investigates the repeatability problem in nonholonomic systems. Nonholonomic systems behave in a way that closed trajectories of the independent variables result in a change in the dependent variables. There are certain nonholonomic systems for which closed paths in the space of the independent variables can be designed such that the net change of the dependent variables is zero over these closed paths. Then these trajectories are like "holonomic loops" over which the nonholonomic system exhibits holonomic behavior globally. Our research is aimed at planning such trajectories for nonholonomic systems. Such systems are important from a practical standpoint, as in the case of kinematically redundant

manipulators under pseudoinverse control. The design of repeatable trajectories will eliminate the drift in redundant manipulators under pseudoinverse control.

Fluid Dynamics, Heat Transfer and Turbomachinery

Distinguished Professor Sarpkaya: The statistical as well as structural characteristics of the turbulent flow field resulting from the interaction of a turbulent jet with clean and contaminated free surfaces were investigated in order to elucidate the physics of the phenomena relevant to the understanding of near-surface structures in ship-generated wakes. It has been shown that the predominant coherent structures are (i) swirling surface depressions whose preferential merging leads to reverse energy cascade and eddy longevity, and (ii) flattened large eddies with axes nearly parallel to the free surface. The entire process is driven by the underlying, nearly isotropic, three-dimensional turbulence field and is of special importance towards the understanding and interpretation of surface signatures generated by ships and submerged bodies.

Professor Kelleher has been continuing work on liquid cooling of electronic components and equipment. The most recent work has dealt with the investigation of the heat transfer capabilities and effectiveness of liquid flow through modules for electronics cooling. The investigation used a Standard Electronic Module, format E (SEM-E) size flow through module with a dielectric polyalphaolefin as the liquid coolant. One surface of the module was populated with six etched foil heaters placed over the flow path. Thermocouples attached to the module surface and also placed in the inlet and outlet tubing provided data to quantify module effectiveness and heat transfer characteristics for a variety of power inputs and liquid coolant flow rates. Work has also been conducted to investigate the details of the heat transfer process internal to the flow through module. To carry out this study, a ten times blow up model of the offset plate finned array structure of the internal passages of the flow through module was constructed. Preliminary heat transfer and flow visualization data have been obtained for this model.

Professor Kelleher has also been conducting a numerical study of the thermal characteristics of the superconducting magnet used in the Advanced Lightweight Influence Sweep System (ALISS). A steady state thermal analysis of the magnet was performed using Commercial Finite Element Modeling software. Two major cases were examined: one with instrumentation heat flux dispersed around the magnet and one with the instrumentation heat flux concentrated in a given location. A separate group of cases were examined to determine the magnitude of the heat flux necessary to initiate quenching of the superconducting properties of the magnet.

Assistant Professor Millsaps: A theoretical, experimental and computational investigation is ongoing whose purpose is to predict flows in complex sealing geometries. Geometries that produce minimum leakage as well the rotordynamic forces (both in forced and self-excited vibration) have been sought. Analytical work, using a lumped parameter model with a linear perturbation solution technique showed that the fluid forces generated by geometrically imperfect radial clearances in labyrinth seals could generate forces that are of the same order of magnitude as those due to residual imbalance. A low speed facility for measuring seal flows using both conventional and Laser Doppler techniques are being built to measure the detailed flow field in these seals. Preliminary Computational Fluid Dynamic (CFD) predictions, using a Reynolds averaged Navier-Stokes code, have been obtained and compared to previous computations and experimental data. Better seals will yield, power systems with greater efficiency and durability

A theoretical and experimental investigation of split resonance and backward whirl in a long slender rotor has been conducted. A computer model was developed to predict steady state responses. This model was used to determine the cause of the backward whirl that was observed experimentally. It was determined that the cause of this complex behavior was non-isotropy of the bearings due to gravity inducing non-symmetric direct stiffnesses in the two orthogonal directions.

Assistant Professor Ashok Gopinath: As part of the ongoing research in developing a feasible thermoacoustic refrigeration system, the origin of the thermoacoustic streaming effect responsible for this refrigerating effect was

investigated. A systematic framework was developed to identify the governing dimensionless parameters of importance. The role in thermoacoustics of a previously unpredicted "second-order" thermal expansion coefficient (important for non-gaseous host fluids) was pointed out. For ideal gas host fluids, the work of earlier contributors was corrected to show that the axial gradient of the time-averaged heat flux at the wall-fluid interface is maximized for a certain optimum channel gap width. Predictions from this study showed very good agreement with existing experimental data in the literature.

The latter part of this project dealt with the behavior of the flow in the vicinity of the stack of a thermoacoustic refrigerator. Some preliminary studies were conducted using LDV techniques to measure the oscillatory velocity fields which were then Fourier analyzed to extract the dc-velocity component of interest. The measurements showed very interesting fluid motion in the form of jets at the ends of the stack. More detailed experiments need to be conducted to understand these phenomena and their influence on the heat-pumping capability of the stack.

Materials Science

Professor McNelley has continued his research on processing of aluminum-based metal matrix composites (MMCs) under a cooperative research and development agreement (CRADA) with funding from Duralcan-USA, a composites manufacturer located in San Diego, California. Initially, this work involved adaptation of processing methodologies developed at the Naval Postgraduate School to the production of composite extrusions. Subsequent efforts have been directed at optimization of the properties of such extruded materials. This work has demonstrated that it is possible to achieve ductility in processed Al 6061 - 10 vol. pct. Al_2O_3 and - 20 vol. pct. Al_2O_3 composites that is comparable to that of the unreinforced matrix while achieving a higher strength as well. The suitability of such processing methods for industrial production of these materials is currently being assessed. This program demonstrates the feasibility of transferring results from Department of Defense funded research to industry. In another program, a sensor system has been developed that is capable of monitoring in real time the aging response of age-hardenable materials. This sensor system utilizes eddy current coils, a specially designed amplifier and computer-controlled data acquisition to obtain resistivity data during aging. In conjunction with a controller, such a system will allow more precise regulation of heat treatment processes and thereby reduce material variability and improve component reliability. Finally, research on processing of superplastic Aluminum has continued with the focus of efforts primarily on the role of processing in the development of the grain boundaries types necessary for extensive superplastic response. This work has also examined the role of alloy composition and the importance of second-phase particles in determining the nature of grain boundaries as they evolve during processing.

Professor Fox has been continuing his work in collaboration with the Annapolis Detachment of the Carderock Division of the Naval Surface Warfare Center on the correlations between mechanical properties and microstructure of Navy high strength steels and their weldments so that new weld consumables and parent steels for Naval applications can be developed. In addition, two projects are being undertaken in collaboration with the Naval Air Warfare Center, Warminster, PA. The first involves the characterization of the hot salt corrosion of silicon carbide fiber-reinforced glass ceramic matrix composites which are potential lightweight replacements for nickel-based superalloys in high temperature aero-engine applications and the second concerns the microstructural characterization of new high temperature intermetallic alloys (including TiAl and NiAl) using new methods in x-ray and electron diffraction. This latter project is also supported by the Materials Development Branch of the Wright Patterson Airforce Base, Dayton, OH. In March 1994 Dr. E.S.K. Menon joined Professor Fox's research group as Research Assistant Professor to work on electron and x-ray diffraction studies of intermetallic alloys and in June 1994 Dr. Atul Kumar joined as National Research Council Postdoctoral Associate to work on corrosion of silicon carbide fiber-reinforced glass ceramic matrix composites.

Professor Indranath Dutta's current research efforts are concentrated in the areas of Metal-Matrix Composites and Electronics Packaging Materials Science. In the area of Composites, the emphasis is on new ways to process discontinuously reinforced aluminum composites to enhance their fracture properties, and on the characterization

of microstructural evolution with processing. A number of related studies, including the roles of thermal residual stresses and matrix phase transformations in determining the final properties of the processed material are also continuing. In the area of Electronics Packaging, Professor Dutta is presently investigating novel methods to evaluate the physical and chemical properties of thin film - substrate interfaces for hybrid micro-electronics packages, including Gold on Aluminum Nitride and CVD Diamond on Aluminum Nitride. In addition, studies are continuing on finding ways to qualitatively evaluate the interfacial adhesion between thin films and substrates by non-destructive means such as X-ray diffraction. Future efforts will focus on attempting to produce adherent metallizations on CVD diamond for ultra-high thermal conductivity substrates for packaging applications.

TOTAL SHIP SYSTEMS ANALYSIS/ASSESSMENT

C.N. Calvano, Associate Professor
Department of Mechanical Engineering
Sponsor and Funding: Naval Sea Systems Command

OBJECTIVE: Improve methods for enhancing warship military effectiveness and for assessing that effectiveness, with emphasis on applying Total Ship Systems Engineering (TSSE) methods. Improve the understanding of the relationship between warship vulnerability reduction and warship effectiveness; improve the degree to which Navy engineers understand and apply Total Ship Systems Engineering methods in their work; improve techniques for integration of combat systems and supporting hull, mechanical and electrical ship systems; conduct research to provide tools and methods to enhance application of TSSE methods and understanding of the potential of modeling methods in warship development; develop innovative total ship survivability and assessment tools and methods.

SUMMARY: The P.I. participated in a simulation based design (SBD) and modeling strategic planning session at the Naval Sea Systems Command, providing input for development of SBD methods for use in warship development. Thesis-associated research was undertaken to develop a computer-based model for progressive flooding of a ship which, when used in conjunction with existing Navy software such as the Ship Hull Characteristics Program, will allow the designer to evaluate the vulnerability of a warship design by varying such things as the rate of watertight bulkhead leakage and ship pumping/de-watering capacity. A review of a trimaran hull form, originally suggested by the Royal Navy, and intended to reduce ship vulnerability to certain anti-ship missiles, was conducted and a student thesis to explore certain damaged stability ramifications of this concept is underway. A seminar on Total Ship Systems Engineering methods was prepared and presented at NAVSEA on 3 March 1995.

CONFERENCE PRESENTATION:

Calvano, C.N. and Riedell, J., LT, "The Regional Deterrence Ship (RDS 2010) A Design for Littoral Warfare in the 2010 Timeframe," American Society of Naval Engineers Combat Systems Symposium on Littoral Warfare Impacts on Naval Engineering Proceedings, Port Hueneme, CA, 22 September 1994.

DOD KEY TECHNOLOGY AREA: Design Automation, Other (Survivability)

KEYWORDS: Combat Survivability, Warship Effectiveness, Warship Design, Trimaran, Ship Vulnerability

DESIGN AND OPERATIONAL EVALUATION OF SLICE CONCEPT

C.N. Calvano, Associate Professor
F.A. Papoulias, Associate Professor
Department of Mechanical Engineering
Sponsor: Office of Naval Research

OBJECTIVE: The objective of this project was to initiate studies on a new hull form, called SLICE, and its potential advantages over a more traditional SWATH.

SUMMARY: Preliminary structural modeling of SLICE hulls indicated the feasibility of such ships to withstand wave loading. Comparative resistance calculations demonstrated that SLICE hulls may offer reduced resistance

in relation to a comparable size SWATH, depending on the range of key parameters, such as speed, length, displacement, and hull separation. Systematic sensitivity studies with regard to steady state forces exerted on the four pods at high speeds, revealed that excessive downward heave forces may develop. These forces are a matter of concern, since the hull offers very little stiffness in heave. Parametric results indicated proper design guidelines that could help in minimizing these heave forces.

DOD KEY TECHNOLOGY AREA: Design Automation

KEYWORDS: SLICE/SWATH Hulls, Ship Structures, Ship Resistance

SYNTHETIC ENVIRONMENTS FOR C3 OPERATIONS

M. Driels, Professor
Department of Mechanical Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: The purpose of this work is to demonstrate how computer simulation modeling can improve the information available to decision makers, and in particular, how a three-dimensional visualization of a combat scenario provides insights that are not apparent from the traditional two dimensional, traditional, data displays.

SUMMARY: Using an off the shelf software package called World Tool Kit, a virtual environment was prototypes to represent an engagement between two surface combatants with air forces involved. The engagement took place on a 300 mile by 300 mile grid and involved about twenty ships and thirty aircraft. The two forces could be controlled by the computer, or by the operator. In addition, the operator could move anywhere in the virtual environment and view any of the forces. By appropriate menu selection, a view from any of the ships, or any of the aircraft could be generated. Several views of the battle scenario were presented on the screen. It was concluded that the data formats presented were of considerable use in tactical planning, and also allowed several "what-if' scenarios to be examined. It was also noted that data generating the displays could be driven by real sensor systems, such as surface or air based radar.

THESIS DIRECTED:

Young, J.M. LT, USN, "Synthetic Environments for C3 Operations," Master's Thesis, September 1994.

DOD KEY TECHNOLOGY AREA: Human-System Interfaces

KEYWORDS: Virtual Environments, Simulation, Combat Modeling

MICROSTRUCTURE-PROPERTY-PROCESSING RELATIONSHIP IN METAL MATRIX COMPOSITES

I. Dutta, Associate Professor
Department of Mechanical Engineering
Sponsor and Funding: Naval Postgraduate School (NSWC-White Oak, DFR)

OBJECTIVE: To investigate microstructural development in metal matrix composites and to determine the effect of CTE mismatch on the properties of MMCs from a mechanistic standpoint.

SUMMARY: The effect of reinforcement distributions and processing conditions on the early stages of precipitation in composite matrices (2014 Al and 606 loading conditions have been investigated. The importance of this project to the Navy and the scientific community lies in proper design of thermo-1 Al) has been studied. Evolution of microstructures and residual stresses in discontinuously reinforced MMCs as a function of thermo-mechanical processing, and corresponding effects on mechanical properties under different mechanical and thermalmechanical treatments to optimize thermo-mechanical properties in these materials.

PUBLICATION:

Dutta, I., Harper, C.P., and Dutta, G., "Role of Al_2O_3 Particulate Reinforcements on Precipitation in 2014 Al-Matrix Composites," Metallurgical Transactions A, Vol. 25A, p. 1591, 1994.

THESIS DIRECTED:

Avenger, D.V., "Microstructure and Aging Response of SiCp Reinforced A356 Al Metal Matrix Composites Subject to Post Fabrication Thermo-Mechanical Processing," Master's Thesis, December 1994.

OTHER:

Dutta, I., "Creep and Thermal Cycling of Continuous Fiber Reinforced Metal-Matrix Composites," Invited Review Paper, to appear in Metal Matrix Composites, Key Engineering Materials series, E.A. Armanios, Y.W. Mai, F.H. Wohlbier, eds., Trans Tech Publications, Switzerland, 1995.

Dutta, I. and Avenger, D., "A TEM Study of Mictrostructural Evolution during Thermo-Mechanical Processing of SiC-Al Composites," in preparation for Journal of Material Science Letters.

Dutta, I., "Some Effects of Thermal Residual Stresses on the Thermo-Mechanical Behavior of Metal-Matrix Composites," Invited Paper, to appear in Proceedings of the Discussion Meeting on Inorganic Matrix Composites, Bangalore, India, 9-11 March 1995.

DOD KEY TECHNOLOGY AREA: Materials and Processes

KEYWORDS: Metal-Matrix Composites, Processing, Heat Treatment, Microstructure

PROCESSING AND CHARACTERIZATION OF CERAMIC SUBSTRATES AND THIN FILM-SUBSTRATE INTERFACES FOR ELECTRONIC PACKAGING APPLICATIONS

I. Dutta, Associate Professor
Department of Mechanical Engineering
Sponsor and Funding: Naval Surface Warfare Center, Crane Division

OBJECTIVE: To correlate processing, microstructure and properties in ceramic substrates and substrate-coating interfaces.

SUMMARY: The sintering kinetics in liquid phase sintered aluminum nitride bulk pieces have been investigated to optimize processing parameters with respect to resultant microstructural changes and thermal conductivity. A new approach to the sintering of ceramic materials via microwave energy is being currently investigated. A novel Constant Depth Scratch Test to measure adhesion between coatings and ceramic substrates has been

developed, including both theoretical and experimental approaches. The test is applicable to both ductile (metal) films as well as brittle (e.g., CVD diamond) films on ceramic substrates. Residual stress generation in metallizations on AlN has also been investigated via X-ray diffraction techniques function of process parameters. The focus is to optimize residual stresses in thin film metallizations and their adhesion to the ceramic substrates for electronic packaging applications.

PUBLICATIONS:

Mitra, S., Dutta, G., and Dutta, I., "Effect of Processing Conditions on the Microstructure and Properties of Dense Aluminum Nitride Sintered with Y_2O_3 Dopants," Journal of American Ceramic Society, in press.

Dutta, I., Lascurain, D., and Secor, E.D., "Measurement of Adhesion at Film-Substrate Interfaces by Constant Depth Scratch Testing," "Materials Reliability in Micro-Electronics," Proceedings of Materials Research Symposium, Vol. 338, p. 507, 1994.

PATENT APPLICATION:

Dutta, I. and Lascurain, D., "A Constant-Depth Scratch Test for the Quantification of Interfacial Shear Strengths," Patent Application #NC75,747, in review.

THESES DIRECTED:

Munns, C., "Evaluation of Residual Stresses in Au Metallizations on AlN Substrates by the Warren-Averbach Technique," Master's Thesis, March 1994.

Campbell, J.C., "The Measurement of Adhesion at Film-Substrate Interfaces Using a Constant Depth Scratch Test," Master's Thesis, December 1994.

Alhambra, E.M., "A Preliminart Attempt at Sintering an Ultrafine Alumina Powder Using Microwaves," Master's Thesis, September 1994.

OTHER:

Dutta, I. and Munns, C.H., "An X-ray Diffraction Study of Adhesion of Au Thin Films to Aluminum Nitride Substrates," to be presented at 124th TMS Annual Meeting, Las Vegas, NV, 13-16 February 1995.

Dutta, I., Munns, C.H., and Dutta, G., "An X-Ray Diffraction Study of Vapor Deposited Gold Thin Films on Aluminum Nitride Substrates," Thin Solid Films, in review.

DOD KEY TECHNOLOGY AREA: Materials and Processes

KEYWORDS: Electronics Packaging, Ceramics, Sintering, Microwave Processing, Coatings, Thin Films, Adhesion, Scratch Test

A COMBINATIVE METHOD FOR THE ACCURATE MEASUREMENT OF STRUCTURE FACTORS AND CHARGE DENSITIES OF INTERMETALLIC ALLOYS

A.G. Fox, Associate Professor
E.S.K. Menon, Research Assistant Professor
Department of Mechanical Engineering
Sponsors: Wright-Patterson Airforce Base and the Naval Air Warfare Center, Warminster, PA

OBJECTIVE: To accurately measure the low-angle structure factors of elements and intermetallic alloys by various diffraction methods so that their electronic bonding mechanisms can be investigated.

SUMMARY: A knowledge of the distribution of bonding electrons in solids can give important information about their physical properties. One way to gain such knowledge is to accurately measure the low-angle structure factors by some means, and then use these to generate maps of the electron charge distributions. In the present work electron diffraction has been used to measure the low-angle structure factors of NiAl. and an electron charge distribution has been generated for this alloy and important bonding information has emerged. During 1991 x-ray diffraction work commenced on the TiAl system and in 1992 continued so that accurate values of the lattice parameters and Debye-Waller factor of TiAl were obtained. During the last quarter of 1992 and during 1993 electron diffraction measurements of the low-angle structure factors of TiAl were made on the 1.5 MeV high voltage electron microscope (HVEM) at the University of California, Berkeley and on the 3.0 MeV HVEM at CEMES/LOE du CRNS, Toulouse, France. During 1994 Dr E.S.K. Menon joined this project as Research Assistant Professor and has continued both the x-ray and electron diffraction work. This has resulted in several publications in 1994.

PUBLICATIONS:

Lu, Z.-W., Zunger, A., and Fox, A.G., "Comparison of Experimental and Theoretical Electronic Charge Distributions in gTiAl," Acta Metallurgica et Materiala, Vol. 42, pp. 3929-3943, 1994.

Menon, E.S.K. and Fox, A.G., "Lattice Parameters and Debye-Waller Factors of g-TiAl Alloys," Naval Postgraduate School Technical Report, NPS-ME-94-009, 1994.

OTHER:

Menon, E.S.K. and Fox, A.G., "On the determination of the Debye-Waller Factor and Structure Factors of NiAl by X-ray Powder Diffraction," submitted to Acta Metallurgica et Materiala, 1994.

Fox, A.G., "Low-Angle Structure Factors, Debye Temperature and Charge Density of NiAl: a Reconciliation between Experiment and First Principles Full Potential Linear Augmented Plane Wave (FLAPW) Calculations in the Local Density Approximation," Scripta Metallurgica et Materiala, Vol. 32, pp 343-347, forthcoming in 1995.

DOD KEY TECHNOLOGY AREA: Materials and Processes

KEYWORDS: Charge Density, Electron Diffraction, X-ray Diffraction, High Temperature Alloys

MICROSTRUCTURES AND MECHANICAL PROPERTIES OF HIGH-STRENGTH, LOW-ALLOY (HSLA) STEELS AND THEIR WELDMENTS

A.G. Fox, Associate Professor
Department of Mechanical Engineering
Sponsors: Annapolis Detachment, Carderock Division of the Naval Surface Warfare Center, MD.

OBJECTIVE: To investigate the microstructure and mechanical properties of HY and HSLA 80-130 series steels and their weldments to evaluate new weld consumables and parent steels for Naval shipbuilding applications.

SUMMARY: In recent years the U.S. Navy has been replacing the HY80-100 series of high strength alloy steels with their high-strength, low-alloy (HSLA) equivalents. This is being done because the stringent weld pre-heat requirements associated with the HY steels are not necessary for the HSLA series. So, despite the higher manufacturing costs of high-strength, low-alloy steels, the U.S. Navy should make significant savings by changing over to HSLA or ultra low carbon bainitic (ULCB) steels for ship and submarine construction. In addition, the Navy's stringent requirement that weld metal have the same strength as the base plate presents an interesting challenge in weld wire development for both HSLA and HY steels. This project aims to support these objectives with fundamental physical metallurgy studies at NPS. This project was very successful with three Masters Theses completed in 1994, two publications and two conference proceedings presented. In addition, Lt M.W. Eakes who completed a thesis in this area received the Navy League Award in December 1994.

PUBLICATIONS:

Haddock, J.T., Hussain, I., Fox, A.G., Batham, J.K., and Jones, E.T.R., "A New MgO/CaO-based reagent for the Ladle Treatment of Steel," Ironmaking and Steelmaking, Vol. 21, pp. 479-486, 1994.

Fox, A.G. and Brothers, D.G., "The Role of Titanium in the Non-Metallic Inclusions which Nucleate Acicular Ferrite in the Submerged Arc Weld (SAW) Fusion Zones of Navy HY-100 Steel," accepted for publication in Scripta Metallurgica et Materiala, 1994.

CONFERENCE PRESENTATIONS:

Brothers, D.G., Kettell, K.W., Fox, A.G., and Franke, G.L., "Flux Composition, Microstructure and Mechanical Properties of HY-100 SAW Weldments," invited talk presented at the 75th Annual American Welding Society Convention, Philadelphia, PA, 11-16 April 1994.

Bhole, S.D. and Fox, A.G., "The Influence of TIG Welding Thermal Cycles on HSLA-100 Steel Plate," invited talk presented at the 33rd Canadian Institute of Metallurgists Conference held at Toronto, Ontario, Canada, 21-25 August 1994.

THESES DIRECTED:

Brothers, D.G, CDR, USN, "The origin of Acicular Ferrite in Gas Metal Arc and Submerged Arc Welds," Master's Thesis, March 1994.

Beno, M.L., LT, USN, "Characterization of Ultra-Low Carbon Bainitic Steels for Use as Weld Wire Consumables," Master's Thesis, September 1994.

Eakes, M.W., LT, USN, "Correlation of Inclusion Size and Chemistry with Weld Metal Composition and Microstructure in Arc Weldments of High Strength Steels," Master's Thesis, December 1994.

DOD KEY TECHNOLOGY AREA: Materials and Processes

KEYWORDS: High Strength Steels, Microstructures

MICROSTRUCTURAL STUDIES OF SILICON FIBER REINFORCED GLASS-CERAMIC COMPOSITES FOR GAS TURBINE APPLICATIONS

A.G. Fox, Associate Professor
Department of Mechanical Engineering
Sponsor: Naval Air Warfare Center, Warminster, PA

OBJECTIVE: To investigate the hot corrosion of silicon fiber reinforced glass-ceramic matrix composites

SUMMARY: The U.S. Navy has an ongoing program of research into silicon fiber reinforced glass-ceramic matrix composites (CMCs) which have many potential uses for gas turbine components. The high strength, toughness and resistance to high temperatures and low density of CMCs could allow a considerable increase in gas turbine engine efficiency if they could be used to replace heavy metallic parts. Unfortunately Naval aircraft operating environment is very severe and any CMC components developed must be resistant to high temperature environments containing salt and aviation fuel which may be rich in sulfur. This work is using electron microscopy and x-ray diffraction to elucidate the mechanisms of hot salt corrosion in lithium, calcium and magnesium alumino silicates reinforced with silicon carbide fibers. The results of this work are helping to determine which CMCs are suitable for Naval applications. During 1994 two Masters theses were completed and in June 1994 Dr A. Kumar joined the research group as a National Research Council Postdoctoral Research Assistant.

THESES DIRECTED:

Newton, P.J., LT, USN, "Sodium Sulfate Corrosion of Silicon Fiber Reinforced Calcium Aluminosilicate Glass-Ceramic Matrix Composites," Master's Thesis, March 1994.

Hunt, R.K., LT, USCG, "A Transmission Electron Microscope Characterization of Sodium Sulfate Corrosion of Silicon Carbide Fiber-Reinforced Lithium Aluminosilicate Glass-Ceramic Matrix Composite," Master's Thesis, September 1994.

OTHER:

Fox, A.G., Hunt, R.K., Maldia, L.C., and Wang, S.W., "Hot Sodium Sulfate Corrosion of a Nicalon Silicon Carbide Fiber-Reinforced Lithium Aluminosilicate Glass-Ceramic Matrix Composite," submitted to Journal of Materials Science, 1994.

DOD KEY TECHNOLOGY AREA: Materials and Processes

KEYWORDS: SiC Fiber-reinforced Glass Ceramic Matrix Composites, Microstructure, Gas Turbine Engine Components

HEAT TRANSFER IN THERMOACOUSTIC REFRIGERATORS

A. Gopinath, Assistant Professor
Department of Mechanical Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: The goal of this project was to investigate the origin of the time-averaged temperature distribution due to the thermoacoustic streaming effect, and to study the influence of acoustic streaming on this process.

SUMMARY: The behavior of the time-averaged temperature distribution due to the thermoacoustic-streaming effect was studied to understand the role of acoustic streaming on convective heat transfer in the parallel plate channel geometry of the stack of a thermoacoustic refrigerator. A dimensionless development of the governing conservation equations was used to identify the important parameters, and the generality of such a formulation and its wide ranging applicability to different solid-fluid combinations was demonstrated. The role in thermoacoustics of a previously unpredicted "second-order" thermal expansion coefficient (important for non-gaseous host fluids) was pointed out. For ideal gas host fluids, the work of earlier contributors was corrected to show that the axial gradient of the time-averaged heat flux at the wall-fluid interface is maximized for a certain optimum channel gap width. Certain simplifications were made to arrive at more manageable forms of the time-averaged temperature distributions of interest in both the fluid gap, and the channel walls. Conjugate wall--fluid effects were found to be crucial in yielding the large axial temperature gradients generated by the thermoacoustic streaming effect. The convective heat transfer rates (due to acoustic streaming), at the ends of the channel were found to play an important role in determining the magnitude of this gradient. A comparison of the predictions from this study with available experimental data in the literature showed very good agreement. More work however needs to be done to determine the precise role of acoustic streaming in influencing the time-averaged heat-pumping effect across the ends of the stack.

Simultaneous studies were conducted on a working two-driver thermoacoustic refrigerator. After installation of the different fluid and thermal subsystems the performance characteristics were investigated by Lt. Cmdr. R. A. Russell as part of his thesis. The latter part of this project dealt with the behavior of the flow in the vicinity of the stack of a thermoacoustic refrigerator. Some preliminary studies were conducted using LDV techniques to measure the oscillatory velocity fields which were then Fourier analyzed to extract the dc-velocity component of interest. The measurements showed very interesting fluid motion in the form of jets at the ends of the stack. More detailed experiments need to be conducted to understand these phenomena and their influence on the heat-pumping capability of the stack.

PUBLICATIONS:

Gopinath, A. and Mills, A.F., "Convective Heat Transfer due to Acoustic Streaming across the ends of a Kundt Tube," Journal of Heat Transfer, Vol. 116, No. 1, pp. 47-53, 1994.

Gopinath, A., "Steady Streaming due to Small Amplitude Superposed Oscillations of a Sphere in a Viscous Fluid," Quarterly Journal of Mechanics & Applied Mathematics, Vol. 47, No. 3, pp. 461-480, 1994.

CONFERENCE PRESENTATIONS:

Garrett, S.L., Perkins, D.K., and Gopinath, A., "Thermoacoustic Refrigerator Heat Exchangers: Design, Analysis and Fabrication," 10th International Heat Transfer Conference, Brighton, England, paper no. 9-HE-9, Vol. 4, pp. 375-380, August 1994.

Gopinath, A. and Sadhal, S.S., "Thermoacoustic Streaming Effects from a Sphere subject to Time-Periodic Temperature Disturbances," 10th International Heat Transfer Conference, Brighton, England, paper no. 11-PP-14, Vol. 5, pp. 279-284, August 1994.

Gaitan, D.F., Gopinath, A., and Atchley, A.A., "Experimental Study of Acoustic Turbulence and Streaming in a Thermoacoustic Stack," 128th Acoustical Society Meeting, Austin, TX, Journal of the Acoustical Society of America, Vol. 96, No.5, Pt.2, p. 3220, November 1994.

OTHER:

The following paper was being prepared for publication during FY94 and has since then been submitted and is currently being considered for publication: Gopinath, A. and Garrett, S.L., "Thermoacoustic Streaming in a Resonant Channel: the Time-Averaged Temperature Distribution."

DOD KEY TECHNOLOGY AREAS: Environmental Effects, Propulsion and Energy Conversion

KEYWORDS: Thermoacoustics, Acoustic Streaming, Refrigeration, Navier-Stokes Equations, Analytical/Numerical Techniques, LDV Measurements

FREQUENCY DOMAIN METHODS IN STRUCTURAL SYNTHESIS AND IDENTIFICATION

J.H. Gordis, Assistant Professor
Department of Mechanical Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: This project is concerned with the theoretical development of a frequency domain theory for structural system identification. The theory is based on a previously developed theory for frequency domain structural synthesis.

SUMMARY: This research concerns the development and validation through practical application of a frequency domain theory for structural system identification and structural damage detection. The frequency domain theory avoids fundamental limitations associated with modal-based methods by the elimination of modal parameter estimation and modal truncation errors, and by the direct treatment of the errors associated with instrumenting the test specimen with a finite number of response measurement transducers. Under development is the necessary theory for the practical identification of an impedance error spectra for a linear math model of a dynamic system and the subsequent decomposition of the impedance error spectra into the constituent error spectra of mass, stiffness, and (non-proportional) damping. Focusing on spatially incomplete identification, the research is investigating the localization of model errors and the relationship between the error spectra identified from spatially incomplete test data and the "true" parameter errors in the original, unreduced analytic model. The research will introduce non-traditional physical coordinate model reduction methods as well as traditional optimization techniques to cope with the limited amount of data typically generated in a vibration test. Experimental studies with simple yet representative structures are underway.

PUBLICATIONS:

Gordis, J.H., "An Analysis of the Improved Reduced System (IRS) Model Reduction Procedure," Modal Analysis, Vol. 9, No. 4, pp. 269-286, 1994.

Gordis, J.H., "Structural Synthesis in the Frequency Domain: A General Formulation," Shock and Vibration, Volume 1, Issue 5, 1994.

Gordis, J.H. and Flannelly, W.G., "Analysis of Stress Due to Fastener Tolerance in Assembled Components," AIAA Journal, Vol. 32, No. 12, pp. 2440-2446, 1994.

CONFERENCE PRESENTATION:

Gordis, J.H., "Structural Synthesis in the Frequency Domain: A General Formulation," presented at the 12th International Modal Analysis Conference, Honolulu, HI, February 1994.

THESIS DIRECTED:

Campbell, M.G., LT, "Structural Damage Detection Using Frequency Domain Error Localization," Master's Thesis, 1994.

DOD KEY TECHNOLOGY AREA: Design Automation

KEYWORDS: Structural Dynamics, Frequency Domain, Synthesis, Identification

TIME DOMAIN METHODS IN STRUCTURAL SYNTHESIS AND IDENTIFICATION

J.H. Gordis, Assistant Professor
Department of Mechanical Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: This project is concerned with the theoretical development and computational implementation of a time domain theory for structural synthesis.

SUMMARY: This research concerns the development of a time domain theory for structural synthesis. This new theory provides the previously unavailable capability of performing exact transient structural synthesis, regardless of damping. The method is based on Volterra integral equations derived from the convolution integral which describe substructure coupling and structural modification. The numerical solution of the integral equations yields a triangular linear system which is solved for the synthesized system transient responses/coupling forces, with no factorization or eigensolution required.

CONFERENCE PRESENTATION:

Gordis, J.H., "Integral Equation Formulation for Transient Structural Synthesis," presented at the 1994 ASME/AIAA/ASCE/AHS/ACS Structures, Structural Dynamics, and Materials Conference, Hilton Head, SC, 1994.

Gordis, J.H., "Efficient Component-Based Structural Analysis for Shock and Vibration: Time and Frequency Domain Methods for Substructure Coupling and Structural Modification," presented at the 65th Shock and Vibration Symposium, San Diego, CA, 31 October - 3 November 1994.

DOD KEY TECHNOLOGY AREA: Design Automation

KEYWORDS: Structural Dynamics, Time Domain, Synthesis, Identification

SHIPBOARD SYSTEMS SURVIVABILITY: DYNAMIC DESIGN ANALYSIS AND TESTING METHODS AND LIVE FIRE TEST SIMULATION

J.H. Gordis, Assistant Professor
Y.S. Shin, Professor
Department of Mechanical Engineering
Sponsor: Naval Sea Systems Command

OBJECTIVE: This continuing project is concerned with the development of computational methods for the component-based structural dynamic analysis of shipboard mast/antennae systems. The goal is to provide the computational tools to allow weapons-effect survivability to be "designed in" to new mast/antennae systems, and to allow the enhancement of survivability for existing mast/antennae systems.

SUMMARY: Shipboard combat systems are subjected to damaging transient forces due to weapons effects such as underwater explosion (UNDEX). In order to improve the UNDEX survivability of combat systems such as the mast/antenna structural system, this project is concerned with the development of modern computational techniques for the prediction of transient response. A class of substructuring methods, known as component mode synthesis, are examined and specialized to the mast/antenna survivability enhancement problem. The computationally efficient and component-based approach of component mode synthesis is consistent with the long term goal of developing a specialized computer-aided design tool for mast/antenna systems.

THESIS DIRECTED:

Tomaiko, T.A., LT, "Normal Modes of Oscillation of the ANS/SPS-67(V)3 Surface Search Radar," Master's Thesis, 1994.

DOD KEY TECHNOLOGY AREA: Design Automation

KEYWORDS: Structural Dynamics, Survivability, Mast, Antenna

BUGS: BASIC UXO GATHERING SYSTEM - SIMULATOR DEVELOPMENT

A.J. Healey, Professor
Department of Mechanical Engineering
R.B. McGhee, Professor
S. Pratt, Computer Systems Programmer
Department of Computer Science
Sponsor: NAVEODTECHCEN, Indian Head, MD

OBJECTIVE: This work is being undertaken to provide a graphics based simulator for the visualization of the controlled motion of multiple cooperating vehicles as proposed for the Basic UXO Gathering System. The System is being designed to provide autonomous clearing of munitions in support of EOD missions.

SUMMARY: The simulator code runs on an high end SGI workstation currently an ONYX Reality Engine workstation and has been developed using the 'performer' tool kit. It is planned to use the simulator as a training tool for the US Army/Marine Corps to evaluate sensor technology as well as control methodologies in semi realistic environments in relation to the performance of the overall BUGS system for land based ordnance clearance operations.

The simulator is built around a terrain base taken from the Marine Corps 29 Palms facility and a small subset of that data base has been selected as a test site for evaluation of clearance operations. Vegetation has been included as uniformly distributed randomly dispersed objects added to the data base.

Munitions simulated include Mk 118 anti-personnel munitions, softball and baseball munitions that would have been dispensed from an airborne canister. These munitions are then randomly distributed around a nominal center with an average density that is selectable by the user.

Clearance operations are then simulated by a fleet of walking machine BUGS that can be controlled to a speed, heading and altitude above ground command. The walking machines are rendered as full kinematically faithful hexapods walking with a double tripod fixed gait, where each bug has an arm (boom) to support a camera, tactile, or magnetic sensor. The sensor has a defines radius of detection so that if a munition is encountered, a command is registered in the machine controller to manipulate the boom and retrieve the object.

Search patterns can be simulated that are directed exhaustive searches if motion sensors are presumed to have sufficient accuracy on board the machines, or random searches if no motion sensors would be presumed to be available.

The characteristics of random versus exhaustive search have been established as part of this research, and the influence of various levels of navigation sensor accuracy and inter bug communication on search effectiveness are being sought.

PUBLICATION:

Healey, A.J., Pratt, S.M., McGhee, R.B., "BUGS: Basic UXO Gathering System Simulator Development," Naval Postgraduate School Technical Report, NPS-ME-94-008, December 1994.

DOD KEY TECHNOLOGY AREA: Other (Robotics, Minecountermeasures)

KEYWORDS: Robotics, Simulation and Modeling, Minewarfare

AUTONOMOUS UNDERWATER VEHICLES

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F.A. Papoulias, Associate Professor
Department of Mechanical Engineering
R.B. McGhee, Professor
Department of Computer Science
R. Cristi, Associate Professor
Department of Electrical and Computer Engineering
D. Brutzman, Instructor
Department of Operations Research
Sponsor: Naval Postgraduate School

OBJECTIVE: As the use of Operated Underwater Vehicles becomes more widespread and their tasking more complex, there is a need to free the vehicle from the power and signal umbilical, and to increase the level of autonomy and the precision of the motion control of these underwater robots in performing mine hunting and ocean monitoring tasks. The objectives of this long term program are to advance the state of the art in intelligent systems for these applications.

SUMMARY: The Rational Behavior Model software architecture was initially developed in previous years of this project and is distinguished by the recognition of three levels of control, each based on a different programming paradigm. Further development of this architecture this year has led to the funding by the National Science Foundation of an expanded study for application to unmanned underwater vehicles in general. We have now succeeded in converting the earlier concept to a version that runs in the NPS AUV II vehicle computers as

part of a virtual world system in our simulation laboratory, and is also being tested in the vehicle in the NPS Hover Tank. Also, during FY94, the NPS AUV II has under gone extensive rebuild following a battery explosion with the vehicle being resurrected as the NPS PHOENIX. We have now developed a series of Tactical Level scripts that have enabled a form of supervisory control to be effected on the vehicle and a series of complex hovering maneuvers under the action of sonar and thruster control have been demonstrated. More recently, a full network configuration of the control Architecture has been completed and experimental results for the control of hover missions have been obtained and evaluated. Additionally, the laboratory facility has been equipped with radio ethernet connections to the main campus to enable remote viewing of robot behavior.

PUBLICATIONS:

Healey, A.J., et al., "Coordination of the Hovering Behaviors of the NPS AUV II using Onboard Sonar Servoing," Proceedings of the 1994 NSF IARP Workshop on Mobile Robots for Subsea Environments, MBARI, Pacific Grove, CA, May 1994 .

Healey, A.J., et al., "Tactical/Execution Level Coordination for Hover Control of the NPS AUV II using Onboard Sonar Servoing," Proceedings of the IEEE Symposium on Autonomous Underwater Vehicle Technology, AUV '94 Cambridge, MA, pp. 129-138, 19-20 July 1994.

Cristi, R., "Navigation and Localization in a Partially Known Environment," Proceedings of the IEEE Symposium on Autonomous Underwater Vehicle Technology, AUV '94 Cambridge, MA, pp. 263-268, 19-20 July 1994.

Kwak, S.H. and Thornton, F.P.B., "A Concurrent, Object Oriented Implementation for the Tactical Level of the Rational Behavior Model Software Architecture for UUV Control," Proceedings of the IEEE Symposium on Autonomous Underwater Vehicle Technology, AUV '94 Cambridge, MA, pp. 54-60, 19-20 July 1994.

THESES DIRECTED:

Brutzman, D.P., "Virtual Worlds for Autonomous Robots," Doctoral Dissertation, September 1994.

Torsiellio, K.A., "Acoustic Positioning of the NPS AUV II During Hover Conditions," Master's Thesis, March 1994.

Marr, W.J., "Using the ST 1000/725 Sonars on the NPS AUV II," Master's Thesis, June 1994.

Norton, N.A., "Evaluation of Hardware and Software for a Small Autonomous Underwater Vehicle Navigation System," Master's Thesis, September 1994.

Rodrigues, J.A., "Development of a Mine Search Algorithm for the NPS Autonomous Underwater Vehicle," Master's Thesis, September 1994.

OTHER:

McGhee, R.B., Clynch, J.R., Healey, A.J., Kwak, S.H., Brutzman, D.P., Norton, N.A., Whalen, R.H., Gay, D.L., and Bachmann, E.R., "At Sea Testing of an Integrated GPS/INS System for Shallow-Water AUV Navigation," submitted to 9th International Symposium on Unmanned Untethered Submersible Technology, Durham, NH, forthcoming in September 1995.

DOD KEY TECHNOLOGY AREAS: Other (Minecountermeasures, Robotics, Autonomous Vehicles)

KEYWORDS: Underwater Robotics, Intelligent Systems, Control

TOWARD AN IMPROVED UNDERSTANDING OF THRUSTER DYNAMICS FOR UNDERWATER VEHICLES

A.J. Healey, Professor
Department of Mechanical Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: As the use of Remotely Operated Underwater Vehicles becomes more widespread and their tasking more complex in deeper waters, there is a need to free the vehicle from the power and signal umbilical, and to increase the level of autonomy and the precision of the motion control of these underwater robots. In a recent paper, Yoerger et. al. (1990) points out that Underwater Vehicle thrusters must be properly modeled if good results are to be obtained for the vehicle motion control. Thrusters are usually comprised of propellers driven by a motor - the usual way in which ships are propelled through the seaway. However, while there is a long history of theoretical research, experimental validation and their tasking more complex in deeper waters, there is a need to free the vehicle from the power and signal umbilical, and to increase the level of autonomy and the precision of the motion control of these underwater robots. In a recent paper, Yoerger et. al. (1990) points out that Underwater Vehicle thrusters must be properly modeled if good results are to be obtained for the vehicle motion control. Thrusters are usually comprised of propellers driven by a motor - the usual way in which ships are propelled through the seaway. However, while there is a long history of theoretical research, experimental validation and practical experiential knowledge concerning the performance of ships propellers, the issues relating to the control of Remotely Operated Vehicles (ROVs) and Autonomous Underwater Vehicles (AUVs) are new because these vehicles are small, with relatively fast response, and have to execute dynamic positioning maneuvers including stationkeeping. They also require thrust to be controlled over the full four quadrant range of propeller operation.

SUMMARY: Yoerger et. al. developed a lumped parameter model of the dynamic response of an ROV thruster that went beyond the popular notion that, for a given unit with fixed pitch blading, thrust and input torque are related to the modified square of the propeller rotational rate. They introduced the idea that fluid momentum considerations in the thruster shrouding area gives rise to a time lag in the response of thrust to stepwise inputs of motor torque. Experimental results under steady state conditions for single quadrant operation certainly verified the well known square law relationship between thrust and propeller rotational speed and it did appear that the thrust response had longer lag times at lower thrust levels. However, little details were provided of the actual experimental thrust data under varied experimental conditions. This work has defined a new model that matches the experimental data for fast thrust response.

PUBLICATION:

Healey, A.J., et al., "Toward an Improved Understanding of Thruster Dynamics for Underwater Vehicles," Proceedings of the IEEE Symposium on Autonomous Underwater Vehicle Technology, AUV '94 Cambridge, MA, pp. 340-352, 19-20 July 1994.

DOD KEY TECHNOLOGY AREA: Other (Autonomous Vehicles)

KEYWORDS: Thrusters, Vehicles, Underwater Robotics Propulsion

AN EXPERIMENTAL STUDY OF SOFTWARE ARCHITECTURES AND SOFTWARE REUSE FOR CONTROL OF UNMANNED UNDERWATER VEHICLES

A.J. Healey, Professor
Department of Mechanical Engineering
R.B. McGhee, Professor
S.H. Kwak, Research Assistant Professor
Department of Computer Science
Sponsor: National Science Foundation

OBJECTIVE: The goal of this project is to investigate alternative software architectures for control of unmanned underwater vehicles, and to find effective means for archiving and retrieving software modules used to implement such software systems. The research is being conducted in cooperation with the Monterey Bay Aquarium Research Institute (MBARI), and with INRIA, a French Government Research Institute.

SUMMARY: This is a three-year project which began in January, 1994. During the first year, much of our work was focused on further development of the "Rational Behavior Model" (RBM) architecture, and its testing in the NPS "Phoenix" autonomous underwater vehicle (AUV). This work was successful, and is reported in [1,2]. We also succeeded in creating a virtual world for Phoenix, using advanced graphics workstations to simulate in real-time both the vehicle dynamics and its ocean environment. This simulation includes a physical copy of the Phoenix control computer, thereby enabling laboratory testing and evaluation of control software running in the target computer, without the expense and hazards associated with in-water experiments [4]. Finally, we cooperated with MBARI in research on automated stationkeeping by an AUV using either sonar or visual target tracking [3]. Results obtained were encouraging, and we intend to pursue further software development and open water testing in CY95.

PUBLICATIONS:

Healey, A.J., McGhee, R.B., Papoulias, F.A., Cristi, R., Brutzman, D.P., Marco, D.B., and Kwak, S.H., "Search and Find Mission Control and Execution Using the NPS AUV II Autonomous Underwater Vehicle," Proceeding of 2nd IARP Workshop on Mobile Robots for Subsea Environments, Pacific Grove, CA, May 1994.

Byrnes, R.B., Healey, A.J., McGhee, R.B., Nelson, M.L., and Kwak, S.H., "A Software Architecture for Intelligent Ships: An Approach to Motion and Mission Control,". Proceedings of Intelligent Ships Symposium, American Society of Naval Engineers, Philadelphia, PA, 1-2 June 1994.

Marks, R.L., Rock, S.M., Lee, M.J., and Wang, H.H., "Automatic Visual Station Keeping of an Underwater Robot, Proceeding of Oceans '94 Conference, Brest, France, September 1994.

THESIS DIRECTED:

Brutzman, D.P., "A Virtual World for an Autonomous Underwater Vehicle," Doctoral Dissertation, December 1994.

DOD KEY TECHNOLOGY AREA: Other (Battlefield Robotics)

KEYWORDS: Robotics, Minehunting, Autonomous Underwater Vehicles (AUV)

EXPERIMENTAL AND COMPUTATIONAL INVESTIGATION OF CONVECTIVE HEAT TRANSFER IN "FLOW THROUGH" MODULES AND INTERNALLY FINNED CHANNELS

M.D. Kelleher, Professor and Chairman
Y. Joshi,* Associate Professor
Department of Mechanical Engineering
Sponsor: Naval Surface Warfare Center, Crane

OBJECTIVE: The objectives of this investigation were to develop an experimental database for convective heat transfer in liquid flow through modules and the internally finned channels found in these modules and to develop computational modeling capabilities to predict the performance of flow through modules.

SUMMARY: The investigation used a Standard Electronic Module, format E (SEM-E) size flow through module with a dielectric polyalphaolefin as the liquid coolant. One surface of the module was populated with six etched foil heaters placed over the flow path. Thermocouples attached to the module surface and also placed in the inlet and outlet tubing provided data to quantify module effectiveness and heat transfer characteristics for a variety of power inputs and liquid coolant flow rates. Work has also been conducted to investigate the details of the heat transfer process internal to the flow through module. To carry out this study, a ten times blow up model of the offset plate finned array structure of the internal passages of the flow through module was constructed. Preliminary heat transfer and flow visualization data have been obtained for this model.

CONFERENCE PRESENTATION:

Kelleher, M.D., Egger, R., Joshi, Y., and Lloyd, J.R., "Modification of the Nucleate Boiling Hysteresis in the Pool Boiling of Fluorocarbons," presented at the 10th International Heat Transfer Conference, Brighton, UK, August 1994.

THESIS DIRECTED:

Bradley, J.M., LCDR, USN, "Natural Convection Cooling of Three-by-Three Array of Leadless Chip Carrier Packages in a Dielectric Liquid," Engineer's Thesis, March 1994.

OTHER:

The paper "Thermal Convection in a Small Box Heated from Below for a High Prandtl Number Fluid," will be presented in the session on "Cooling of Electronic Equipment" at the 4th ASME/JSME Thermal Engineering Joint Conference in March 1995.

DOD KEY TECHNOLOGY AREA: Other (Heat Exchangers)

KEYWORDS: Heat Transfer, Electronics Cooling

* Now at the University of Maryland

THERMAL ANALYSIS OF THE ADVANCED LIGHTWEIGHT INFLUENCE SWEEP SYSTEM (ALISS) SUPERCONDUCTING MAGNET

M.D. Kelleher, Professor and Chairman
Department of Mechanical Engineering
Sponsor: Naval Surface Warfare Center, Carderock Division, Annapolis Detachment

OBJECTIVE: The objective of this work were to develop a thermal model to predict the quenching characteristics of the superconducting magnet in the Advanced Lightweight Influence Sweep System.

SUMMARY: A numerical study of the thermal characteristics of the superconducting magnet used in the Advanced Lightweight Influence Sweep System (ALISS) has been conducted. A steady state thermal analysis of the magnet was performed using Commercial Finite Element Modeling software. Two major cases were examined: one with instrumentation heat flux dispersed around the magnet and one with the instrumentation heat flux concentrated in a given location. A separate group of cases were examined to determine the magnitude of the heat flux necessary to initiate quenching of the superconducting properties of the magnet.

DOD KEY TECHNOLOGY AREA: Other (Superconductors)

KEYWORDS: Heat Transfer, Conduction, Superconducting Cooling

BIOMECHANICAL STUDY OF HUMAN KNEE: BEFORE AND AFTER LIGAMENT INJURY

Y.W. Kwon, Associate Professor
Department of Mechanical Engineering
Sponsor: Oakland Naval Hospital and Naval Postgraduate School

OBJECTIVE: The goal of this project was to develop a new kinematic model to measure and compare the continuous motions of intact knees, posterior cruciate ligament (PCL) deficient knees and reconstructed knees; and to recommend the optimal reconstruction technique. This work was part of a continuing project.

SUMMARY: A new six degree of freedom kinematic model which allows measurement of continuous, simultaneous translation and rotation of the loaded human knee under several conditions. The advantage of this model over previous models were unconstrained motion at the femur and the tibia, continuous independent recording throughout a range of motion from full extension to 110 degrees of flexion, measurement of the relative motion of the femur and the tibia in three-dimensions, and continuous loading. This model was applied to the intact and PCL deficient knees as well as reconstructed knees. Kinematic motions of quadriceps or hamstring deficient knees were also studied as well as different surgical techniques for ligament reconstruction. Some of the major findings were: there was a hysteresis in the motion of the human knee during a cycle between extension and flexion, increasing the quadriceps force did not reproduce any characteristics of normal knee kinematics at any angle of flexion despite of greatly increased joint compressive forces, and the current ligament reconstruction technique overcorrected the knee motion.

OTHER:

Adkison, D., DeMaio, M., Kwon, Y.W., and Scholfield, J., "Continuous Motion Kinematics of the Intact and PCL-Deficient Knee," Annual Meeting of Arthroscopic Association of North America, upcoming in May 1995.

DOD KEY TECHNOLOGY AREA: Other (Biomechanics, Human Health)

KEYWORDS: Human Knee Motion, Posterior Cruciate Ligament (PCL), PCL-deficient

EFFECTS OF INTERNAL EQUIPMENTS ON DYNAMIC RESPONSE OF A SUBMARINE HULL SUBJECTED TO UNDERWATER EXPLOSION

Y.W. Kwon, Associate Professor
Y.S. Shin, Professor
Department of Mechanical Engineering
Sponsor: Naval Surface Warfare Center, Carderock Division

OBJECTIVE: The goal of this project was to develop an efficient finite element modeling technique for submerged stiffened shell structures subjected to underwater explosion.

SUMMARY: Detailed modeling of a stiffened shell structure required a large number of elements because densely located stiffners usually needed a great number of elements compared to that for the base shell structure. As a result, a smearing technique was developed for simplification of the finite element model. The study showed that the smearing technique should be applied with care. When the base shell structure had a very low stiffness as compared to that in the smeared structure (i.e. stiffners had a large effect on the overall stiffness) the globally smeared model might produce erroneous results. In this case, local smearing yielded an excellent results compared to the fully detailed model. Otherwise, the global smearing technique worked very well. In addition, a simplified beam model (surface of revolution element) was investigated to represent the global whipping mode of the a shell structure subjected to underwater explosion. In addition, combinations of simplified beam models, smeared shell models and detailed models were examined to determine what combination resulted in computationally efficient and accurate dynamic response of a stiffened shell structure subjected to underwater explosion.

DOD KEY TECHNOLOGY AREA: Design Automation

KEYWORDS: Stiffened Shell, Smearing Technique, Finite Element Modeling

MODELING OF MATRIX DAMAGE EVOLUTION IN COMPOSITE STRUCTURES

Y.W. Kwon, Associate Professor
Department of Mechanical Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: The objective of this project was to derive a damage/failure model which could describe the prospective damage and predict the failure stresses of laminated fibrous composite structures.

SUMMARY: A micro/macromechanics model was proposed to predict the damage progress in laminated composite structures. This model used both micromechanics and macromechanics analyses. The finite element method was employed for the macromechanical analysis while a simplified micromechanics model was developed for the micromechanical analysis. The two analyses were coupled and run in tandem. The micromechanical analysis was performed at the numerical integration points of each finite element to determine the fiber and matrix

stresses. The failure criteria were applied to the micro-stress level to check fiber breakage and matrix cracking. As a result, the damage progress could be traced using this model. The predicted failure loads and paths using the developed model agreed very well with experimental data for various layered composite plates subjected to either inplane or out-of plane loads.

PUBLICATIONS:

Kwon, Y.W. and Berner, J.M., "Analysis of Matrix Damage Evolution in Laminated Composite Plates," Engineering Fracture Mechanics, Vol. 48, No. 6, pp. 811-817, 1994.

Kwon, Y.W. and Berner, J.M., "Micromechanics Model for Damage and Failure Analyses of Laminated Fibrous Composites," Engineering Fracture Mechanics, accepted for publication.

Kwon, Y.W. and Yang, S.-T., "Bending Failure of Laminated Fibrous Composite Plates With a Hole," Materials and Design Technology-1995, ASME PD-Vol. 71, accepted for publication.

CONFERENCE PRESENTATION:

Kwon, Y.W. and Berner, J.M., "Matrix Damage Analysis of Fibrous Composites," Second International Conference on Computer Structure Technology, Athens, Greece, August-September 1994.

THESES DIRECTED:

Berner, J.M., "Finite Element Analysis of Damage in Fibrous Composites Using a Micromechanical Model," Master's Thesis, December 1993.

Yang, S.-T., "Study of Failure in Fibrous Composites Subjected to Bending Loads", Master's Thesis, June 1994.

Hamilton, B.H., "Study of Damage Evolutions in Composite Plates Subjected to Bending Loads Using Micro-Macro Analysis," Master's Thesis, September 1994.

DOD KEY TECHNOLOGY AREA: Materials and Processes

KEYWORDS: Fibrous Composite Structure, Damage and Failure, Micro/Macromechanics model

FAILURE OF UNBALANCED SANDWICH COMPOSITES SUBJECTED TO IMPACT AND COMPRESSION

Y.W. Kwon, Associate Professor
Department of Mechanical Engineering
Sponsor: Unfunded

OBJECTIVE: The objective of this project was to investigate the compressive failure of unbalanced sandwich composites subjected to impact loading.

SUMMARY: An unbalanced sandwich composite made of titanium and glass reinforced plastic facesheets with a phenolic honeycomb core was studied experimentally for its compressive strength after impact loading. The composite specimens, in simply supported configurations, were impacted transversely and then subjected to compressive axial loads. Samples were impacted on both the titanium and GRP sides. This study investigated initiation and progress of damage in the unbalanced sandwich composite beams caused by various impact loads. Some of the major findings were given below. For impacts from the same height, impacts on the titanium side

resulted in 30%-40% greater reductions in compressive strength. Momentum was the best parameter to predict residual compressive strength.

PUBLICATIONS:

Kwon, Y.W., Murphy, M.C., and Castelli, V., "Buckling of Unbalanced, Sandwich Panels With Titanium and GRP Skins," Journal of Pressure Vessel Technology, ASME Transactions, accepted for publication.

Kwon, Y.W. and McDonald, E.S., "Optimization Techniques for Contact Stress With Application to Low Velocity Impact to Composite Beams," Materials and Design Technology, PD-Vol. 62, ASME 1994, pp. 151-63.

Kwon, Y.W. and Fuller, L.B., "Compressive Failure of Unbalanced Sandwich Composites After Impact Loading," Recent Advances in Structural Mechanics, ASME PVP -Vol. 295/NE-Vol. 16, 1994, pp. 53-63.

THESIS DIRECTED:

Fuller, L.B., "Damage and Compressive Failure of Unbalanced Sandwich Composite Panels Subject to Low-Velocity Impact," Master's Thesis, March 1994.

DOD KEY TECHNOLOGY AREA: Materials and Processes

KEYWORDS: Unbalanced Sandwich Composite, Compressive Failure, Impact Loading

GRAIN BOUNDARIES IN SUPERPLASTIC ALUMINUM

T.R. McNelley, Professor
Department of Mechanical Engineering
Sponsor: Proposed to the Office of Naval Research
Prior Funding: Naval Postgraduate School

OBJECTIVE: The goal of this program is to study the role of grain boundaries in fine-grained, superplastic aluminum alloys and the development of such grain boundaries during thermomechanical processing of these materials.

SUMMARY: Two different mechanisms of microstructural refinement during thermomechanical processing at 573K of Al-10Mg-0.1Zr have been identified. With a brief interpass anneal grain boundaries developed via a twin chain mechanism. The use of a prolonged interpass anneal resulted in high angle boundaries associated with recrystallization and superplastic elongations in excess of 1000% during straining at a low temperature of 573K. Recrystallization via particle-stimulated nucleation (PSN) was attributed to the coarsening of precipitates during the prolonged interpass anneals. Boundaries of recrystallization nuclei were associated with a lattice rotation of approximately 40° about <111>. Similar processing studies for the commercial 2519 alloy indicated that the critical particle size for PSN is larger in this material.

PUBLICATIONS:

Crooks, R., McNelley, T.R., and Kalu, P.N., "Microstructural Development in a Superplastic P/M 7064 Alloy," to be published in The 4th International Conference on Aluminum Alloys: Their Physical and Mechanical Properties, Vol III, T.H. Sanders and E.A. Starke, eds., The Georgia Institute of Technology, Atlanta, GA, pp.282-289, 1995.

Crooks, R., McNelley, T.R., Kalu, P.N., and Hales, S.J., "Grain Boundary Misorientation Distribution and

Superplasticity in Al-10Mg-0.1Zr, to be published in Superplasticity and Superplastic Forming, A.K. Ghosh and T.R. Bieler, eds., The Metallurgical Society, Warrendale, PA, 1995.

CONFERENCE PRESENTATIONS:

Crooks, R., McNelley, T.R., and Kalu, P.N., "Microstructural Development in a Superplastic P/M 7064 Alloy," the 4th International Conference on Aluminum Alloys, Atlanta, GA, 11 September 1994.

OTHER:

McNelley, T.R., "Processing and Superplasticity in Al-Mg Alloys," NSF/DoE Workshop on Basic Research Needs for Vehicles of the Future, New Orleans, LA, forthcoming in January 1995.

Crooks, R., McNelley, T.R., Kalu, P.N., and Hales, S.J., "Grain Boundary Misorientation Distribution and Superplasticity in Al-10Mg-0.1Zr," Symposium on Superplasticity and Superplastic Forming, 124th. Meeting of TMS, Las Vegas, NV, forthcoming 13 February 1995.

DOD KEY TECHNOLOGY AREA: Materials and Processes

KEYWORDS: Aluminum, Superplasticity, Recrystallization, Grain Boundaries, Thermomechanical Processing

THERMOMECHANICAL PROCESSING AND DUCTILITY ENHANCEMENT OF DURALCAN COMPOSITE MATERIALS

T.R. McNelley, Professor
Department of Mechanical Engineering
Funding: DURALCAN-USA, San Diego, CA

OBJECTIVE: The goal of this program is obtain improved combinations of strength, ductility and toughness in Al-based metal-matrix composite materials by thermomechanical processing.

SUMMARY: Discontinuously reinforced Al-Al_2O_3 composite materials have many attractive properties but lack adequate ductility and toughness for many applications. Dramatic improvements in composite ductility have been attained in extruded 6061 Al-Al_2O_3 processed using methods designed to redistribute the Al_2O_3 particles as well as achieve a fully recrystallized matrix grain structure via particle-stimulated nucleation of recrystallization. Further improvements in ductility have been obtained with use of controlled heat treatments on processed material. Processing methods suitable for production of extruded materials have also been designed and evaluated.

PUBLICATIONS:

McNelley, T.R and Crooks, R., "Thermomechanical Processing and Ductility Enhancement of Particulate Reinforced Aluminum (PRA)," Proceedings of the 16th Annual DoD Symposium on Metal Matrix Composites, H.M. Berkowitz, ed., Institute for Defense Analysis and DoD Metal Matrix Composites Information Analysis Center, Purdue University, W. Lafayette, IN, 1994.

McNelley, T.R. and Shelton, D.K., "Microstructural Control and Ductility Improvement via Processing of Particle-Reinforced 6061 Aluminum MMC Extrusions," Proceedings of the 17th Annual DoD Symposium on Metal Matrix Composites, H.M. Berkowitz, ed., DoD Metal Matrix Composites Information Analysis Center, Purdue University, W. Lafayette, IN, forthcoming in 1995.

PRESENTATION:

McNelley, T.R. and Crooks, R., "Thermomechanical Processing and Ductility Enhancement of Particulate Reinforced Aluminum (PRA)," 16th Annual Metal Matrix Composites Working Group Meeting, Park City, UT, 3 February 1994.

OTHER:

McNelley, T.R. and Shelton, D.K., "Microstructural Control and Ductility Improvement via Processing of Particle-Reinforced 6061 Aluminum MMC Extrusions," 17th Annual Metal Matrix Composites Working Group Meeting, Salt Lake City, UT, upcoming on 8 February 1995.

DOD KEY TECHNOLOGY AREA: Materials and Processes

KEYWORDS: Metal-Matrix Composites, Processing, Ductility, Particle Distribution, Grain Refinement

CONTINUOUS MEASUREMENT OF AGING USING EDDY CURRENT SENSORS DURING HEAT TREATMENT OF PRECIPITATION HARDENING ALLOYS

T.R. McNelley, Professor
Department of Mechanical Engineering
Sponsor: Naval Air Warfare Center, Warminster, PA

OBJECTIVE: The goal of this program is the development of sensors for the continuous measurement of the aging response during heat treatment of a precipitation hardening alloy. Intelligent processing requires such a sensor to monitor material response in real time and provide input to a controller.

SUMMARY: This research involved further development of a sensor system for the continuous monitoring of the aging response of 7075 Aluminum alloy during intelligent heat treatment of the material. Intelligent processing requires sensors to monitor material response in real time. A sensor consisting of two spiral-wound probes and a bridge circuit with a bridge carrier amplifier has been used to obtain data reflecting the changing resistivity of 7075 Aluminum during either isothermal or multi-step aging treatments. Transient effects during initial rapid heating to test temperature as well as during slower temperature excursions associated with multi-step treatments have been characterized. Mechanical property data were correlated with the resistivity data. Sensors capable of operation at temperatures up to 500° C will be fabricated for applications involving higher temperature alloys.

OTHER:

Master's thesis expected in March 1995, "Sensor Development for Intelligent Processing of Age Hardenable Aluminum Alloys," by R.A. Hall.

DOD KEY TECHNOLOGY AREA: Materials and Processes

KEYWORDS: Intelligent Processing, Heat Treating, Aluminum Alloys

MICROSTRUCTURE-CRYOGENIC BEHAVIOR CORRELATIONS IN A WELDED ALUMINUM-LITHIUM ALLOY

T.R. McNelley, Professor
Department of Mechanical Engineering
Funding: Martin-Marietta Manned Space Systems, New Orleans, LA

OBJECTIVE: The goal of this program is to characterize the microstructure of aluminum lithium (Al-Li) alloy 2195 weldments following initial welding by variable palarity plasma arc welding (VPPAW) as well as following subsequent gas tungsten arc welding (GTAW) repair cycles. Of principal interest are initial VPPAW welds of 2195 using 4043 filler material and GTAW repaired 2195/4043 weldments. Characterization methods will include optical microscopy, scanning electron microscopy (SEM) techniques (secondary electron and backscattered imaging methods as well as electron backscattered pattern analysis), and transmission electron microscopy (TEM).

SUMMARY: Failure analysis has shown that intergrannular cracking can occur through a thin, equiaxed zone (EZ) of grains lying between the fusion zone (FZ) and the heat affected zone (HAZ) of 2195 weldments. The EZ is characterized by relatively fine equiaxed grains with grain boundaries decorated with continuous second phase (CSP) particles. The origin of the EZ and the exact character of the CSP has yet to be determined. The grain structure of the EZ may reflect heterogeneous nucleation and non-equilibrium solidification processes. In some of the equiaxed grains as well as in the coarse FZ grains discrete particles have been seen in association with contrast variations which, in turn, suggest composition gradients due to coring. The amount and composition of CSPs will be correlated with welding parameters and repair conditions. Phase analysis using electron backscattered pattern analysis will be conducted to determine the nature of the CSP and grain boundary phases appearing on grain boundaries in the HAZ.

OTHER:

Master's thesis expected in September 1995, "Effect of Weld Repair Cycles on Al Alloy 2195," by M.R. Grant.

DOD KEY TECHNOLOGY AREA: Materials and Processes

KEYWORDS: Welding, Cryogenic Materials, Space Shuttle External Tank, Aluminum Alloys

ADVANCED GAS TURBINE SEALS

K.T. Millsaps, Jr., Assistant Professor
Department of Mechanical Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: To advance the state-of-the-art in gas turbines sealing technology.

SUMMARY: Analytical work on the forces generated by geometrically imperfect sealing knives and inner gland surfaces have been investigated. It has been found that very small asymmetries can create radial of the same order of magnitude as residual unbalance in high power density machines. Guidelines which can be used by engine designers, have been developed.

A detailed mechanical design for a low speed test section for measurement of seal flow has been finished. It will be fabricated and installed in the low speed boundary layer tunnel in the new ME building as soon as possible.

A Reynolds averaged Computational Fluid Dynamic (CFD) simulation code has been used to investigate the flow in a labyrinth seal. Initial predictions for flow coefficients match existing experimental data within 10%. However, the results are not very consistent with previously published CFD results in similar geometries.

Preliminary design on a high speed flow and heat transfer rig for advanced seals has been completed

PUBLICATIONS:

Millsaps, K.T. and Martinez. M., "Dynamic Forces From Single Gland Labyrinth Seals: Part I - Ideal and Viscous Decomposition," ASME Journal of Turbomachinery, Vol. 119, pp. 686-694, October 1994.

Millsaps, K.T. and Martinez. M., "Dynamic Forces From Single Gland Labyrinth Seals: Part II - Upstream Coupling," ASME Journal of Turbomachinery, Vol. 119, pp. 693-700, October 1994.

Millsaps, K.T. and Martinez. M., "Rotordynamic Forces in Labyrinth Seals: Theory and Experiment," Seventh Conference on Rotordynamic Instability Problems in High-Performance Turbomachinery, 10-12 May 10-12 1993, Texas A&M University, NASA CP-5231, 1994.

Millsaps, K.T. and Williston, W.C., "Synchronous Rotor Vibration Driven by a Rotating Geometrically Imperfect Labyrinth Seal," accepted for the 1995 International Gas Turbine Conference, Den Haag, Netherlands, June 1994. (* Also being considered for journal publication).

CONFERENCE PRESENTATION:

Millsaps, K.T., "Labyrinth Seal Induced Vibration Problems," invited talk - Panel, 31st AIAA-ASME-SAE Joint Propulsion Conference, Indianapolis IN, May 1994.

THESES DIRECTED:

Williston, W.C., LCDR, USN, "Synchronous Vibrations resulting from Non-Uniform Labyrinth Seal Gaps," Master's Thesis, December 1993.

Konicki, J.S., LT, USN, "Design of a 2-Dimensional Planar Labyrinth Seal Test Facility," Master's Thesis, December 1993.

DOD KEY TECHNOLOGY AREA: Propulsion and Energy Conversion

KEYWORDS: Labyrinth Seals, Fluid-Induced Forces, Synchronous Vibrations, Computational Fluid Dynamics

ROTORDYNAMICS TEST FACILITY

K.T. Millsaps, Jr., Assistant Professor
Department of Mechanical Engineering
Sponsor: Unfunded

OBJECTIVE: To investigate split resonance and backward whirl phenomena and determine the physical mechanisms that create it.

SUMMARY: A rotordynamics test facility has been developed. This table top rig consists of a Bentley Nevada rotor kit along with appropriated (proximeter and accelerometer) instrumentation. A lab PC 486-66 along with a PC data acquisition board and software is being used to acquire and process the data which give time resolved

rotor orbits. Two lateral transverse resonant frequencies, one in each of the orthogonal direction, have been identified. Operation between these frequencies creates reverse whirl orbits. An analytical model was developed which models the long slender rotor. This model contains linear, direct and cross stiffness and damping which result from the bearing dynamics. Using this model, the cause of split resonance and backward whirl has been identified as being the result of non-symmetric direct stiffness. This was induced by gravity and not bearing non-circularity as previously thought.

PUBLICATION:

Millsaps, K.T., Simei, F.A., and Vejvoda, C.E., "Split-Resonance and Backward Rotor Whirl Induced by non-symmetric Direct Bearing Stiffnesses," accepted for publication ASME IGTI.

CONFERENCE PRESENTATION:

Millsaps, K.T. and Vejvoda, C.E., "Split Resonance and Backward Whirl Phenomena," Bentley Rotordynamics Technology Conference, Sponsored by the Bentley Nevada Corporation, 18 August 1994.

THESIS DIRECTED:

Vejvoda, C.E., "Analytic and Experimental Investigation of Rotordynamic Response and Backward Whirl induced by Split Resonance," Master's Thesis, December 1994.

DOD KEY TECHNOLOGY AREA: Propulsion and Energy Conversion

KEYWORDS: Rotordynamics, Split-Resonance, Backward Whirl, Gravity Effects, Bearings

ATTITUDE CONTROL OF A SPACE STRUCTURE USING A 3-R MANIPULATOR

R. Mukherjee, Assistant Professor
Department of Mechanical Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: The objective of this research was to develop an algorithm for the reorientation of a space structure using a three link rigid robot manipulator.

SUMMARY: We developed a "Surface Integral Algorithm" for the reorientation of a space structure using a three link rigid manipulator. The manipulator was assumed to be PUMA-type and mounted above the center of gravity of the space structure. Numerical and graphical simulations were used to demonstrate the efficacy of the algorithm. A testbed was also created for the experimental validation of the algorithm.

PUBLICATION:

Mukherjee, R. and Zurowski, M., "Reorientation of a structure in space using a three link rigid manipulator," AIAA Journal of Guidance Control and Dynamics, Vol. 17, No. 4, pp. 840-847, July 1994.

THESES DIRECTED:

Zurowski, M., LT, "Trajectory Planning for Space Manipulators," Master's Thesis, December 1993.

Maddox, D.L., LT, "An Experimental Testbed for a Free-Floating Manipulator," Master's Thesis, December 1993.

DOD KEY TECHNOLOGY AREA: Other (Space Systems)

KEYWORDS: Attitude Control, Nonholonomic Motion Planning, Surface Integral Algorithm

DEVELOPMENT OF A FLEXIBLE SURGICAL ROBOTIC ARM

R. Mukherjee, Assistant Professor
Department of Mechanical Engineering
Sponsor: Advanced Research Projects Agency (ARPA)

OBJECTIVE: The objective of this research is to develop a flexible surgical robotic manipulator which will aid in minimally invasive surgery.

SUMMARY: We have so far designed a superelastic alloy tube as the actuator for the surgical manipulator. The actuators will be thermally activated and we have designed an actuation system for the feedback control of the actuators using the minimum number of electrical connecting wires. Currently we are working on the calibration of the superelastic alloy actuators and the integration of the components of the surgical manipulator.

PUBLICATION:

Mukherjee, R. and Thiel, R., "Development of an Actuation System for Control of an SMA-Actuated Surgical Manipulator," First International Symposium on Medical Robotics and Computer Assisted Surgery, 1994 (MRCAS '94), Pittsburgh, PA.

CONFERENCE PRESENTATION:

Mukherjee, R. and Thiel, R., "Development of an Actuation System for Control of an SMA-Actuated Surgical Manipulator," First International Symposium on Medical Robotics and Computer Assisted Surgery, 1994 (MRCAS '94), Pittsburgh, PA.

PATENT APPLICATION:

Mukherjee, R. and Christian, T. F., "An Actuation System for the Control of Multiple Shape Memory Alloy Elements."

DOD KEY TECHNOLOGY AREA: Other (Health Care)

KEYWORDS: Minimally Invasive Surgery, Shape Memory Alloy, Superelastic Alloy

REPEATABILITY IN NONHOLONOMIC MECHANICAL SYSTEMS

R. Mukherjee, Assistant Professor
Department of Mechanical Engineering
Sponsor: National Science Foundation

OBJECTIVE: There are certain nonholonomic systems for which certain closed paths in the space of the independent variables do not produce any net change of the dependent variables. These trajectories are like "holonomic loops" over which the nonholonomic system exhibits holonomic behavior globally. Our research is aimed at planning such drift-free trajectories for nonholonomic systems.

SUMMARY: We have so far studied the repeatability problem in a planar space robot and a three link redundant manipulator under pseudoinverse control. Preliminary studies indicate that repeatability can be achieved in the absence of integrability of the nonholonomic constraints of motion.

PUBLICATION:

Mukherjee, R. and Zurowski, M., "Pseudo-holonomic behavior of planar space robots," 1994 IEEE International Conference on Robotics and Automation, 1994.

CONFERENCE PRESENTATION:

Mukherjee, R. and Zurowski, M., "Pseudo-holonomic behavior of planar space robots," 1994 IEEE International Conference on Robotics and Automation, San Diego, CA.

THESIS DIRECTED:

Emond, B.R., LT, "Optimal Control of a Two-Wheeled Mobile Robot," Master's Thesis, September 1994.

DOD KEY TECHNOLOGY AREA: Design Automation

KEYWORDS: Nonholonomic Systems, Pseudo In Verse Control, Repeatable Trajectories

NONLINEAR DYNAMICS AND TACTICAL EVALUATION OF SUBMARINE NEAR SURFACE RESPONSE

F.A. Papoulias, Associate Professor
Department of Mechanical Engineering
Sponsor: Naval Postgraduate School

OBJECTIVE: The objective of this project was to initiate efforts in characterizing and classifying submarine near surface response, in forms that can be directly utilized during preliminary design phases.

SUMMARY: Submarine operations at periscope depth become increasingly important as new roles for the Navy in littoral waters are emerging. Particular emphasis in this work was placed on computation of steady state forces on the body as a function of speed, depth, and wave frequency and direction. Solution of the problem was accomplished by singularity distributions on the actual surface of the body and discretization in the form of plane quadrilateral elements. Parametric studies were conducted in order to assess the effects of body shape and size.

THESIS DIRECTED:

Crook, T.P., LCDR, USN, "An Initial Assessment of Free Surface Effects on Submerged Bodies," Master's Thesis, September 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Wave Making Resistance, Suction Forces, Submarine Response

OPERATIONAL AND TACTICAL EVALUATION OF SHALLOW WATER NEAR SURFACE SUBMARINE RESPONSE

F.A. Papoulias, Associate Professor
Department of Mechanical Engineering
Sponsor: NSWC - Carderock Division

OBJECTIVE: The objective of this project was to determine mission and operation requirements of submarines in shallow water/near surface/littoral environments.

SUMMARY: A comprehensive study of shallow water characterization was undertaken. Shallow water operations and missions were defined. Missions with hard requirements were identified. Examples of such missions include navigation, weapons deployment, and surveillance. The effects of crucial environmental factors, such as layer depth, gradients, and proximity were classified. Finally, stealth requirements relating to maneuverability and missions that can be improved using automatic control were studied.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Shallow Waters, Near Surface Effects, Submarine Response

TURBULENT VORTEX/FREE-SURFACE INTERACTIONS

T. Sarpkaya, Distinguished Professor
Department of Mechanical Engineering
Sponsor: Chief of Naval Research (ONR)

OBJECTIVE: The continuation of basic and applied research towards the understanding of the phenomena resulting from the interaction of *turbulent vortices with clean or contaminated free surfaces.* The quantification of the characteristics of turbulence (stresses, structures, and turbulent kinetic energy) through extensive measurements (LDV), flow visualization (LIF), Proper-Orthogonal-Decomposition (POD), and numerical analysis.

SUMMARY: The statistical as well as structural characteristics of the turbulent flow field resulting from the interaction of a turbulent jet with clean and contaminated free surfaces were investigated in order to elucidate the physics of the phenomena relevant to the understanding of near-surface structures in ship-generated wakes.

Turbulence intensities, energy spectra, and turbulent stresses are measured with an LDV in the region between a single trailing vortex and the free surface. Amplification of the streamwise and transverse components of turbulent velocity, coupled with a sharp reduction in the vertical turbulent velocity, was found near the free surface. The energy spectra shows that, as the free surface is approached, there is a preferential attenuation of low frequencies (large scales) for the vertical velocity fluctuations and a net energy gain at the same frequencies for the streamwise and transverse turbulence components. Thus, the free-surface redistributes the normal component of the turbulent kinetic energy into streamwise and spanwise components at large eddy scales, and renders the near-free-surface turbulence strongly anisotropic. The predominant coherent structures are (i) swirling surface depressions whose preferential merging leads to reverse energy cascade and eddy longevity, and (ii) flattened large eddies with axes nearly parallel to the free surface. The entire process is driven by the underlying, nearly isotropic, three-dimensional turbulence field.

PUBLICATIONS:

Sarpkaya, T., "Review of the Flow-Induced Vibrations," Applied Mechanics Reviews, Vol. 47, No. 11, p. B103, November 1994.

Sarpkaya, T. and Neubert, D., "Interaction of a Streamwise Vortex with a Free Surface," American Institute of Aeronautics and Astronautics Journal, Vol. 32. No. 3, pp. 594-600, March 1994.

Sarpkaya, T., "Vortex Element Methods for Flow Simulation," Advances in Applied Mechanics, Vol. 31, pp. 113-247, May 1994.

Sarpkaya, T., Merrill, C., and Carroll, J., "Coherent Structures in Vortex/Free-Surface Interaction," American Institute of Aeronautics and Astronautics, Paper No. 94-0530, pp. 1-12, January 1994.

Sarpkaya, T., "Vortices, Turbulence, and Free Surface," Proceedings of the Invited Meeting of the ONR, 1-9 February 1994.

Sarpkaya, T., "Hydrodynamic Damping and Flow-Induced Vibrations: Reflections and New Results," Proceedings of the Active Control of Vibration and Noise-ASME-DE-Vol. 75, pp. 293-301, November 1994.

Sarpkaya, T., "Unsteady Flows: Analysis and Experiments," Handbook of Fluid Dynamics, Senior Ed. J.A. Schetz, John Wiley & Sons, in press, to appear November 1995.

Sarpkaya, T., "Interaction of Vorticity, Free-Surface, and Surfactants," Annual Review of Fluid Mechanics, Vol. 28, pp. 1-35, in press, to appear in November 1995.

Sarpkaya, T., "Vortex Breakdown and Turbulence," American Institute of Aeronautics and Astronautics, Paper No. AIAA 95-0433, pp. 1-13, to appear January 1995.

Sarpkaya, T., "Quandaries of the Creation, Convection, and Confusion of Vorticity," Proceedings of the International Conference on Vortex Methods for Engineering Applications, Vol. 1, pp. 1-36, Albuquerque, NM, to appear February 1995.

Sarpkaya, T., "Interaction of Vorticity, Free Surface, and Surfactants," Proceedings of the ONR meeting on Free-Surface Turbulent Flows, Vol. 1, pp. 1-14, Caltech, CA, to appear February 1995.

Sarpkaya, T., "The Interaction of Swirling Jets with a Free Surface," Proceedings of the ONR meeting on Free-Surface Turbulent Flows, Vol. 1, pp. 34-42, Caltech, CA, February 1995.

THESES DIRECTED:

Merrill, C.F., LT, USN, "Numerical Analysis of Single-Vortex/Free-Surface Interaction," Master's Thesis, December 1993.

Magee, M.P., LT, USN, "Spectral Characteristics of the Vortex/Free-Surface Interaction," Master's Thesis, December 1993.

Hofert, G.D., LT, USN, "Spectral Analysis of Vortex/Free-Surface Interaction," Master's Thesis, June 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Vorticity, Free Surface, Surface Signatures, SAR Images

NUMERICAL STUDY OF UNDEX PROBLEMS: WATER-BACKED COMPOSITES, SURFACE COATINGS, AND GAS BUBBLE-STRUCTURE INTERACTION

Y.S. Shin, Professor
Y.W. Kwon, Associate Professor
Department of Mechanical Engineering
Sponsor and Funding: Defense Nuclear Agency

OBJECTIVE: To advance our understanding on (i) dynamic response and failure of water backed composite structures subjected to an underwater explosion, (ii) effects of surface coating on dynamic behavior of structures exposed to a shock loading, and (iii) numerical simulation and modeling of gas bubble, structures and their interaction using Lagrangian-Eulerian finite element analysis approach. (a continuing project)

SUMMARY: Both air-backed and water-backed composite cylinders were studied experimentally and numerically. This study focused on improvement of numerical modeling techniques to better predict the experimental results as well as comparison of dynamic responses of air-backed and water-backed structures. The effects of surface coating on dry and wet structures subjected to shock loading were studied. The coating was either an elastic material or a viscoelastic rubber material. This study showed a softer coating material trapped excessive strain energy in the structure increasing its stresses and deformation. A threshold value existed in the material and geometric properties below which the coating had an adverse effect on the structure. For the gas bubble-structure interaction, the numerical simulation of explosive gas bubble motion in the fluid was investigated. The rigid, the free surface (constant pressure) and non-reflecting fluid boundary conditions were considered. The results of the Lagrangian-Eulerian finite element analysis are quite promising. The numerical modeling includes 1- and 2-dimensional axisymmetric problems.

PUBLICATIONS:

Kwon, Y.W., Bergersen, J.K., and Shin, Y.S., "Effect of Surface Coatings on Cylinders Exposed to Underwater Shock," Journal of Shock and Vibration, Vol. 1, No. 3, pp. 253-266, 1994.

Shin, Y.S. and Hooker, D.T., "Damage Response of Submerged Imperfect Cylindrical Structures To Underwater Explosion," pp. 435-448, Proceedings of the Third International Conference on Structures under Shock and Impact III, Madrid, Spain, 1-3 June 1994.

Shin, Y.S. and Hooker, D.T., "Shock-Induced Damage Response Patterns of Submerged Structures," ASME PVP Vol. 272, Sloshing, Fluid-Structure Interaction and Structural Response due to Shock and Impact, pp. 167-173, ASME PVP Conference, Minneapolis, MN, 19-23 June 1994.

Brasek, T.P., Kwon, Y.W., and Shin, Y.S., "Effect of Surface Coating on One-Dimensional System Subjected to Unit Step Pressure Wave," Naval Postgraduate School Technical Report, NPS-ME-94-006, 1994.

Brasek, T.P., Kwon, Y.W., and Shin, Y.S., "Response of Dual-Layered Structures Subjected to Shock Pressure Wave, Naval Postgraduate School Technical Report, NPS-ME-94-007, 1994.

OTHER:

Y.S. Shin gave the invited 3-hour lectures on Underwater Explosions and Their Responses to Structures at 65th Shock and Vibration Symposium, San Diego, CA, 31 October - 3 November 1994.

DOD KEY TECHNOLOGY AREA: Other (Survivability, Modeling and Simulation)

KEYWORDS: Underwater Explosion, Composites, Nonlinear Dynamic Response, Gas Bubble

DYNAMIC RESPONSE OF COMBAT SYSTEM EQUIPMENTS TO UNDERWATER EXPLOSION

Y.S. Shin, Professor
Department of Mechanical Engineering
Sponsor and Funding: Naval Sea Systems Command, Code 03K213

OBJECTIVE: To develop, design, build and testing "tuned" mounting fixture to simulate the ship-shock environment and its effect to combat system equipments using U.S. Navy's Mediumweight Shock Machine with tuned mounting fixture. (a continuing project)

SUMMARY: Shipboard combat system equipments must be designed to withstand severe shock excitations induced by underwater explosion, either conventional or nuclear. The response of combat system equipments to underwater explosion is basically vibrational in nature. The U.S. Navy's shock qualification requirements are mandated in MIL-S-901D. Of particular interest is the U.S. Navy's Mediumweight Shock Machine(MWSM) used for shock qualification of equipment ranging from 230 to 6000 lbs. This hammer-anvil device delivers high energy, high frequency shock excitation to item affixed to it. This type of high frequency excitation waveform is significantly different from the actual waveforms that have been observed at various equipment locations during ship shock trials. The differences can be reduced by substituting a specially designed "tuned" test mounting fixture for the default mounting fixtures currently used to affix test items to the MWSM. FY94's study was an experimental investigation into the dynamic response of the recently built Two-Degree-of-Freedom (2DOF) Tuned Deck Simulator (TDS) for MWSM to evaluate its potential role in the pre-acceptance shock qualification of new shipboard combat systems equipment. Upon completion of final characterization testing, the 2DOF-TDS could be integrated into the mediumweight shock qualification procedures of MIL-S-901D. This improvement could significantly enhance the capacity of a warship to absorb damage and still maintain its mission integrity.

PUBLICATION:

Flynn, T.V., Shin, Y.S., and McLean, M., "Experimental Investigation into the Dynamic Response of Two DOF Tuned Deck Simulator for Shock Qualification of Shipboard Systems," Proceedings of 65th Shock and Vibration Symposium, Vol. I, pp. 19-32, San Diego, CA, 31 October - 3 November 1994.

CONFERENCE PRESENTATION:

Flynn, T.V., Shin, Y.S., and McLean, M., "Experimental Investigation into the Dynamic Response of Two DOF Tuned Deck Simulator for Shock Qualification of Shipboard Systems," presented at the 65th Shock and Vibration Symposium, San Diego, CA, 31 October - 3 November 1994.

THESIS DIRECTED:

Flynn, T.V., CDR, USN, "Experimental Investigation into the Dynamic Response of Two DOF Tuned Deck Simulator for Shock Qualification of Shipboard Systems," Master's Thesis, June 1994.

DOD KEY TECHNOLOGY AREA: Other (Survivability, Modeling and Simulation)

KEYWORDS: Mediumweight Shock Machine, Multi-DOF Tuned Mounting Fixture, Underwater Explosion, Shock Spectra

SHOCK AND VIBRATION RESEARCH IN SUPPORT OF ALISS
(Advanced Lightweight Influence Sweep System)

Y.S. Shin, Professor
Department of Mechanical Engineering
Sponsor and Funding: Cardrock Division of Naval Surface Warfare Center

OBJECTIVE: The scientific objectives include (i) to study the operational environment in which the ALISS must be designed to perform and to make a recommendation on shock and vibration design criteria, (ii) to conduct a review of the magnet shock test apparatus currently in use and to make any design modification if any, and (iii) to review the common cryogenic supports which are candidates for use in the ALISS and to design a shock test apparatus to test the performance of these cryogenic supports. (a continuing project)

SUMMARY: This is a on-going shock and vibration research project in support of Advanced Lightweight Influence Sweep System (ALISS). ALISS is an Advanced Technology Demonstration to validate the feasibility of superconducting technology to sweep magnetic influence mines. A Superconducting Mine Countermeasures (SCMCM) system would be small, light, and simple compared to currently deployed MCM system. When ALISS is constructed as a superconducting mine countermeasure, the system must perform satisfactorily under the extremes of shock and vibration environment encountered in military applications. The tasks conducted include (i) the data reduction, analysis and results of Landing Air Cushion Vehicle (LACV-30-07) for developing wave loading and vessel vibration criteria, and (ii) normal mode and transient response analysis of 1/4-scale superconductor magnet SCMCM model.

PUBLICATION:

Shin, Y.S. and Hoy, E., "Data Reduction, Analysis and Results of LACV-30-07 Air Cushion Vehicle Tests, Fort Story, VA," Naval Postgraduate School Technical Report, NPS-ME-94-002, February 1994.

THESIS DIRECTED:

Hoy, E., LT, USN has finished his thesis on December 1994.

DOD KEY TECHNOLOGY AREA: Other (Mine Countermeasures, Superconductor)

KEYWORDS: ALISS, Superconducting Mine Countermeasures, Light Weight Influence Mine Sweep System, Shock and Vibration

VIBRATION ANALYSIS OF SHIPBOARD RECIPROCATING MACHINERY

Y.S. Shin, Professor
Department of Mechanical Engineering
Sponsor and Funding: NAVSEA DET PERA(CV), Code 1822

OBJECTIVE: To develop advanced machinery condition monitoring technique and diagnostics method for the non-stationary and transient shipboard reciprocating machinery such as high/low pressure air compressors.

SUMMARY: The current shipboard machinery vibration monitoring and diagnostic procedures use frequency domain spectra to identify possible faults and problem areas. This method has proven to be inadequate for reciprocating machinery analysis. In reciprocating machinery the vibration signal is no longer a stationary, ergodic process, but is time-dependent and in some cases transient. This study proposes the use of both Pseudo Wigner-Ville Distribution and Wavelet Analysis as two advanced methods for diagnostics tools. These methods employ a time-frequency domain distribution for the detection of fault location and severity level. To demonstrate

the benefits of a time-frequency representation, vibration data from two types of reciprocating air compressors are processed for analysis. To simulate the faulty conditions, artificial glitches were introduced in the test data and analyzed.

PUBLICATIONS:

Shin, Y.S., Liu, C.S., and Jeon, J.J., "Determination of Vibration Alert Level in Condition Monitoring of Rotating Machinery," Proceedings of the 12th International Modal Analysis, Vol. II, pp. 1483-1495, Honolulu, HI, 31 January - 3 February 1994.

Liu, C.S., Shin, Y.S., and Jeon, J.J., "Settlement of Alarm Thresholds in Vibration Monitoring for Rotating Machinery," Proceedings of the 48th Meeting of the Mechanical Failure Prevention Group, pp. 77-92, Wakefield, MA, 19-22 April 1994.

Jeon, J.J. and Shin, Y.S., "Time-Frequency Domain Analysis of Acoustic Signatures Using Pseudo Wigner-Ville Distribution," Proceedings of 5th Western Pacific Regional Acoustics Conference, Vol. 2, pp. 674-679, Seoul, Korea, 23-25 August 1994.

Shin, Y.S. and Jeon, J.J., "Wavelet Analysis of Nonstationary Acoustic and Vibration Signatures," Proceedings of Inter-Noise 94, Vol. 3, pp. 1903-1906, Yokohama, Japan, 29-31 August 1994.

Shin, Y.S. and Liu, C.S., "Vibration Alert Level in Shipboard Machinery Condition Monitoring and Diagnostics," accepted, to appear in Journal of Naval Engineers.

CONFERENCE PRESENTATIONS:

Shin, Y.S., Liu, C.S., and Jeon, J.J., "Determination of Vibration Alert Level in Condition Monitoring of Rotating Machinery," presented at the 12th International Modal Analysis, Honolulu, HI, 31 January - 3 February 1994.

Liu, C.S., Shin, Y.S., and Jeon, J.J., "Settlement of Alarm Thresholds in Vibration Monitoring for Rotating Machinery," presented at the 48th Meeting of the Mechanical Failure Prevention Group, Wakefield, MA, 19-22 April 1994.

Jeon, J.J. and Shin, Y.S., "Time-Frequency Domain Analysis of Acoustic Signatures Using Pseudo Wigner-Ville Distribution," presented at the 5th Western Pacific Regional Acoustics Conference, Seoul, Korea, 23-25 August 1994.

Shin, Y.S. and Jeon, J.J., "Wavelet Analysis of Nonstationary Acoustic and Vibration Signatures," presented at the Inter-Noise 94, Yokohama, Japan, 29-31 August 1994.

THESIS DIRECTED:

Hardening J.E., LCDR, USCG, "Time-Frequency Domain Distribution and Its Application To Reciprocating Machinery Analysis," Master's Thesis, September 1994.

DOD KEY TECHNOLOGY AREA: Other (Machine Condition Monitoring)

KEYWORDS: Shipboard Machinery Monitoring, Vibration Alert Level, Shipboard Fire Pump, Condition Monitoring and Diagnostics

DEPARTMENT
OF
MECHANICAL ENGINEERING

1994
Faculty Publications
and Presentations

JOURNAL PAPERS

Calvano, C.N. and Ball, R.E., "Establishing the Fundamentals of a Surface Ship Survivability Discipline," American Society of Naval Engineers Journal, Vol. 106, No. 1, pg. 71, January 1994.

Driels M. and Turkgenci Y., "Selective Backdriveability and its Application to a Direct Drive Robotic Finger Design," Transactions ASME, Journal of Mechanical Design, Vol. 116, pp. 44-46, March 1994.

Driels M. and Beierl P., "A Finite Memory Model for Haptic Teleoperation," Transactions IEEE Systems, Man and Cybernetics, Vol. 24, No. 4, pp. 690-698, April 1994.

Driels M. and Pathre, U., "Robot Calibration Using a Vision Based Automatic Theodolite," International Journal of Advanced Manufacturing Technology, Vol. 9, pp. 114-125, 1994.

Driels M, and Swayze W., "Automated Partial Pose Measurement System for Manipulator Calibration Experiments," Transactions IEEE on Robotics and Automation, Vol. 10, No. 4, pp. 430-440, August 1994.

Dutta, I., Harper, C.P., and Dutta, G., "Role of Al_2O_3 Particulate Reinforcements on Precipitation in 2014 Al-Matrix Composites," Metallurgical Transactions A, Vol. 25A, p. 1591, 1994.

Gopinath, A. and Mills, A.F., "Convective Heat Transfer due to Acoustic Streaming across the ends of a Kundt Tube," Journal of Heat Transfer, Vol. 116, No. 1, pp. 47-53, 1994.

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Gordis, J.H., "An Analysis of the Improved Reduced System (IRS) Model Reduction Procedure," Modal Analysis, Vol. 9, No. 4, pp. 269-286, 1994.

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Kwon, Y.W., Bergersen, J.K., and Shin, Y.S., "Effect of Surface Coatings on Cylinders Exposed to Underwater Shock," Journal of Shock and Vibration, Vol. 1, No. 3, pp. 253-266, 1994.

Kwon, Y.W. and Berner, J.M., "Analysis of Matrix Damage Evolution in Laminated Composite Plates," Engineering Fracture Mechanics, Vol. 48, No. 6, pp. 811-817, 1994.

Lu, Z.-W., Zunger, A., and Fox, A.G., "Comparison of Experimental and Theoretical Electronic Charge

Distributions in gTiAl," Acta Metallurgica et Materiala, Vol. 42, pp. 3929-3943, 1994.

Memory, S.B., Chilman, A.V., and Marto, P.J., "Nucleate Pool Boiling of a Turbo-B Bundle in R-114," Journal of Heat Transfer, Vol. 116, pp. 670-678, 1994.

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Mukherjee, R. and Anderson, D.P., "A Surface Integral Approach to the Motion Planning of Nonholonomic Systems," ASME Journal of Systems, Measurement and Control, Vol. 116, No. 3, pp. 315-325, 1994.

Mukherjee, R. and Zurowski, M., "Reorientation of a structure in space using a three link rigid manipulator," AIAA Journal of Guidance Control and Dynamics, Vol. 17, No. 4, pp. 840-847, July 1994.

Papoulias, F.A., Venne, D.V., and Cummings, G.P., "Effects of Positional Information Time Lags on Autonomous Vehicle Guidance and Control," International Shipbuilding Progress, Vol. 41, No. 428, pp. 361-392, 1994.

Papoulias, F.A. and Aydin, I., "Out-of-Plane Solutions and Bifurcations of Submersibles in Free Positive Buoyancy Ascent," Journal of Ship Research, Vol. 38, No. 4, pp. 259-271, 1994.

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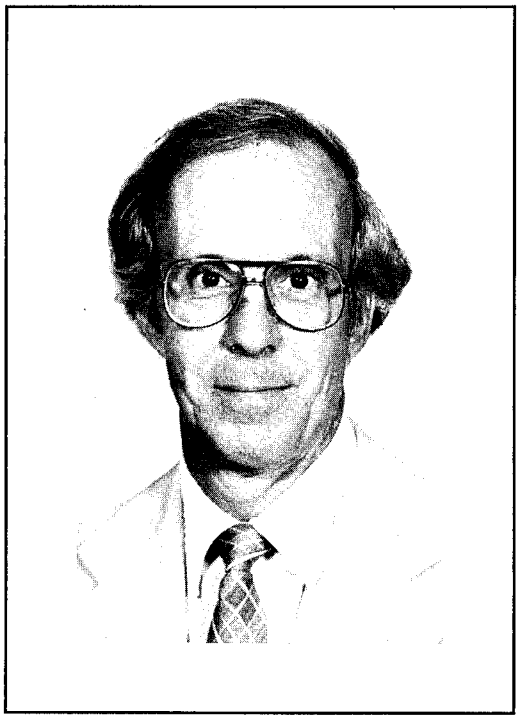
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Department of Meteorology

The following thirty-six research summaries describe projects which were carried out under the direction of faculty members in the Department of Meteorology during FY94. The projects were carried out by a dozen Principal Investigators with funding from 11 different sponsors. The projects range from very applied research for the operational Navy and National Weather Service to basic theoretical studies sponsored by NSF, ONR and NASA. Major research areas in the Department include tropical cyclones, coastal meteorology, synoptic and mesoscale meteorology, boundary layer meteorology, remote sensing, electromagnetic and optical propagation in the atmosphere, atmospheric aerosols (their sources and interaction with clouds), numerical atmosphere and ocean modeling, and tropical meteorology and air-sea interaction. All of these research efforts involve our officer students whose contributions are documented in their M.S. Theses or Ph.D. Dissertations.

TROPICAL CYCLONE MOTION AND PREDICTION

L.E. Carr, III, Assistant Professor
Department of Meteorology
Sponsor: Office of Naval Research

OBJECTIVE: The long-term goal of this project is to apply dynamical principles to the tropical cyclone motion problem and translate the dynamically-based understanding into better track predictions. One objective is to use these dynamics to explain systematic motion tendencies and track changes. A second objective is to develop a framework to improve tropical cyclone track forecasting based on dynamically-based reasoning and conceptual models.

SUMMARY: Carr and Elsberry have documented a class of sudden poleward track changes in western North Pacific tropical cyclones that are poorly forecast because of the rapidity and magnitude of the turning. They demonstrate that these cases are associated with the interaction of a tropical cyclone with a monsoon gyre. A simple barotropic model of this interaction is successful in simulating the sudden track changes, which indicates that horizontal vorticity advection is a primary mechanism. A systematic approach to tropical cyclone track prediction has been developed. The new approach emphasizes the integrated nature of the motion, intensity, and size aspects of the tropical cyclone problem. A pattern recognition approach is defined in terms of four recurrent synoptic patterns, and the synoptic regions within each pattern. The influences of storm intensity and of vertical wind shear are accounted for in the selection of the optimum level for defining the steering. A new tangential wind profile is defined to derive a specific beta-induced propagation speed as a function of storm size and latitude. A conceptual model is derived for the interaction of a tropical cyclone with a monsoon gyre, which Carr and Elsberry have demonstrated can cause sudden poleward track changes. Another conceptual model addresses ridge modification that is triggered by a large tropical cyclone and results in poleward deflections of the cyclone. In addition, six types of tropical cyclone - tropical cyclone interactions are identified. The report by Carr and Elsberry describing the overall systematic approach is to be followed by reports designed for application in specific tropical cyclone regions, beginning with the western North Pacific.

PUBLICATIONS:

Carr, L.E., III and Elsberry, R.L., "Monsoonal interactions leading to sudden tropical cyclone track changes," Monthly Weather Review, (in press).

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Carr, L.E., III and Jeffries, R.J., "Improving tropical analyses with satellite imagery interpretation," presented at USPACCOM Tropical Cyclone Conference, Tokyo, Japan, 8-11 March 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Tropical cyclone motion, tropical cyclone prediction, tropical meteorology

GLOBAL AND TROPICAL CIRCULATIONS

C.-P. Chang, Professor
Department of Meteorology
Sponsor: Naval Postgraduate School

OBJECTIVE: This project is to analyze the tropical motions systems contained in the analysis and forecast fields of the Navy's global numerical weather prediction model.

SUMMARY: A spectral study of synoptic disturbances over the equatorial western Pacific during northern winter 1992, was carried out, using radiosonde and Navy global model's analysis and 48 h forecast fields. The vertical structure based on radiosonde data contrasts sharply with the typical summer structure previously observed. This contrast may be explained by the reversal in vertical shear due to the Asian monsoon, in the same way as the variations between contrasting ENSO phases. Although the structure variation is reproduced by the analysis field, the forecast field produces a downstream propagation of central Pacific waves into area where the disturbances are not observed by radiosonde.

PUBLICATION:

Chang, C.-P., and Zambresky, L., "Observed and Navy global model climatologies of synoptic disturbances over the tropical western Pacific during northern winter 1991-92: A spectral analysis," Monthly Weather Review, Vol. 123, pp. 430-443.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Tropical Waves, Asian Monsoon, El Niño, Southern Oscillation

TROPICAL AND MONSOON STUDIES

C.-P. Chang, Professor
R.T. Williams, Professor
Department of Meteorology
Sponsor: National Science Foundation

OBJECTIVE: This is a continuing project to study the structure and properties of large-scale and frontal motions in the tropical and Asian monsoon regions.

SUMMARY: The project consists of two parts, observational and modeling studies. In the observational study we used the multiple-set canonical correlation analysis technique to study large-scale tropical motions over the western Pacific during northern summer of 1989-1991. Two major spatial modes are found, a northwestward propagating disturbance that has a quasi-period of 8-9 days and is related to tropical cyclone activities, and a larger scale pattern that consists of both quasi-stationary seasonal change and a westward propagating 20-day mode. In the modeling study a 3-D model was used to examine the stratified flow over mountains with different horizontal scales. Depending on the mean wind speed and the mountain scale, the lee trough may be generated either by flow over or around the mountain, and it may drift downwind or stay stationary. Furthermore, the mountain influences on the frontal intensity and deformation are local effects only, and that the advection of a front is increased by strong downslope winds.

PUBLICATIONS:

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Williams, R.T. and Chan, J.C., "Numerical studies of the beta effect in tropical cyclone motion. Part II: Zonal mean flow effects," Journal of Atmospheric Sciences, Vol. 51, pp. 1065-1076, 1994.

CONFERENCE PRESENTATIONS:

Chang, C.-P. and Chen, G.T., "Development of low-level southwesterly surges in the South China Sea: A comparison between May and June," SCSMEX Workshop, Goddard Space Flight Center, Greenbelt, MD, January 1994.

Chang, C.-P., "The South China Sea Monsoon Experiment. International Conference on Weather Analysis and Forecasting in the Asian-Pacific Monsoon Region," Pacific Science Association, Taipei, Taiwan, June 1994.

Chang, C.-P., "Tropical circulations associated with southwest monsoon development over the South China Sea," International Symposium on Monsoon Meteorology and Climate, Guangzhou, China, November 1994.

THESIS DIRECTED:

Cardenas Amores, J.A., LT, Ecuadorian Navy, "Intraseasonal oscillations over the tropical western Pacific and Eastern Indian Ocean for the northern summers of 1989-1991," Master's Thesis, June 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Tropical Waves, Tropical Cyclones, Topographic Effects, Fronts

AIR OCEAN SHIPBOARD MEASUREMENT

K.L. Davidson, Professor
Department of Meteorology
Sponsor: Space and Naval Warfare Command, SPAWAR PMW 165

OBJECTIVE: Objectives are to merge off-the-shelf hardware and software developments with requirements for air-ocean sensor suites and configure them for use in operational shipboard assessment of near-surface radar/radio refractive conditions. Further, to perform special analyses/interpretations on existing coastal zone refractive data.

SUMMARY: NPS personnel mounted and operated available/previously deployed and recently acquired instrumentation on the roof of Spanagel Hall. Performance and operational characteristics were evaluated with full exposure and for extended periods. Evaluated ship arrangement and deployment of five selected sensor and display systems suites during 9 day (7-16 November) R/V Point Sur cruise off Monterey. A contract was made with contractor for development of computer program to operate the Small Combatant Integrated Meteorology Retrieval System (SCRIMS). A computer program was developed and demonstrated for acquisition, archiving

and display of meteorological data on small combatant; including source, executable code, and user's guide.

DOD KEY TECHNOLOGY AREA: Environmental Effects, Sensors

KEYWORDS: Meteorological Measurement, Marine Atmosphere Boundary Layer, Radar Refraction

EVALUATION OF EFFECTS OF SEA SURFACE TEMPERATURE MEASUREMENTS ON EVAPORATION DUCT ESTIMATION

K.L. Davidson, Professor
Department of Meteorology
Sponsor: Naval Oceanographic Office, Code N512
Stennis Space Center, MS

OBJECTIVE: Objectives of this work are: (1) to participate in data collection designed to evaluate shipboard measurement of sea surface temperature for assessment of near-surface radar/radio refractive conditions, and (2) to perform special analyses interpretations on sensitivity of measured SST to evaporation duct strength estimates.

SUMMARY: This study evaluated SST measurement options from the usual method of SST determination, which is sea water intake. Evaluations were performed on the impact on describing near-surface refraction profiles. NPS personnel participated in a 3 day data collection effort from 12-1 September 1994. The collection occurred from a NAVOCEANO hydrography survey launch coastal vessel in the vicinity near Gulfport, MS. NPS obtained and recorded continuous measurements of temperature, humidity, vector wind, and atmospheric pressure from a vessel mounted mast and SST from a infrared (IR) thermometer (Everest Interscience, Inc.) and a in situ (bulk) sensor. The air measurements were made with an existing NPS system, a Coastal Climate WeatherPak. The NAVOCEANO radiometer sensed SST was merged with the NPS data. NPS performed quantitative analyses to determine values of evaporation duct strength. Emphasized in interpretations were differences associated with different (choice of) sensor used to obtain SST values. A report was prepared that included a data atlas and a summary evaporating duct strengths with discussion of impact of SST sensing method.

PUBLICATION:

Frederickson, P.A., Davidson, K.L., and Jones, F.K., "The Effect of Infrared Sea Surface Temperature Measurements on Evaporation Duct Height Estimation," Naval Postgraduate School Technical Report, NPS-MR-94-003, 16 pp, November 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects, Sensors

KEYWORDS: Sea Surface Temperature, Measurements, Radar Refraction, Evaporation Duct

FLEET AIR OCEAN EQUIPMENT

K.L. Davidson, Professor
Department of Meteorology
Sponsor: Space and Naval Warfare Command, SPAWAR PMW 165

OBJECTIVE: To perform engineering development of new air ocean sensors for use in operational shipboard assessment of near-surface radar/radio refractive conditions.

SUMMARY: The general effort was to improve methods for the operational (military) assessment of

conditions of lower atmosphere that affect radar and radio (microwave) propagation. Because of the variability of both the air-surface humidity difference and the turbulence, local measurements are necessary for knowing possible affects on ship operations. Accomplishments were to obtain a merged NPS and JHU/APL VOCAR evaporation duct relevant data set and also a NAVCENTCOM SHAREM data set, on which a thesis was completed. The data sets were collected using completely different approaches to estimating humidity and temperature gradients in the surface layer. The NPS approach is to obtain values at the sea surface and at one level near 15 meters. For example, the JHU/APL approach is define to surface layer gradients by measuring at more than one level in the air or by rocketsondes where continuous height sensing is made while the sensors fall under a parachute. The SHAREM data set was collected on operational ships with both ship and special installed sensors.

DOD KEY TECHNOLOGY AREA: Environmental Effects, Sensors

KEYWORDS: Meteorology Measurement, Marine Atmosphere Boundary Layer, Radar Refraction, Evaporation Duct

IRAMMP METEOROLOGY

K.L. Davidson, Professor
Department of Meteorology
Sponsor: Naval Command Control and Ocean Surveillance Center, RDT&E Division (NRaD)

OBJECTIVE: Buoy fabrication and data collection will support IR thermal imager program (IRAMMP) that is designed to determine performance with target approaching from close to the horizon. Objectives of this effort is to 1) perform buoy data-link development and testing and moor buoy with mean air, ocean surface and motion sensors in Monterey Bay for two week period from 8 June to 4 July, 2) instrument contracted boat obtain meteorological data, and 3) provide shorebased imager location with facilities.

SUMMARY: An equipment preparation, collection/analyses campaign was performed. We prepared/Modified and tested existing NPS flux buoy for deployment. The buoy was deployed at a preset mooring during the 2nd week of June but data recording and transmission ended after 2 days due to power connector failure. Data were collected from the 15-30 June period from the MBARI (M1 and M2) buoys, from the Scripps Oceanographic Institution wave buoy, and from a leased vessel. The leased vessel was instrumented with NPS sensors; including turbulence, mean air and surface, and rawinsonde. NPS also participated in test planning meetings and provide preliminary evaluations of possible surface layer stratification conditions over Monterey Bay during test period. NPS collated data collected on buoys and leased fishing vessel and forwarded it to NRL (Washington) for incorporation into IR sensor performance analyses.

DOD KEY TECHNOLOGY AREA: Environmental Effects, Sensors

KEYWORDS: IR Refraction, Marine Atmosphere Boundary Layer, Meteorological Measurements

MEASUREMENT OF LITTORAL ZONE ATMOSPHERIC BOUNDARY LAYER PROPERTIES

K.L. Davidson, Professor
Department of Meteorology
Sponsor: Naval Research Laboratory, Code 7410

OBJECTIVE: Goals are: (1) To provide NRL-SSC Code 7410 advice and review assistance in formulating status of existing measurement approaches and systems for the littoral zone; with emphasis on near-surface

EM/EO propagation conditions, and (2) to perform special analyses/interpretations on buoy obtained data to evaluate critical elements for near-surface refractive descriptions

SUMMARY: In littoral zone measurement evaluations, contributions were made to discussions and studies pertaining to the evaluation of littoral zone measurement requirements and capabilities. The area of primary responsibility was relative to the assessment of EM and EO propagation. Meetings were attended with sponsor and contractor personnel with regard to the design and initial draft a report littoral zone measurements. Review was performed of draft prepared for submission to TOWS Program Office. In Littoral Zone EM Buoy Capabilities. Evaluation of buoy capabilities for coastal zone EM descriptions was carried out in conjunction with an ONR coordinated Infrared Analysis, Measurement, and Modeling Program (IRAMMP) field effort. Radiosonde cross sections obtained during the VOCAR experiment were prepared and sent to contractor for use in evaluating coastal marine boundary layer sampling methods.

DOD KEY TECHNOLOGY AREA: Environmental Effects, Sensors

KEYWORDS: Measurements, EM/EO Propagation, Sea Surface Temperature, Marine Atmosphere Boundary Layer, Evaporation Duct

VERIFICATION OF MARINE AEROSOL MODELS

K.L. Davidson, Professor
Department of Meteorology
Sponsor: Naval Command Control and Ocean Surveillance Center, RDT&E Division (NRaD)

OBJECTIVE: Evaluate/formulate marine atmospheric boundary layer aerosol models on basis of analyses and interpretation of measurements of near-surface influencing factors.

SUMMARY: Atmospheric vector wind, temperature, and humidity and aerosol size distribution data collected by NPS from ships and buoys in collaborative experiments were interpreted relative to existing model (NOVAM, surface layer equilibrium) specifications. The data include those from experiments in the California bight VOCAR experiment in August 1993, in the Holland coastline (near-MPN) MAPTIP experiment in October 1993, and the Monterey Bay vicinity EOMET experiment in November 1994. Examination are on the detection of aerosol from multi-frequency satellite interpretation is satellite image and of near-surface profiles relative to predictions based on a surface source, turbulent transport and gravitational settling. The data were from the Marine Aerosol Properties and Thermal Imaging Program (MAPTIP) experiment off Holland in October-November 1993. Results show that the model is reasonable unless there is an influence by offshore advected aerosol, i.e. sea surface source is violated.

PUBLICATION:

Davidson, K.L., Fredrickson, P.A., and de Leeuw, G., "Surface Layer Turbulence and Aerosol Profiles during MAPTIP," Proceedings of the 2nd Symposium of the Sensor and Propagation Panel of AGARD on Propagation Assessment in Coastal Environments, Bremerhaven, Germany, 19-23 September 1994.

CONFERENCE PRESENTATION:

Davidson, K.L., Frederickson, P.A., and de Leeuw, G., "Surface Layer Turbulence and Aerosol Profiles During MAPTIP," 2nd Symposium of the Sensor and Propagation Panel of AGARD on Propagation Assessment in Coastal Environments, Bremerhaven, Germany, 19-23 September 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects, Sensors

KEYWORDS: Aerosol, EO propagation, Marine Atmosphere Boundary Layer

WIND/METEOROLOGICAL ANALYSES (NORCSEX-1991)

K.L. Davidson, Professor
Department of Meteorology
Sponsor: Naval Research Laboratory - SSC, Code 7240

OBJECTIVE: To perform analyses/interpretations on in situ and regional meteorological data corresponding to the Norwegian Continental Shelf EXperiment during November 1991 (NORCSEX'91) off the west Coast of Norway to obtain information on what was responsible for ERS-1 sensor detected features of the ocean. Data considered were shipboard obtained vector wind, pressure, temperatures and humidities and rawinsonde profiles.

SUMMARY: NORCSEX'91 was conducted off the west coast of Norway centered on Haltenbaaken (64°30'N, 9°E) from 6 through 29 November 1991 by collaborating scientists. NPS performed continuous measurements of the atmospheric surface layer and regular spaced measurements of the boundary layer profile and performed analyses to demonstrate and validate ERS-1 capabilities of detecting near surface mesoscale wind field variations. Accomplishments were to: a) contribute to a SAR wind algorithm, b) relate friction velocity surface layer momentum fluxes from ultra-sonic anemometer and hot-film anemometer records and related these to friction velocities obtained by applying existing algorithms to ERS-1 c-band backscatter, c) relate surface layer wind and rawinsonde profile information to occurrence of SAR detected windows, d) Formulated relationship between friction velocity and backscatter data from another experiment (FASINEX) that led to NORCSEX ERS-1 required C-band algorithm.

PUBLICATION:

Weissman, D.E., Davidson, K.L., Brown, R.A., Friehe, C.A., and Li, F., "The Relationships Between the Microwave Radar Cross Section and both the Wind Speed and Stress - Model Function Model Development Using FASINEX Data," Journal of Geophysical Research, Vol. 99, pp. 10,087-10,108, 1994.

CONFERENCE PRESENTATION:

Davidson, K.L., Weissman, E.E., Onstott, R.G., and van Halsema, D., "Evaluation of C-Band Scatterometer Algorithms with ERS-1 and NORCSEX'91 data," OCEANS'94 OSATES Conference, Special Sensors and Data for Oceanography, Brest, France, 13-16 September 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects, Sensors

KEYWORDS: Wind Stress, Marine Atmosphere Boundary Layer, Remote Sensing, Scatterometer, Radar Refraction

IN SITU ESTIMATION AND DISPLAY OF COASTAL ZONE REFRACTIVE CONDITIONS

K.L. Davidson, Professor
C.H. Wash, Professor
Department of Meteorology
Sponsor: Space and Naval Warfare Command, SPAWAR PMW 165
Washington, D.C.

OBJECTIVE: Objectives are: (1) to perform special analyses/ interpretations on existing coastal zone refractive data, (2) to evaluate current operational shipboard assessment of near-surface radar/radio refractive conditions, and (3) to examine approaches to applying visualization to display of 3-dimensional propagation predictions (RPO).

SUMMARY: Existing data sets and digital analyses procedures available to or developed by NPS investigators were analyzed/interpreted relative their descriptive qualities of coastal atmospheric refractive conditions. These lead to assessment of procedures for and value of merging real-time satellite imagery with in situ shipboard data for estimating regional variation of refractive conditions. Analyses yielded quantitative value of evaporation duct strength uncertainties caused by measurement uncertainties, with emphasis on uncertainties associated with different (choice of) sensor obtained sea surface temperature values. Special analyses were be performed on VOCAR Pt. Mugu radiosonde and GB-HIS data collected coincidentally with PSU/ARL collection of LIDAR data. Examinations were be performed on the application of visualization procedures, previously used for predicted cloud obstructions, to RPO predictions.

PUBLICATION:

Wash, C.H. and Davidson, K.L., "Remote Measurements and Coastal Atmospheric Refraction," Proceedings IARSS'94, Pasadena, CA, Vol. 1, pp. 397-401, August 1994.

CONFERENCE PRESENTATION:

Wash, C.H. and Davidson, K.L., "Remote Measurements and Coastal Atmospheric Refraction," IARSS'94, Pasadena, CA, August 1994.

THESIS DIRECTED:

Walsh, D.J., LT, USN, "Multispectral NOAA Marine Atmospheric Boundary Layer (MABL) Estimates During VOCAR," Master's Thesis, July 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects, Sensors

KEYWORDS: Marine Atmosphere Boundary Layer, Radar Refraction, Evaporation Duct

COASTAL REGION REFRACTIVE ASSESSMENTS (VOCAR)

K.L. Davidson, Professor
C.H. Wash, Professor
Department of Meteorology
Sponsor: Naval Command Control and Ocean Surveillance Center, RDT&E Division (NRaD), Code 54

OBJECTIVE: The goal is to obtain models and approaches for estimating refraction conditions in the coastal region from analyses and interpretation of in situ atmospheric data and from remote sensors (satellite and ground-based).

SUMMARY: Performed in situ observations (ship and buoy based) and analyses for evaluation/development of remote sensing approaches for characterizing coastal refraction phenomena. Collection of in situ data occurred off Monterey Bay during August 1994 (5-day, R/V Sproul) collaborative vertical description effort with NRL (Hooper, LIDAR), and off Monterey Bay during November 1994 (8-day, R/V Point Sur). Efforts are relate in situ observed features to both passive (multiple wavelength radiometers) and active (radar) sensors presently borne by operational and research satellites.

PUBLICATION:

Davidson, K. L. and Wash, C.H., "Remote Measurement of Atmospheric Refraction Conditions in the Coastal Region," Proceedings 2nd Symposium of the Sensor and Propagation Panel of AGARD on Propagation Assessment in Coastal Environments, Bremerhaven, Germany, 19-23 September 1994.

CONFERENCE PRESENTATION:

Davidson, K.L. and Wash, C.H., "Remote Measurement of Atmospheric Refraction Conditions in the Coastal Region," 2nd Symposium of the Sensor and Propagation Panel of AGARD on Propagation Assessment in Coastal Environments, Bremerhaven, Germany, 19-23 September 1994.

THESIS DIRECTED:

Walsh, D.J., LT, USN, "Multispectral NOAA Marine Atmospheric Boundary Layer (MABL) Estimates During VOCAR," Master's Thesis, Naval Postgraduate School, Monterey, CA, July 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects, Sensors

KEYWORDS: Marine Atmosphere Boundary Layer, Radar Refraction, Evaporation Duct

SAGE III SCIENCE TEAM

P.A. Durkee, Associate Professor
Department of Meteorology
Sponsor: National Aeronautics and Space Administration

OBJECTIVE: The objectives during phase B of SAGE III development were to examine global aerosol distribution observations from NOAA AVHRR and SAGE I and II measurements and identify regions of potentially high aerosol-climate impact. Primary emphasis was on the upper tropospheric observations available from SAGE I and II. A second objective was to examine case studies of AVHRR-SAGE II comparisons. AVHRR aerosol optical depth was compared to profiles of extinction from SAGE II. Issues such as upper tropospheric cloud contamination were also considered. The goal of this work was to show the usefulness of analyses incorporating SAGE III observations with nadir views from high spectral and spatial resolution radiometers on EOS such as MODIS.

SUMMARY: The SAGE III instrument is now scheduled to make its first flight aboard a Russian Meteor satellite in 1997. Preparations for launch will be the primary activity of the science team until then. In anticipation of analysis with SAGE III, global summaries of aerosol optical depth have been prepared for April 1982-84 using NOAA-7 AVHRR. Features such as Saharan dust, continental plumes of anthropogenic pollution, and advected smoke from biomass burning were detected. Also apparent in these analyses was a distinct difference between optical depth in the northern and southern hemispheres. These results are consistent with SAGE I tropospheric results reported by Kent et al. (1988) and SAGE II results distributed by Kent to the SAGE

III Science Team (unpublished). From these results it appears that much of the hemispheric differences observed in the total aerosol optical depth from AVHRR measurements are due to upper tropospheric aerosols advected from continental sources (anthropogenic and terrestrial). Comparisons between SAGE II extinction profiles and AVHRR optical depth are in progress. Cases are being identified from April (peak in Asian dust transport across the Pacific) and July (Saharan dust cases) 1985. To the extent that tropospheric aerosols are included in the SAGE III studies, this effort will investigate relationships between various aerosol optical depth regimes and cloud reflectance characteristics. These studies will include examination of multispectral radiative signatures of aerosol features and the impact of MODIS estimates of aerosol characteristics.

DOD KEY TECHNOLOGY AREA: Environmental Effects, Sensors

KEYWORDS: Aerosols, Climate

STUDIES OF THE EFFECTS OF SHIP ACTIVITY ON CLOUD PROPERTIES

P.A. Durkee, Associate Professor
Department of Meteorology
Sponsor: Office of Naval Research and Office of Naval Intelligence

OBJECTIVE: Satellite observations of ship tracks in stratiform clouds will be analyzed and compared to meteorological and aircraft measurements. Phenomenological studies will define the physical, temporal and radiative characteristics of tracks including occurrence statistics. Mechanism studies will incorporate aircraft measurements to begin to determine formation processes.

SUMMARY: Funding for this project began in April 1992. During 1994 the Monterey Area ShipTrack (MAST) Experiment was conducted during June 1994. This was an international experiment with more than 60 scientists performing ship and aircraft observations off the central California coast. The one-month experiment, based at NPS, included 4 airborne platforms (UK C130, Univ. of Washington C131a, NRL blimp, NASA ER-2), a research ship (R/V Glorita), 5 Dedicated US Navy ships, and more than a dozen civilian and classified satellite systems. As chief scientist for the experiment, Prof. Durkee lead the planning sessions and mission design meetings. NPS also hosted the initial data workshop in December 1994 where data from 33 ship plumes and shiptracks were presented (an increase by a factor of 10 over the data previously available). Another component of the ONR/ONI project conducting during 1994 was a series of space shuttle experiments designed to expand our shiptrack understanding at high spatial resolution and over broad geographic areas. The experiment is sponsored by the tri-service Space Test Program and was flown on three flights during summer 1994 (STS-68, STS-65, and STS-64). Prof. Durkee's research group conducted crew familiarization briefings and crew training sessions. During the missions NPS prepared real-time analysis and target selection for the relay to crew in orbit. These missions provided the first high resolution imagery of shiptrack formation in the southern hemisphere. During 1994, 5 METOC Curriculum and 5 Space Systems Curriculum MS students worked on this project (8 theses completed and 2 near completion).

PUBLICATIONS:

Hindman, E.E., Porch, W.M., Hudson, J.G., Durkee, P.A., "Ship produced cloud lines of 13 July 1991," Atmospheric Environment, Vol. 28, 3393-3403, 1994.

Twohy, C.H., Durkee, P.A., Huebert, B.J., and Charlson, R.J., "Effects of aerosol particles on droplet size distribution and satellite-derived reflectance in coastal stratiform clouds," Journal of Geophysical Research (in press).

Porch, W.M., Kao, C.-Y., Buckwald, M.I., Unruh, W.P., Durkee, P.A., Hindman, E.E., and Hudson, J.G., "The effects of external forcing on the marine boundary layer: Ship trails and solar eclipse," accepted for publication in Atmospheric Environment.

Durkee, P.A., "Science Plan for the Monterey Area Ship Track Experiment," Naval Postgraduate School Technical Report, Monterey, CA, 1994.

CONFERENCE PRESENTATIONS:

Durkee, P.A., Nielsen, K.E., and Skupniewicz, C., "Aerosol-cloud interactions: Implications derived from investigations of ship effects in marine clouds," presented at International Conference on Aerosols and Atmospheric Optics: Radiative Balance and Visual Air Quality, Snowbird, UT, 29 September 1994.

Durkee, P.A., Nielsen, K.E., Skupniewicz, C., and Kuciauskus, A., "Investigations of shiptracks in marine clouds," presented at the 7th Conference on Satellite Meteorology and Oceanography, Monterey, CA, 8 June 1994.

Durkee, P.A. and Skupniewicz, C., "Interactions between continental aerosol particles and marine stratocumulus clouds," presented at the Second International Conference on Air-Sea Interaction and Meteorology and Oceanography of the Coastal Zone, Lisbon, Portugal, 22-27 September 1994.

THESES DIRECTED:

Kirschbaum, A., "The design and implementation of the military applications of shiptracks experiment on space transportation system," Master's Thesis, 1994.

George, G. and Haegley, G., Classified Thesis, 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects, Other (Ship Surveillance)

KEYWORDS: Aerosols, Clouds, Climate

SHIPBOARD AND SATELLITE INVESTIGATIONS OF MARINE AEROSOL PARTICLES

P.A. Durkee, Associate Professor
Department of Meteorology
Sponsor: National Aeronautics and Space Administration (NASA)

OBJECTIVE: Analysis of satellite observations of aerosol and cloud radiative properties will be conducted by NPS in conjunction with NOAA PMEL research cruises and the ACE-1 experiment.

SUMMARY: Data was collected during two cruises of the NOAA ship *Surveyor*. During April/May 1993, data was collected aboard the *Surveyor* from Tahiti to Seattle and during November/December 1993, data was collected on a reverse track from Seattle to Tahiti. This satellite data is being analyzed for aerosol properties related to ship-board measurements. Hemispheric and regional variations are evident in the data and the results will provide open ocean analysis of marine aerosol formation and transport mechanisms. Preparations are under way for the ACE-1 (Aerosol Characterization Experiment) scheduled for November-December 1995 south of Australia. ACE-1 is an international experiment (11 countries) designed to study the characteristics of natural and anthropogenic aerosols in the clean southern hemisphere. As part of the planning committee Prof. Durkee coordinated the use of satellite observations for mission planning and analysis.

DOD KEY TECHNOLOGY AREA: Environmental Effects, Sensors

KEYWORDS: Aerosols, Climate

AEROSOL STUDIES WITH REMOTELY PILOTED AIRCRAFT

P.A. Durkee, Associate Professor
Department of Meteorology
Sponsor: Office of Naval Research and Office of Naval Intelligence

OBJECTIVE: This proposal describes the formation of a joint research effort based at NPS that would demonstrate, for the first time, the unique capabilities of RPAs for environmental measurements.

SUMMARY: The Office of Naval Research along with the NPS and California Institute of Technology (CIT) are planning a set of field programs to demonstrate unique scientific research strategies and technology development with remotely piloted aircraft (RPA). This proposal describes the formation of a joint research effort based at NPS that would demonstrate, for the first time, the unique capabilities of RPAs for environmental measurements. In October 1992 a joint effort with ONR was initiated to investigate the possibility of using unmanned aircraft to make long-duration, low-altitude measurements of the coastal and remote marine environment. Under an SBIR grant, Aurora Flight Sciences Corporation is configuring a Cessna 337 Skymaster for manned and unmanned flight. Under this proposal ONR funded NPS to prepare instrumentation for this platform in coordination with CIT. The NASA ERAST (Environmental Research Aircraft and Sensor Technology) program is now interested in supporting our efforts as part of the national strategy for developing remotely piloted aircraft for scientific measurements. The aircraft will become available for experimental use during 1995-1996.

DOD KEY TECHNOLOGY AREA: Environmental Effects, Sensors

KEYWORDS: Aerosols

FEASIBILITY STUDY OF A WEST COAST PICKET FENCE SPECIFICATION OF UPSTREAM BOUNDARY CONDITIONS FOR STORM

R.L. Elsberry, Professor
P.A. Hirschberg, Assistant Research Professor
R.J. Lind, Meteorologist
Department of Meteorology
Sponsor: National Science Foundation

OBJECTIVE: The objective of this project was to demonstrate that a "Picket Fence" of extra rawinsonde stations along the U.S. west coast would improve the time and spatial resolution of flow features entering the U.S. from the conventional data-sparse Pacific Ocean. A consequence of this improved specification of the "upstream boundary" conditions will be a more accurate forcing of the mesoscale weather systems that develop over the central U.S.

SUMMARY: To accomplish the objectives of the Picket Fence Experiment, an array of seven new rawinsonde stations interspersed among the seven operational stations was deployed along the west coast of the U.S. during the STORM-Fronts Experiment Systems Test (STORM-FEST) in February-March 1992. Additionally, rawinsondes were launched every 3 h at all sites rather than the regular 12-h intervals to improve the temporal

resolution of the data during four intensive observation periods. The field portion of the experiment demonstrated the operational feasibility of obtaining extra spatial and temporal observations via the Picket Fence approach and is documented in Lind et al. (1992). The potential boundary-condition impact of the Picket Fence was investigated by comparing the fluxes of mass, heat, etc., across the west coast resolved with various spatial and temporal combinations of Picket Fence data against a standard calculated with only the 12-h regular upper-air sites. In the best case, when a wave system crossed the middle of the Picket Fence, significantly different fluxes were calculated with the full spatial and 3-h Picket Fence observations, which therefore validates the hypothesis.

PUBLICATIONS:

Hirschberg, P.A., Lind, R.J., Bolduc, S.J., and Elsberry, R.L., "The Picket Fence Experiment during STORM-FEST," Bulletin of the American Meteorological Society, (in press).

Hirschberg, P.A., Lind, R.J., Bolduc, S.J., and Elsberry, R.L., "Fluxes across the west coast resolved by Picket Fence observations during STORM-FEST," Proceedings AMS Sixth Conference on Mesoscale Processes, Portland, OR, July 1992, pp. 449-452.

CONFERENCE PRESENTATION:

Hirschberg, P.A., Lind, R.J., Bolduc, S.J., and Elsberry, R.L., "Fluxes across the west coast resolved by Picket Fence observations during STORM-FEST," presented at the AMS Sixth Conference on Mesoscale Processes, Portland, OR, July 1992.

THESIS DIRECTED:

Bolduc, S.J., LCDR, USN, "Fluxes across the west coast resolved by Picket Fence observations during STORM-FEST," Master's Thesis, September 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Additional Observations, Boundary Conditions, Mesoscale Predictability

TROPICAL CYCLONE MOTION STUDIES

R.L. Elsberry, Professor
Department of Meteorology
Sponsor: Office of Naval Research

OBJECTIVE: A long-term goal of this project is to develop a unified view of mesoscale, synoptic-scale, and large-scale environmental components of the tropical cyclone motion problem. A better understanding and a prediction capability for the large-scale environment then should lead to more accurate tracks over longer than the present 72-h forecasts.

SUMMARY: Dobos *et al.* (1994) have compared the profiler winds in the 600-1800 m layer with surface sustained (10 minute) winds and gusts as four typhoons passed near Okinawa. The investment by ONR in tropical cyclone motion research since 1987 has led to considerable progress. This accumulation of knowledge is being incorporated in book chapters, review articles and as potential applications to track forecasting. In addition to authoring the chapter on motion, R. L. Elsberry is serving as the Editor of the new book A Global Perspective on Tropical Cyclones, which is to be published by the World Meteorological Organization early in 1995.

PUBLICATIONS:

Dobos, P.H., Lind, R.J., and Elsberry, R.L., "Tropical cyclone boundary layer structure based on surface wind comparisons with radar wind profiler observations," Weather and Forecasting, (in press).

Elsberry, R.L., "Tropical cyclone motion," A Global Perspective on Tropical Cyclones, (R. L. Elsberry, Ed.), Chap. 4, World Meteorological Organization, Geneva, Switzerland.

Elsberry, R.L., "Tropical cyclone motion -- How can we predict the potentially dangerous track?," Oceans: Physical-Chemical Dynamics Human Impact, (S.K. Majumdar, E.W. Miller, G.S. Forbes, R.F. Schmalz, and A.A. Panah, Eds.), Pennsylvania Academy of Science, pp. 255-268.

Elsberry, R.L., "Recent advancements in dynamical tropical cyclone track predictions," Meteorology Atmospheric Physics, (in press).

Elsberry, R.L., "Past performance and plans for the U.S. Navy Fleet Numerical Meteorology and Oceanography Center global model prediction of tropical cyclones," Proceedings, International Meeting Numerical Prediction Tropical Cyclones, Tokyo, Japan, 17-21 January 1994, pp. 220-223.

CONFERENCE PRESENTATIONS:

Elsberry, R.L. and Harr, P.A., "Overview of the Tropical Cyclone Motion (TCM-93) experiment," presented at the 1994 USPACCOM Tropical Cyclone Conference, Tokyo, Japan, 8-11 March 1994.

Elsberry, R.L. and Harr, P.A., "Some aspects of the large-scale circulation variability over the tropical western North Pacific," International Conference Weather Analysis Forecasting Asian-Pacific Monsoon Region, Taipei, Taiwan, 5-7 June 1994.

Elsberry, R.L. and Harr, P.A., "Overview of TCM-92 and TCM-93 field experiments," presented at TEXMEX Workshop, Portland, OR, 16-17 July 1994.

Elsberry, R.L., "Past performance and plans for the U.S. Navy Fleet Numerical Meteorology and Oceanography Center global model prediction of tropical cyclones," International Meeting on Numerical Predictions of Tropical Cyclones, Tokyo, Japan, 17-21 January 1994.

Smith, D. and Elsberry, R.L., "Tropical cyclone development and intensification in large vertical wind shear," presented at the 1994 USPACCOM Tropical Cyclone Conference, Tokyo, Japan, 8-11 March 1994.

THESIS DIRECTED:

Smith, D.K., LT, USN, "Tropical cyclone development and intensification under moderate to strong vertical wind shear," Master's Thesis, March 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Tropical cyclone motion, tropical cyclone prediction, tropical meteorology

ATMOSPHERIC FORCING DURING THE ANZONE WINTER FLUX EXPERIMENT (ANZFLUX)

P.S. Guest, Meteorologist
K.L. Davidson, Professor
Department of Meteorology
Sponsor: National Science Foundation

OBJECTIVE: This research was a closely integrated part of a multiple investigator program which addressed the problem of explaining the anomalously high heat fluxes which occur across the oceanic mixed layer in the eastern Weddell Sea. Our focus concerned interactions of the atmosphere with the ice and ocean surfaces.

SUMMARY: As part of the Antarctic Zone Flux Experiment (ANZFLUX), which occurred in the Eastern Weddell Sea during July and August, 1994, all atmospheric terms of the heat and momentum budgets at the ice-atmosphere interface were measured from instruments deployed on ice floes during two ice camp phases. A wide variety of weather conditions occurred during the ice camp phases with several intense storm passages interspersed with clear, low wind periods. The mean values and variations of the total heat flux were primarily controlled by the net longwave radiation which in turn was a strong function of cloud cover and cloud height. Therefore the largest upward heat fluxes occurred when the were few or no clouds or the clouds were high (i.e. cirrus). Although the ocean mixed layer had large heat fluxes (as measured by other ANZFLUX researchers) during the strong wind events, the ice-atmosphere heat fluxes were not correlated with wind speed, a result of the buffering effect of the ice.

CONFERENCE PRESENTATION:

Guest, P.S., "The surface heat and momentum budgets of the eastern Weddell Sea in winter," (poster), The IAPSO XXI General Assembly, Honolulu, HI, August 1994.

OTHER:

We are currently working on a manuscript entitled "The Surface Heat Budget of the Eastern Weddell Sea in Winter."

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Air-Ice-Sea Interactions, Weddell Sea, Polar Meteorology, Heat Flux, Momentum Flux

ATMOSPHERIC FORCING OF ICE AND OCEAN IN ARCTIC REGIONS

P.S. Guest, Meteorologist
K.L. Davidson, Professor
Department of Meteorology
Sponsor: Office of Naval Research

OBJECTIVE: The long term objectives of our studies are to detect, understand and predict phenomena in the marine Arctic atmosphere which control air-ice-sea interaction processes.

SUMMARY: We completed several studies of factors affecting the heat and momentum budgets of sea ice, and we also completed a meteorological analysis of marginal ice zones over a full range of time and space scales. We are continuing to analyze the direct relationship between momentum transfer from the atmosphere and lead formation in the central Arctic.

PUBLICATIONS:

Guest, P.S. and Davidson, K.L., "Factors affecting variations of snow surface temperature and air temperature over sea ice in winter," The Polar Oceans and Their Role in Shaping the Global Environment, Nansen Centennial Volume, (O.M. Johannessen, R.D. Muench, and J.E. Overland, Eds.), American Geophysical Union, pp. 435-442, 1994.

Guest, P.S. and Davidson, K.L., "The temperature and energy balance at the marine ice-atmosphere interface during the polar winter," Snow and Ice Covers: Interactions with the Atmosphere and Ecosystems, IAHS Publication No. 223, (H.G. Jones, T.D. Davies, A. Ohmura, and E.M. Morris, Eds.), IAHS Press, Wallingford UK, 1994.

Guest, P.S., Davidson, K.L., Overland, J.E., and Frederickson, P.A., "Atmosphere-ocean interactions in the marginal ice zones of the Nordic seas," Arctic Oceanography: Marginal Ice Zones and Continental Shelves, (W. Smith and J. Grebmeier, Eds.), American Geophysical Union, (in press).

Guest, P.S., Glendening, J.W., and Davidson, K.L, "An observational and numerical study of wind stress variations within marginal ice zones," Journal of Geophysical Research, (in press).

Fett, R.W., Davidson, K.L., and Overland, J.E., "Opening and closing of the "Husky 1" Lead Complex," The Polar Oceans and Their Role in Shaping the Global Environment, Nansen Centennial Volume, (O.M. Johannessen, R.D. Muench, and J.E. Overland, Eds.), American Geophysical Union, pp. 455-473, 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Air-Ice-Sea Interactions, Surface Energy Budget, Leads, Marginal Ice Zone

DIGITAL FILTER INITIALIZATION IN THE OCEAN

R.L. Haney, Professor
Department of Meteorology
Sponsor: Office of Naval Research, Code 124

OBJECTIVE: This research is to test and verify a new method of initializing a primitive equation model of the coastal oceans. The initialization method, referred to as Digital Filter Initialization (DFI), was recently developed by Lynch and Huang (Monthly Weather Review 1992) for use in an intermittent data assimilation system in the atmosphere. The DFI method consists of applying a digital filter to time series of model variables generated by short term backward and forward integrations starting from an uninitialized analysis. The objective of this study is to examine the performance of the DFI method in controlled numerical experiments in the coastal oceans.

SUMMARY: The DFI dynamic initialization method is being tested and verified using data from primitive equation model simulations of linear Rossby waves, growing baroclinic waves, and nonlinear flow over steep coastal topography. Preliminary results show that the accuracy of the method is dependent on the choice of filter span (i. e., the model integration period) and the number of times the DFI procedure is repeated. Acceptable accuracy is obtainable for some values of these parameters but not all.

PUBLICATIONS:

Haney, R.L., Hale, R.A., and Collins, C., "Estimating subpycnocline density fluctuations in the California Current region from upper ocean observations," Journal of Atmospheric and Oceanic Technology, (in press).

Viudez, A., Haney, R.L., and Tintore, J., "Circulation in the Alboran Sea as determined by quasi-synopic hydrographic observations. Part 2. Mesoscale ageostrophic motion diagnosed through density dynamical assimilation," Journal of Physical Oceanography, (submitted).

CONFERENCE PRESENTATIONS:

Haney, R.L., Hale, R.A., and Collins, C., "Estimating subpycnocline density fluctuations in the California current region from upper ocean observations," 1994 Ocean Sciences Meeting, San Diego, CA, 21-25 February 1994.

Viudez, A., Haney, R., and Tintore, J., "Digital filter initialization in the Alboran Sea," 1994 Ocean Sciences Meeting, San Diego, CA, 21-25 February 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Ocean Data Assimilation, Coastal Ocean Dynamics

STRUCTURE AND DYNAMICS OF COASTAL OCEAN FILAMENTS (EBC/ARI)

R.L. Haney, Professor
Department of Meteorology
Sponsor: Office of Naval Research, Code 322PO

OBJECTIVE: The broad objective of this research is to explore the structure and dynamics of cold filaments in eastern boundary current (EBC) regions using model-data assimilation.

SUMMARY: In-situ hydrographic data and remotely sensed sea surface temperature data were analyzed to describe the kinematics and dynamics of a closed cyclonic eddy observed off Point Arena, California in May 1993. The hydrographic data were first objectively analyzed, and the resulting density field was used in a primitive equation (PE) model with a digital filter initialization method to diagnose a dynamically balanced velocity field, including the vertical motion. The results reveal a closed cyclonic circulation about 80 km in diameter with meanders in the otherwise nearly circular flow, and maximum horizontal currents of about 40 -50 cm/s at the surface. The meanders have associated patterns of radially aligned patches of sinking and rising motion, extending coherently to about 500 m depth, with maximum vertical velocities of 20-22 m/day between 100 and 150 m depth. The vertical motion obtained using the quasi-geostrophic (QG) omega equation is in good agreement with that from the initialized PE model except that the QG vertical velocities are about 30 percent stronger in magnitude. These differences are shown to be caused by the neglect of ageostrophic advections in the QG system.

PUBLICATION:

Viudez, A., Tintore, J., and Haney, R.L., "Circulation in the Alboran Sea as determined by quasi-synoptic hydrographic observations. Part 1. Three-dimensional structure of the two anticyclonic gyres," Journal of Physical Oceanography, (submitted).

CONFERENCE PRESENTATIONS:

Chumbinho, R., Haney, R.L., and Ramp, S., "Three dimensional circulation and dynamics of the Ramp Eddy off Pt. Arena, California," 41st Annual EPOC Meeting, Mt. Hood, OR, 28 Sep - 1 Oct 1994.

Haney, R.L., "Dynamical estimates of the vertical circulation in eastern boundary current eddies," 41st Annual EPOC Meeting, Mt. Hood, OR, 28 Sep - 1 Oct 1994.

THESIS DIRECTED:

Chumbinho, R.P., LT, PT Navy, "The Kinematics and Dynamics of a Cyclonic Eddy off Pt. Arena, California," Doctoral Dissertation, December 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Ocean Data Assimilation, Coastal Ocean Dynamics

ATMOSPHERIC CIMREP

R.L. Haney, Professor
Department of Meteorology
Sponsor: Commander, Naval Meteorology and Oceanography Command (COMNAVMETOCCOM)
Funding: COMNAVMETOCCOM, Code N3

OBJECTIVE: The Principal Investigator will develop and chair the Atmospheric COMNAVMETOCCOM Independent Model Review Panel (CIMREP), which is tasked with performing independent validation checks on models submitted to the Oceanographic and Atmospheric Master Library (OAML), and providing recommendations concerning incorporation of those models into OAML, including future model improvements.

SUMMARY: An Atmospheric CIMREP has been established to evaluate and provide recommendations concerning the incorporation into OAML of the Radio Physical Optics (RPO) Propagation Model. The RPO model, developed at the Naval Command, Control and Ocean Surveillance Center (NCCOSC), is designed to predict EM propagation in a horizontally variable atmospheric environment.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Electromagnetic Propagation

TROPICAL CYCLONE PREDICTION

P.A. Harr, Research Assistant Professor
Department of Meteorology
Sponsor: Office of Naval Research

OBJECTIVE: The long-term goals of this project are to understand the large-scale environmental controls on tropical cyclone motion, as well as the potential effects of Mesoscale Convective Systems (MCS) on both motion and genesis of tropical cyclones. The objectives are to extend track forecasting to longer than 72 h, and to improve short-term (less than 24 h) forecast accuracy.

SUMMARY: Harr and Elsberry have documented the large-scale environmental variability using complex empirical orthogonal function analyses and a fuzzy cluster analysis. In contrast to earlier work, the daily variability was examined irrespective of whether a tropical cyclone existed. This more general approach leads to characteristic circulation regimes that link the Asian monsoon circulations with those over the western North Pacific tropical cyclone regions. The variability is resolved by six regimes (clusters) and a seventh regime that is occupied when the circulation switches from one cluster to another cluster. Each cluster is shown to be physically consistent with the divergent wind patterns and the Outgoing Long-wave Radiation, which is a proxy for deep tropical convection and precipitation. More importantly, certain clusters tend to favor recurving tropical

cyclone tracks, whereas others favor westward tracks. In addition to demonstrating that the large-scale circulation controls both the genesis and the track type, this result suggests a potential for forecasting track type beyond 72 h. The key to a successful long-range forecast will be to predict when the large-scale environment will transition from one regime to another regime. Harr and Elsberry demonstrate that a remarkably small set of transitions occur among the six clusters. That is, the tropical atmosphere changes occur along only a few paths. If these transitions can be accurately predicted via statistical techniques, or by the global dynamical models, a useful tool will exist for longer range tropical cyclone forecasts. Unique data sets have been collected in two field experiments during 1992 and 1993. Harr and Elsberry have described the most interesting case in which a large MCS formed adjacent to Typhoon Robyn. As hypothesized, a midtropospheric vortex formed due to vortex stretching under the MCS cloud shield. However, the rapid translation of the MCS did not allow the vortex-tropical cyclone interaction to occur. Rather, the sudden slowing and northward turn of Typhoon Robyn are attributed to large-scale environmental flow changes. Project personnel have collaborated with NPS colleagues to develop improved statistical analysis tools (Chen *et al.* 1994). The multiple-set canonical correlation analysis technique has advantages in extracting signals from multiple fields. This technique has been utilized in the Chang *et al.* (1994) analysis of northwestward-moving waves with 8-day periodicity.

PUBLICATIONS:

Chen, J.-M., Chang, C.-P., and Harr, P.A., "Multiple-set canonical correlation analysis, Part I: The method," Monthly Weather Review, (November issue).

Chang, C.-P., Chen, J.-M., Harr, P.A., and Carr, III, L.E., "Northwestward propagating synoptic wave patterns over the tropical western Pacific and the periodicity of tropical cyclone activity during northern summer, Monthly Weather Review, (submitted).

Harr, P.A. and Elsberry, R.L., "Large-scale circulation variability over the tropical western North Pacific. Part I. Spatial patterns and tropical cyclone characteristics," Monthly Weather Review, (in press).

Harr, P.A. and Elsberry, R. L., "Large-scale circulation variability over the tropical western North Pacific. Part II. Persistence and transition characteristics," Monthly Weather Review, (in press).

CONFERENCE PRESENTATIONS:

Boothe, M.A., Harr, P.A., and Elsberry, R.L., "Non-intensification of TS Lois in a seemingly favorable monsoon environment," presented at TEXMEX Workshop, Portland, OR, 16-17 July 1994.

Harr, P.A. and Elsberry, R.L., "The TCM-93 field experiment in the western North Pacific," Keynote Address, 48th Interdepartmental Hurricane Conference, Miami, FL, February 1994.

Harr, P.A. and Elsberry, R.L., "Large scale controls on tropical cyclone characteristics," presented at the 1994 USPACCOM Tropical Cyclone Conference, Tokyo, Japan, 8-11 March 1994.

Harr, P.A. and Elsberry, R.L., "Formation of Typhoon Robin and subsequent mesoscale convective system interaction," presented at TEXMEX Workshop, Portland, OR, 16-17 July 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Tropical Cyclone Motion, Tropical Cyclone Prediction, Tropical Meteorology

EXAMINATION OF PRESSURE TENDENCY MECHANISMS IN IDEALIZED SIMULATIONS OF EXTRATROPICAL CYCLOGENESIS

P.A. Hirschberg, Assistant Research Professor
Department of Meteorology
Sponsor: Naval Postgraduate School

OBJECTIVE: The objective of this project was to examine pressure tendency mechanisms in idealized simulations of extratropical cyclogenesis with a new height coordinate-based numerical model.

SUMMARY: A numerical simulation of an idealized extratropical cyclogenesis from Navy's Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) was used to examine the pressure tendency mechanisms following the surface low center. The novelty of this study, performed in collaboration with Dr. James D. Doyle of the Naval Research Laboratory Monterey, was that density and pressure tendency components could be extracted directly from COAMPS because it is a height coordinate-based model. It was found that horizontal density advection, which maximizes near a developing tropopause undulation was the primary mechanism by which the density and hydrostatic pressure was reduced in the column following the developing low center. In general, these results are consistent with historical as well as more recent studies that suggest the importance of tropopause-level temperature advection in the promotion of observed height tendency patterns accompanying the superposition of tropopause- and ground-based potential vorticity anomalies during cyclogenesis.

PUBLICATIONS:

Hirschberg, P.A. and Doyle, J.D., "An examination of pressure tendency mechanisms in an idealized simulation of extratropical cyclogenesis," Tellus, (in press).

Hirschberg, P.A., Doyle, J.D., Langland, R.H., and Fritsch, J.M., "Tropopause undulations and extratropical cyclones," Proceedings Symposium on The Life Cycles of Extratropical Cyclones, Bergen, Norway, 27 June - 1 July 1994, pp. 438-443.

CONFERENCE PRESENTATION:

Hirschberg, P.A., Doyle, J.D., Langland, R.H., and Fritsch, J.M., "Tropopause undulations and extratropical cyclones," presented at the Symposium on The Life Cycles of Extratropical Cyclones, Bergen, Norway, 27 June - 1 July 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Extratropical Cyclogenesis, Tropopause, Numerical Modeling, Pressure Tendency

GLOBAL AND TROPICAL CIRCULATIONS

T. Murphree, Research Assistant Professor
C.-P. Chang, Professor
J.M. Chen, Research Assistant Professor
Department of Meteorology
Sponsor: Naval Research Laboratory

OBJECTIVE: This continuing project is designed to: **(1)** identify the dominant mechanisms of short term climate change in the global atmosphere-ocean system; **(2)** evaluate the atmospheric and oceanic simulations produced by operational analyses and forecasts; and **(3)** improve atmospheric and oceanic analysis and forecast systems.

SUMMARY: In collaboration with colleagues at NRL-Monterey and at NPS, we have pursued four main research topics during 1994.

1. Teleconnection dynamics. We have extended our earlier studies of teleconnection mechanisms to an analysis of the mechanisms underlying observed climate anomalies (e.g., those during the La Niña event of 1988-89 or the midwestern US flooding in 1993). Our results suggest that many of the major teleconnection wave trains over the North Pacific and North America were initiated by fluctuations in the heating over southeast Asia and/or the tropical Pacific. The phase of these wave trains was determined primarily by the sign of the heating fluctuations. However, the amplitude and propagation path of the wave trains were governed by instabilities and dynamical boundaries in the extratropics. Variations in these tropical and extratropical processes *during* the anomaly events caused significant intraseasonal variations in the anomalies (e.g., in the North American upper tropospheric height anomalies during the 1991-1993 El Niño).

2. Tropical heating and extratropical jets. Our results in this work have shown that large intraseasonal variations in the extratropical jets may be forced by intraseasonal variations in tropical convective heating. This tropical-extratropical interaction is most evident in observed fields but is often missing in NOGAPS model runs. This appears to be due to errors in the NOGAPS simulations of tropical heating, including the location, strength, and variability of this heating. These tropical errors lead, in turn, to errors in the NOGAPS simulation of the jets. However, the NOGAPS simulation of these jets is much more realistic when extratropical processes force the jet.

3. Tropical cyclone impacts on the global atmosphere. In this work, we have used a series of experimental NOGAPS forecasts to analyze the global impacts of individual western Pacific tropical cyclones. Our procedure involved selectively applying various versions of the NOGAPS tropical cyclone bogus procedure, including a negative bogus that effectively eliminates individual cyclones. We found that individual tropical cyclones may have large impacts on the global circulation. The first of these impacts develops when the tropical cyclone's divergent outflow crosses the subtropical jet. This produces a flux of ambient vorticity which generates Rossby waves. These waves are then amplified and guided by the large scale background flow as they propagate into distant parts of the atmosphere. The resulting far field disturbances occur one to two weeks after the tropical cyclone forms and persist for up to a week. Such disturbances may include, for example, major disruptions of the storm tracks over North America. These results indicate that improved modeling of tropical cyclones may lead to significantly better extended range weather forecasts for the midlatitudes. Our results are currently being used to evaluate and improve the tropical and global forecasts produced by NOGAPS.

4. Air-sea interactions in the equatorial Pacific. In our fourth project, we examined large scale air-sea interactions in the tropical Pacific during the 1991-93 El Niño. The observational part of the study showed that tropical cyclones may be both a cause of, and a response to, equatorial Kelvin waves in the ocean. This occurs as tropical cyclones generate Kelvin waves in the west Pacific which then propagate eastward. By modifying the local heat content of the upper ocean, these waves may create suitable conditions for tropical cyclone formation. Most (80%) of the central Pacific tropical cyclones during the study period formed in association with the high

heat content (i.e., the downwelling) phase of an ocean Kelvin wave. Their formation appears to have resulted from increased heating of the atmosphere over the wave and a consequent wind pattern that favored cyclone development just north or south of the equator. These results indicate that present tropical cyclone forecast systems (e.g., the Navy's) are deficient in not adequately accounting for the evolution of the upper ocean. In addition, we found that the Navy's ocean analysis system, OTIS, gives a poor representation of the evolution of the tropical upper ocean. Thus, we have made recommendations for improving the OTIS analyses. We have also conducted ocean model experiments designed to simulate these tropical air-sea interactions. A tropical basin model was driven with 12-hourly wind stresses derived from NOGAPS analyses. The model results indicate that synoptic scale wind variations (e.g., those associated with tropical cyclones) are critical in simulating the evolution of El Niño events.

PUBLICATIONS:

Gelaro, R. and Murphree, T., "Teleconnections Associated With Individual Tropical Cyclones," Proceedings of the Tenth Pacific Climate Workshop, National Oceanic and Atmospheric Administration, Pacific Grove, CA, April 1994.

Murphree, T., "Atmosphere - Ocean Processes During the 1991-1993 El Niño: A Historical Perspective," California Cooperative Fisheries Investigations Reports, Vol. 36, (accepted).

Reynolds, C., Gelaro, R., and Murphree, T., "Observed and Simulated Relationships Between Tropical Heating and Extratropical Circulation Anomalies," Proceedings of the Tenth Conference on Numerical Weather Prediction, American Meteorological Society, Portland, OR, July 1994.

Reynolds, C., Gelaro, R., and Murphree, T., "Observed and Simulated Relationships Between Tropical Heating and Extratropical Circulation Anomalies," Proceedings of the Nineteenth Annual Climate Diagnostics Workshop, Climate Analysis Center, National Meteorological Center, College Park, MD, November 1994.

CONFERENCE PRESENTATIONS:

Kent, J., Murphree, T., and Gelaro, R., "Interactions Between Equatorial Ocean Kelvin Waves and Tropical Cyclones During the 1991-1993 El Niño," The First Pacific Basin Meeting, The Oceanography Society, Honolulu, HI, July 1994.

Murphree, T., "Monitoring Ocean Climate," Acoustic Thermometry of Ocean Climate Meeting, Marine Technology Society, Monterey, CA, May 1994.

Murphree, T., "Atmosphere - Ocean Processes During the 1991-1993 El Niño: A Historical Perspective," California Cooperative Fisheries Investigations Conference, Lake Tahoe, CA, October 1994.

Reynolds, C., Gelaro, R., and Murphree, T., "Observed and Simulated Relationships Between Tropical Heating and Extratropical Circulation Anomalies," The Tenth Conference on Numerical Weather Prediction, American Meteorological Society, Portland, OR, July 1994.

Reynolds, C., Gelaro, R., and Murphree, T., "Observed and Simulated Relationships Between Tropical Heating and Extratropical Circulation Anomalies," The Nineteenth Annual Climate Diagnostics Workshop, Climate Analysis Center, National Meteorological Center, College Park, MD, November 1994.

THESES DIRECTED:

Kent, J., LCDR, USN, "Air-Sea Interaction Patterns in the Equatorial Pacific," Master's Thesis, December 1993.

Sitler, T., LT, USN, "An Observational Study of Long Waves in the Equatorial Pacific Ocean During the 1991-1993 El Niño," Master's Thesis, June 1994.

Springer, C., LCDR, USN, "Short Term Teleconnections Associated with Western Pacific Tropical Cyclones," Master's Thesis, June 1994.

Weddle, C., LT, USN, "The Effects of Westerly Wind Bursts on a Tropical Ocean General Circulation Model," Master's Thesis, December 1993.

Woll, S., LT, USN, "Short Term Telecommunications Associated With an Individual Tropical Cyclone," Master's Thesis, December 1993.

OTHER:

Gelaro, R. and Murphree, T., "Intraseasonal Variations in Tropical- Extratropical Teleconnection Mechanisms," Journal of the Atmospheric Sciences, (submitted).

Murphree, T. and Gelaro, R., "The Far Field Impacts of Individual Tropical Cyclones, to be submitted to Journal of the Atmospheric Sciences.

Murphree, T., Kent, J., and Gelaro, R., "Interactions Between Equatorial Ocean Kelvin Waves and Tropical Cyclones During the 1991-1993 El Niño," to be submitted to Journal of Geophysical Research - Oceans.

Reynolds, C., Gelaro, R., and Murphree, T., "Observed and Simulated Relationships Between Tropical Convection and Extratropical Circulation Anomalies," to be submitted to Journal of Climate.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Air-sea Interaction, Analysis and Forecast Systems, Atmosphere-ocean System, Climate Dynamics, El Niño, La Niña, Modeling, Teleconnections, Tropical Cyclones

MESOSCALE COASTAL METEOROLOGICAL STUDIES

W.A. Nuss, Associate Professor
Department of Meteorology
Sponsor: Naval Postgraduate School

OBJECTIVE: The objective of this study is to relate mesoscale variability along the California coast to the observed and forecast synoptic-scale forcing.

SUMMARY: This research project is related to a coastal meteorology project funded by the Office of Naval Research. During 1994, 9 drifting buoys were deployed to characterize the mesoscale variability of the California coastal region through temperature and pressure measurements. The buoy data was collected from 1 June and continues up to the present time. Processing software to retrieve scientifically useful measurements from these drifting buoys was developed during 1994 and was used to begin to quality control these observations. The buoy observations were compared to the large scale pressure and temperature analyses to identify the measurement biases of these observations. The large scale analyses to characterize the synoptic-scale forcing have been collected and are being processed into composite synoptic patterns. The mesoscale variability remains to be obtained through reanalysis of the coastal observations plus the quality controlled buoy data.

CONFERENCE PRESENTATION:

Nuss, W.A., "Performance of the NPS WOCE/SVP barometric drifters," 9th Surface Velocity Program Conference, LaJolla, CA, 2-4 November 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Coastal Meteorology, Drifting Buoys, Observation

REAL-TIME ENVIRONMENTAL INFORMATION NETWORK AND ANALYSIS SYSTEM (REINAS)

W.A. Nuss, Associate Professor
Department of Meteorology
Sponsor: Office of Naval Research
(University of California, Santa Cruz)

OBJECTIVE: The objective of this research is to develop a mesoscale observing network for the Monterey Bay region and assist University of California, Santa Cruz develop computer data base and visualization tools.

SUMMARY: During 1994, surface meteorological stations and 4 915MHz wind profilers were deployed to take measurements during the summer of 1994. These observing stations were used as prototypes to provide input to UCSC in order to develop the data base load paths for these instruments. These instruments also provided a baseline network to provide initial analyses of the sea-breeze variability around the Monterey Bay region and to begin to identify critical observing gaps for future deployments. In addition to these observing stations, the Navy Operational Regional Atmospheric Prediction System (NORAPS) was ported from Fleet Numerical Meteorological and Oceanographic Center to the NPS cray computer in order to make real-time local forecasts. The model was successfully ported and made to run in real-time on the NPS cray computer. These data were provided to UCSC for visualization development taking place at UCSC. Considerable meteorological consulting support was also provided to UCSC for visualization development and development of data base loading software for several instruments.

PUBLICATION:

Mantey, P.E., Long, D.D.E., Garcia-Luna, J.J., Pang, A.T., Kolsky, H.G., Gritton, B.R., and Nuss, W.A., "REINAS: Real-time Environmental Information Network and Analysis System: Phase III - SYSTEMS DESIGN," Univ. of California, Santa Cruz Technical Report, March 10, 1994.

THESIS DIRECTED:

Knapp, M., LT., USN, "Synoptic-scale Influence on the Monterey Bay Sea Breeze," Master's Thesis, September 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Observations, Sea-Breeze, Visualization

MESOSCALE COASTALLY-TRAPPED RESPONSE TO SYNOPTIC-SCALE VARIABILITY

W.A. Nuss, Associate Professor
Department of Meteorology
Sponsor: Office of Naval Research

OBJECTIVE: The primary long term goal of this ongoing project is to understand the role that synoptic-scale circulations play in the generation, propagation and decay of coastally-trapped disturbances. Additional goals are to understand the interaction of large-scale flows with coastal topography and the nature of the mesoscale response on the lee and windward sides of the topography, as well as to improve our forecasting of the mesoscale structure based upon the large-scale circulation.

SUMMARY: The basic approach for this research project is to analyze the large-scale and mesoscale coastal circulations using routine and special surface and upper-air observations to produce scale-separated objective analyses. Drifting buoy and special rawinsonde observations were collected during the summer of 1994 as part of the field effort of the Coastal Meteorology ARI. The Naval Postgraduate School deployed 9 surface velocity program barometric drifting buoys equipped with a prototype temperature sensor. These buoys were deployed in two batches using a helicopter off the coast of California. NPS also launched rawinsondes in Monterey from 1 June to 31 August. These observations are presently being quality checked in order to begin the production of mesoscale surface analyses using multiquadric objective analysis software. Two coastally-trapped stratus surges were identified during the summer of 1994 and analysis of these events has begun. For the first event, which occurred during June 1994, a satellite image loop was prepared and preliminary surface analyses were constructed. Preliminary analyses suggest that the synoptic-scale offshore flow along the central California coast generated a lee trough along the coast to initiate coastal southerlies.

CONFERENCE PRESENTATIONS:

Nuss, W.A., "Buoy observing plans for the summer 1994 field effort," presented at Coastal Meteorology Workshop, La Jolla, February 1994.

Nuss, W.A., "Synoptic evolution related to the June 10 coastally trapped disturbance," presented at Coastal Meteorology Workshop, Monterey, December 1994.

OTHER:

The P.I. was selected as the Chief Scientist for the entire Office of Naval Research Coastal Meteorology Accelerated Research Initiative, of which this project is a part. As such, several project reports have been generated for use by the other Coastal Meteorology investigators for planning and discussion purposes.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Coastal Meteorology, Observations

MESOSCALE OBJECTIVE ANALYSIS USING MULTIQUADRIC INTERPOLATION

W.A. Nuss, Associate Professor
Department of Meteorology
Sponsor: Office of Naval Research

OBJECTIVE: The objective of this research is to develop a mesoscale objective analysis program based upon the multiquadric interpolation method for use with mesoscale data over the Monterey Bay region.

SUMMARY: The effort in 1994 was a continuation of research carried out by National Research Council (NRC) fellow, Supachai Sirayanone, while under NPS support as an NRC postdoctoral fellow. This funded effort in 1994 covered the period from July to December and resulted in the development and testing of a method for blending model forecasts with new observations in the multiquadric scheme. The blending scheme tested consisted of setting the multiquadric smoothing parameter to differing values for the model and the observations based upon error estimates of the two components. In addition to this blending approach, computer software was developed to reduce the number of model points required to completely specify the model first guess used in the blending. This reduction of points has helped to keep the matrix size manageable when doing the model blending, which allows for direct solution over the entire analysis domain at one time.

PUBLICATION:

Sirayanone, S. and Hardy, R.L., "The multiquadric-biharmonic method as used for mineral resources, meteorological, and other applications," International Journal of Scientific Computing and Modeling, (in press).

CONFERENCE PRESENTATION:

Sirayanone, S., "Contribution of the multiquadric-biharmonic method to weather data analysis," 14th IMACS World Congress, Georgia Institute of Technology, Atlanta, GA, 11-15 July 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Objective Analysis, Interpolation

A DIAGNOSIS OF DIABATIC AGEOSTROPHIC CIRCULATIONS ASSOCIATED WITH TWO MODEL-PREDICTED CASES OF RAPID MARITIME CYCLOGENESIS

P.M. Pauley, Research Associate Professor
C.H. Wash, Professor
Department of Meteorology
Sponsor: Naval Postgraduate School

OBJECTIVE: Two model-predicted cases of rapid maritime cyclogenesis over the Atlantic were compared to gain insight into the differences between storms that are highly sensitive to diabatic processes (i.e., latent heat release) and those that are relatively insensitive.

SUMMARY: Previous work on the problem of rapid oceanic cyclogenesis has shown that these storms are sensitive to latent heating, but with a wide range of sensitivity. This research examined differences between two cases of rapid cyclogenesis to better understand why some cases are highly sensitive to latent heat release (LHR) and others are relatively insensitive. The two cases were chosen from the Kuo and Low-Nam (1990) suite of nine cases as the ones with the greatest and least difference in predicted central pressure, comparing forecasts using the Kuo cumulus parameterization and those with no LHR feedback. Four predictions were obtained for each case--ones using the Kuo, Arakawa-Schubert, and explicit cumulus parameterizations as well as the one with no LHR feedback. Diabatic heating rates were estimated for each prediction using a heat budget approach. These heating rates were then used to compute the diabatic contribution to the vertical motion. Finally, the diabatic vertical motion was used to compute the diabatic contribution to the ageostrophic vertical circulation, following the procedures of Keyser et al. (1988). Results showed that the diabatic omega had an upward motion maximum associated with the cyclone's warm frontal precipitation. The corresponding upper-tropospheric diabatic ageostrophic wind increased the kinetic energy of the flow via cross-contour flow toward lower isobaric heights north of the warm front. A key difference in the case that was sensitive to LHR was that this generation of kinetic energy

helped develop a jet streak which in turn helped to deepen the surface cyclone. The case that was relatively insensitive to LHR had less diabatic generation of kinetic energy and a weaker jet streak.

PUBLICATION:

Allen, J.W. and Pauley, P.M., "A Comparison of Latent Heating Effects in Two Cases of Rapid Oceanic Cyclogenesis," Preprints of the Tenth Conference on Numerical Weather Prediction, Portland, OR, July 1994, pp. 135-137.

CONFERENCE PRESENTATION:

Allen, J.W. and Pauley, P.M., "A Comparison of Latent Heating Effects in Two Cases of Rapid Oceanic Cyclogenesis," poster presentation by P.M. Pauley at the Tenth Conference on Numerical Weather Prediction, Portland, OR, July 1994.

THESIS DIRECTED:

Allen, J.W., LCDR, USN, "The Influence of Cumulus Parameterization on Jet Streak Development in Model Forecasts of Rapid Oceanic Cyclogenesis," Master's Thesis, December 1993.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Diabatic Ageostrophic Circulations, Rapid Maritime Cyclogenesis, Heat Budget, Vertical Motion, Kinetic Energy, Jet Streak

A COMPARISON OF CYCLONE FORECASTS IN NMC'S ETA AND NGM MODELS

P.M. Pauley, Research Associate Professor
Department of Meteorology
Sponsor: Unfunded

OBJECTIVE: The goal of this research was to catalog extratropical cyclones in both analyses and forecasts from two of the National Meteorological Center's models for a five month period.

SUMMARY: This research used a combination of manual and numerical techniques to first locate extratropical cyclones as minima in the sea-level pressure field, to match predicted and analyzed cyclones verifying at the same time, and to track individual cyclones through their life cycle. The resulting information was used to compare performance of NMC's NGM and Eta models in terms of central pressure, location, 1000-500 mb thickness at the cyclone center, and mean precipitation in the core of the cyclone. The latter quantity serves as a proxy for latent heat release. Statistics and graphics portraying the results were presented in a thesis by LT Jay Colucci, USN, who completed his M.S. in December 1994, after the close of the CY94 reporting period.

OTHER: Wendell Nuss (Associate Professor of Meteorology) and I have been working on a proposal to be submitted to NSF that would seek funding to examine the sensitivity of extratropical cyclones to latent heat release for a large number of cases. This work served as a proof of concept for some aspects of the proposed research and will be used both to plan and to justify the proposed research.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Cyclones, Life Cycle, Latent Heat Release

A STUDY OF INCORPORATING TROPICAL CYCLONE ASYMMETRY AND PERSISTENCY INTO THE NOGAPS

M.S. Peng, Research Associate Professor
Department of Meteorology
Sponsor: Naval Research Laboratory-Monterey

OBJECTIVE: To study the effect of implementing a wavenumber-one asymmetry, induced by the planetary vorticity gradient, on tropical cyclone prediction in NOGAPS.

SUMMARY: This is a new project started in 1994 and will be continued in 1995. A barotropic model was used to generate the wavenumber-one asymmetry induced by the planetary vorticity gradient associated with a specified symmetric wind profile. The wavenumber-one asymmetry was retrieved after the vortex had been transformed to polar coordinates and Fourier analysis was performed. The wavenumber-one asymmetry was then rotated and its magnitude adjusted so that the flow near the center matched the previous typhoon's movement. This part has been completed and is ready to be implemented into the NOGAPS.

OTHER:

M.S. Peng has been nominated to serve on the AMS Committee on Hurricanes and Tropical Meteorology.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Tropical Cyclone, Asymmetry

AN EVALUATION OF SATELLITE-BASED OBSERVATIONS OF TROPOPAUSE-LEVEL THERMAL ANOMALIES IN IMPROVING THE NOWCASTING AND FORECASTING OF EXTRATROPICAL CYCLONES

C.H. Wash, Professor
P.A. Hirschberg, Assistant Research Professor
Department of Meteorology
Sponsor: National Weather Service

OBJECTIVE: The objective of this project is to determine the utility of Microwave Sounding Unit (MSU) brightness-temperature analyses in improving the nowcasting and forecasting of extratropical cyclone events especially over conventional data-sparse regions.

SUMMARY: A statistical analysis was performed on a six-month global data set consisting of satellite-derived channel 3 Microwave Sounding Unit (MSU) brightness temperature data from the Marshall Space Flight Center and various conventionally-derived fields obtained from the National Meteorological Center Global Data Assimilation System (GDAS) to quantify the potential usefulness of MSU analyses in the nowcasting and forecasting of baroclinic waves especially over conventional data-sparse regions. High positive spatial and temporal correlations were obtained between the MSU and the 400-100-mb thickness over all wavelengths in the data. Most significantly, relatively high negative MSU-500-mb correlations for the short wave-length portion of the data suggest that the MSU can be used to track mid-level synoptic-scale baroclinic waves. An MSU collection and analysis procedure was also developed to generate MSU analyses from locally obtained polar-orbiter data.

PUBLICATION:

Parke, M.C., Hirschberg, P.A., and Wash, C.H., "An evaluation of nowcasting and forecasting of extratropical

cyclone systems with the aid of satellite-based observations of tropopause-level thermal anomalies," Proceedings AMS Seventh Conference on Satellite Meteorology and Oceanography, Monterey, CA, June 1994, pp. 351-354.

CONFERENCE PRESENTATIONS:

Parke, M.C., Hirschberg, P.A., and Wash, C.H., "An evaluation of nowcasting and forecasting of extratropical cyclone systems with the aid of satellite-based observations of tropopause-level thermal anomalies," presented at the AMS Seventh Conference on Satellite Meteorology and Oceanography, Monterey, CA, June 1994.

Skupniewicz, C.E., Parke, M.C., Hirschberg, P.A., and Richardson, K.L., "Comparison of microwave sounding unit and National Meteorological Center gridded temperature fields," presented at the Fourth Annual TeraScan Scientific Applications Workshop, San Diego, CA, 28 February - 2 March 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Forecasting, Satellite Remote Sensing, Tropopause

MECHANISMS OF TROPICAL CYCLONE STRUCTURE CHANGE

R.T. Williams, Professor
M.S. Peng, Research Associate Professor
Department of Meteorology
Sponsor: Office of Naval Research

OBJECTIVE: To determine the mechanisms which cause changes in tropical cyclone structure.

SUMMARY: A series of numerical experiments have been carried out using the NRL limited-area baroclinic model to study the mechanisms that affect tropical cyclone intensity. The first part which concerns the beta-effect was nearly finished. To eliminate effects from difference thermodynamic fields, all the experiments used the same initial and environmental conditions. The vortex developed into a very intense cyclone without a mean flow on an f-plane. When a uniform zonal flow was included, the cyclone structure became asymmetric due to interaction of the vortex and the mean flow and the intensity of the vortex was reduced. When the integration was carried out with variable f, the intensity of the cyclone was further reduced due to the beta-gyre induced by planetary vorticity gradient. The results were transformed into polar coordinates following the cyclone center. When the planetary vorticity gradient was included, the wavenumber-one structure around the cyclone center showed a large broad area of flow across the center. This cross-center flow may shear the thermodynamic profile that reduces the convective instability and inhibits the development of the cyclone.

PUBLICATION:

Williams, R.T. and Chan, J.C.-L., "Numerical studies of tropical cyclone motion, Part II: Zonal mean flow effects," Journal of the Atmospheric Sciences, Vol. 51, pp. 1065-1076, 1994.

CONFERENCE PRESENTATION:

Peng, M.S., "Tropical cyclone intensification," presented at the Conference on Weather Analysis and Forecasting, Central Weather Bureau, Taipei, 24-26 November 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Tropical Cyclone, Vortex, Beta-effect, Intensity

NUMERICAL MODELING OF TROPICAL CYCLONE STRUCTURE CHANGE

R.T. Williams, Professor
M.S. Peng, Research Associate Professor
Department of Meteorology
Sponsor: Naval Research Laboratory-Monterey

OBJECTIVE: To determine the dynamics associated with interaction between a vortex and the environmental flow which cause differences in tropical cyclone intensities.

SUMMARY: The Naval Research Laboratory (NRL) limited-area numerical prediction model was used for this study. A gradient-wind balanced vortex was imbedded in a basic flow with various magnitudes and shears. Among the vortices developed with the presence of a basic flow, the strong vortices had a major feature of a concentrated outflow jet in the upper level. All the weaker vortices obtained had less concentrated outflow jet. If the basic flow at the outflow layer is too large, then the flow pattern is unidirectional. If the basic flow at the outflow layer is too weak, the pattern is more divergent. Both are not favorable for cyclone intensification. Cases with different vertical shear were compared with the uniform westerly flow solution. The results showed that the larger the vertical shear was, the weaker the vortex was. Our investigation suggested that weaker vortices were obtained in flows with vertical shear because the large mean flow in the outflow layer did not allow a concentrated outflow jet to form.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Tropical Cyclone, Vortex, Flow

FRONTAL MODELING

R.T. Williams, Professor
M.S. Peng, Research Associate Professor
Department of Meteorology
Sponsor: National Science Foundation

OBJECTIVE: The goal of this research is to improve the modeling of atmospheric surface fronts.

SUMMARY: A two-dimensional numerical model was developed to study atmospheric fronts. A stretched grid was introduced into the finite difference equations so that very high resolution could be achieved in the immediate vicinity of the surface front. Numerical experiments with confluence forcing showed that a large scale initial temperature field could collapse to a very small scale in the absence of turbulent diffusion. Additional studies were made with two K-theory boundary layer parameterizations. Under these conditions the frontal scale reached only about 100 km. The forecast model with no turbulent diffusion was used to study the evolution of an initially unbalanced potential temperature disturbance in an atmosphere with a constant potential temperature elsewhere. It was found that a frontal discontinuity would form depending on the initial Rossby number. In other cases an initial oscillation developed. Maritime frontogenesis was studies with the NRL three-dimensional regional model. Fronts were found in a growing cyclone which was in a baroclinic current over water with a fixed north-south

temperature gradient. Experiments were carried out with K-theory and second order closure boundary layer parameterizations. Both formulations showed the importance of vertical mixing of momentum in the cold air behind the cold front, but the second order closure solution was more realistic.

CONFERENCE PRESENTATIONS:

Blumen, W., Wu, R., and Williams, R.T., "Geostrophic Adjustment: Frontogenesis and energy conversion," Fourth International Symposium on Structured Flows, Grenoble, France, 29 June - 2 July 1994.

Peng, M.S. and Williams, R.T., "Frontal scale and boundary layer effects," Sixth Conference on Mesoscale Processes, Portland, OR, 17-22 July 1994.

THESIS DIRECTED:

Thompson, W.T., "Impact of Physical Processes on Maritime Frontogenesis," Doctoral Dissertation, June 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Fronts, Boundary Layer, Numerical Model

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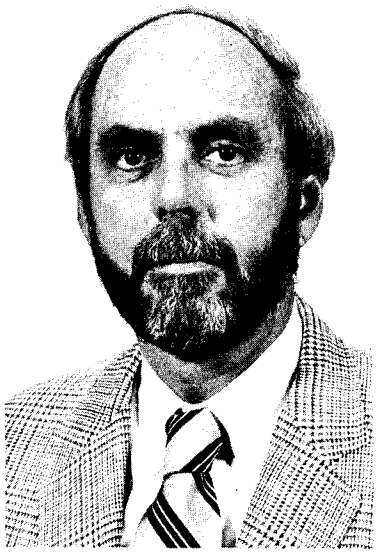
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Elsberry, R.L., "Tropical cyclone motion," A Global Perspective on Tropical Cyclones, (R.L. Elsberry, Ed.), Chapter 4, World Meterological Organization, Geneva, Switzerland, 1994.

Elsberry, R.L., "Tropical cyclone motion -- How can we predict the potentially dangerous track?," Oceans: Physical-Chemical Dynamics Human Impact, (S.K. Majumdar, E.W. Miller, G.S. Forbes, R.F. Schmalz, and A.A. Panah, Eds.), Pennsylvania Academy of Science, 1994.

Pauley, P.M., "Cyclones, Anticyclones, Air Masses, and Fronts," Chapter 11 in Meteorology: The Atmosphere and the Science of Weather, authors J.M. Moran and M.D. Morgan, 4th ed., Macmillan Publishing Company, Inc., pp. 242-275, 1994.

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Department of National Security Affairs

The research conducted by the faculty in the Department of National Security Affairs expanded in scope and depth during the 1994 Academic Year. More senior faculty were joined by new faculty who were recruited to broaden the teaching and research interests sponsored by the Department. These included in particular the areas of Special Operations and Low Intensity Conflict, Regional Security Policy, and Intelligence Studies. Most of the faculty spent much time outside of Monterey conducting research. These included short trips to Washington, D.C., Norfolk, Honolulu, capital cities in Asia, the Middle East, and Europe.

The research themes pursued by the faculty include the following:

(1) National and Regional Security and Defense Policies including virtually all of Europe, East and West, Russia and Ukraine; Latin America; the Middle East; South, East and South East Asia. The research in these areas deals with such topics as civil/military relations, foreign relations between and among groups of states, the role of regional organizations such as NATO and the UN, and bilateral relations with the United States.

(2) The general topics of revolutions, low intensity conflict, and special operations. While dealing with the overall theme of political violence and insurrections, and covering much of the world, the strongest focus has been on different cases in Latin America.

(3) U.S. defense policy, particularly regarding the role of different national institutions including the Executive and Legislative branches and the different services.

(4) The overall theme of intelligence, and how it is becoming increasingly joint. Here the emphasis is primarily on the emerging themes of intelligence and the new or changing structures whereby the United States obtains and processes information.

(5) U.S. Naval strategy, and particularly the implications for the Navy of the new doctrine in "From the Sea." The focus on new naval strategy holds implications for the relationships with other services and allied services.

(6) The economics of U.S. and other countries' defense strategies. Here the emphasis is on the costs of defense, the economic implications of defense, and such themes as "economic warfare."

(7) Certain "hot" topics of tremendous importance including counter-proliferation, cyberwar, peacekeeping, deterrence, and arms control. In many cases these topics are situated in a national or regional context, and they often bridge several of the themes noted in the other categories.

The faculty in the Department have developed a research agenda which encompasses the most important and relevant themes of international security and defense. They are virtually all active researchers with great experience in their areas of topics of choice and with an emphasis upon analysis and policy. The research is increasingly supported by reimbursable funding. The results of the research is provided to sponsors through reports and briefings, and is often made available to a larger public through the publication of scholarly articles and books.

REGIONAL DETERRENCE

J. Arquilla, Assistant Professor
Department of National Security Affairs
Sponsor: Naval Postgraduate School

OBJECTIVE: Explore the manner in which deterrence of aggression should be employed to encourage stability in the new, polycentric international system.

SUMMARY: Briefly, the research focuses upon a variety of domestic and external constraints likely to weaken deterrence, with special attention given to the problems posed by gradualism (the use of force only as a last resort) and multilateralism.

PUBLICATIONS:

Arquilla, J., "Bound to Fail? Regional Deterrence after the Cold War," Comparative Strategy, Vol. 14, No. 2, forthcoming in Spring 1995.

Arquilla, J. and Moyano, M., "The Origins of the South Atlantic War," International Security, forthcoming in 1995.

CONFERENCE PRESENTATION:

Arquilla, J., "Information, Deterrence, and National Power," Keynote speech presented at the Worldwide Psychological Operations Conference, September 1994.

THESES DIRECTED:

Borje, A., "The Spratly Dispute," Master's Thesis.

Chang, M., "Korean Unification," Master's Thesis.

Davis,D., "Iranian Security Policy," Master's Thesis.

OTHER:

Arquilla, J. and Fredricksen, H., "Graphing an Optimal Grand Strategy," in review at Military Operations Research.

DOD KEY TECHNOLOGY AREA: Other (International Security)

KEYWORDS: Deterrence, Agression

NAVAL POWER AND POLITICS AFTER THE COLD WAR

J.S. Breemer, Associate Professor
Department of National Security Affairs
Sponsor: Naval Postgraduate School

OBJECTIVE: The purpose of this research was to examine the implications of the end of the Cold War and the consequent demise of the Soviet naval threat for the future "strategic purpose" of blue water naval power, including the U.S. Navy in particular.

SUMMARY: The research explored the basic assumption, implicit in the U.S. Navy's "...From the Sea" white paper that the absence, for the foreseeable future, of a major threat to the oceanic sea lines of communications dictates a fundamental reassessment of the future uses and usefulness of U.S. naval power. It reviewed the traditional role of naval power in providing security at sea, and found that, absent an obvious challenge to that security, the U.S. Navy must radically revise the way its has historically been a key contributor to the Nation's security. Specifically, the research concluded that "land control" is about to replace "sea control" as the Navy's foremost strategic purpose. Subsequent research examines the implications of this shift for Navy roles and missions, force sizing, weaponeering, and so on. The research is continuing with FY1995 DFR support.

PUBLICATIONS:

Breemer, J.S., "Naval Strategy is Dead," U.S. Naval Institute Proceedings, Vol. 120, No. 1092, pp. 49-53, February 1994.

Breemer, J.S., "The End of Naval Strategy: Revolutionary Change and the Future of American Naval Power," Strategic Review, Vol. 22, No. 2, pp. 40-53, Spring 1994; Maritime Security and Conflict Resolution at Sea in the Post-Cold War Era, P. Haydon and A.L. Griffiths, (eds.), Halifax: Dalhousie University, Centre for Foreign Policy Studies, pp. 135-142, 1994.

Breemer, J.S., "Out of the Blue: The U.S. Submarine Fleet After the Cold War," Maritime Patrol Aviation, Vol. 3, No. 1, pp. 64-67, September 1994.

Breemer, J.S., "Home from the Sea: Have We Entered an New Era of Maritime Strategic Thinking?" scheduled for publication in 1995 in the Proceedings of the 1994 Colloquium on Maritime Forces in Global Security, Dalhousie University, Halifax, N.S., Canada.

Breemer, J.S., "The Navy Gets the Gravy and the Army Gets the Helicopters," Proceedings of the conference, "The Canadian Defense Industry: Surviving Changing Procurement Priorities," Ottawa, Canada, pp. 97-101, 1 November 1994.

CONFERENCE PRESENTATIONS:

Breemer, J.S., "Out of the Blue: The U.S. Submarine Fleet After the Cold War," presented at the conference on "Sea Power for the Next Decade," London, U.K., 6 May 1994.

Breemer, J.S., "Home From the Sea: Have We Entered a New Era of Maritime Strategic Thinking?" presented at the 1994 Colloquium on Maritime Forces in Global Security," Dalhousie University, Halifax, N.S., Canada, 24 June, 1994.

Breemer, J.S. "The Navy Gets the Gravy and the Army Gets the Helicopters," presented at the Financial Post conference, "The Canadian Defence Industry: Surviving Changing Priorities," Ottawa, Canada, 1 November 1994.

THESES DIRECTED:

Greenburg, D.S., MAJ, USMC, "Planning and Investing for Logistics Support of Marine Expeditionary Forces in the 21st Century," Master's Thesis, December 1994.

Healy, P.F., LCDR, USN, "Planning and Investing for a Maritime Reconnaissance Strike Complex: The U.S. Navy in the 21st Century," Master's Thesis, June 1994.

OTHER:

The following papers are presently being reviewed for future publication: Breemer, J.S., "European Naval Power After the Cold War: Decline or Renewal?" and Breemer, J.S., "Home from the Sea: Joint Warfare and the Roots of Naval Power."

DOD KEY TECHNOLOGY AREA: Other (Naval Strategy, Submarines)

KEYWORDS: U.S. Navy, Naval Strategy, Joint Warfare

POLITICAL ATTITUDES IN PORTUGAL, 1973-1993

T.C. Bruneau, Professor and Chairman
Department of National Security Affairs
Dr. Mario Bacalhau, NORMA, Lisbon
Sponsor: Luso-American Development Foundation, Lisbon

OBJECTIVE: The goal of this project was to conduct a public opinion survey in Portugal in order to evaluate the political attitudes and behavior of the population some twenty years after the revolution of 25 April 1974. The results will be published in a book that will appear in the Spring of 1995.

SUMMARY: Portugal is an excellent case study of a country which has undergone tremendous political change in a very short period of time. The authoritarian regime of Premier Oliveira Salazar was overthrown in a coup on 25 April 1974 which quickly became a revolution. Within two years a democratic regime emerged which has subsequently become consolidated. In 1973 Thomas Bruneau met Dr. Mario Bacalhau in Lisbon and they initiated a collaborative research relationship which has continued until the present. In late 1993 they obtained a substantial grant from the Luso-American Development Foundation in Lisbon to conduct a survey, in line with two previous surveys they had conducted (1978 and 1984), and to write a book. They completed a first draft of the book reporting the data in the Fall of 1994.

PUBLICATION:

Bacalhau, M. and Bruneau, T., Atitudes, Opinioes e Comportamentos Politicos dos Portugueses: 1973 - 1993, Lisbon, forthcoming in 1995.

OTHER:

It is anticipated that the book, or an abbreviated version of it, will be published as well in English. Thomas Bruneau will present the data from the survey at the upcoming meeting of the International Conference Group on Modern Portugal, Durham, NH, September 1995.

DOD KEY TECHNOLOGY AREA: Other (Political Attitudes)

KEYWORDS: Portugal, Democratization, Regime Transition

A FAMILY QUARREL: THE RUSSIAN-UKRAINIAN RELATIONSHIP

R. Laba, Associate Professor
Department of National Security Affairs
Sponsor: U.S. Department of Energy

OBJECTIVE: To explain the Russian-Ukrainian conflict.

SUMMARY: Since the breakup of the Soviet Union in 1991, Western analysis of post-Soviet realities has been dominated by three policy-related schools--arms control, transition to democracy, and free market. All claim that if we prevent proliferation, we help Russia to become democratitc or turn to the free market, this will be good for them and good for us.

This paper abandons the categories with which these schools work. The categories used here are state and ethno-nation. It is original in three parts: (1) Its interpretation of the fall of the USSR. The major interpretation available to date emphasizes the drive to democracy and the fight againstt communism of Yeltsin and his allies. In contrast, the analysis presented here claims thata the Russian "democrats" unintentionally destroyed the USSR and paid dearly for their political miscalculation with Ukraine. This interpretation suggests a poisoned beginneing of Russian democracy and of Russia's relationship with Ukraine that has created the increasingly visible problems with Russia's democracy with its free-market reforms and foreign policy direction. More unpleasant consequences are likely in the future. (2) The analysis presents new evidence on the creation of the state boundaries between Russia and Ukraine. This is the first time that this historical evidence has been presented in English. It is known to only a handful of individuals in Russia and Ukraine. (3) The analysis is the first to juxtapose the problem of the state maps of Russia and Ukraine with their demographic and ethno-national map.

These three interpretations lead to the conclusion that Ukraine and Russia are involved in a deeply entangled ethno-nationall relationship which is likely to becomme more conflicted and more dangerous in the succeeding years. These are different and much more sobering conclusions than those offered by the arms control school, the transition to democracy school, and the free-market school which dominate our understanding of and policies toward the post-Soviet world in 1995.

PUBLICATIONS:

Laba, R., "State, Nation, and Identity in the Russian-Ukrainian Conflict," European Security, forthcoming Summer 1995.

Laba, R., "The End of the Soviet Union: An Ethtno-national Interpretation," submitted for journal review.

Laba, R., "Solidarity," Garland Encyclopedia of Non-Violence, Cambridge, MA: Albert Einstein Institute of Non-Violence, forthcoming in 1996.

CONFERENCE PRESENTATION:

Laba, R., "Nuclear Arms in Ukrainian Politics," Stanford University, Center for International Security and Arms Control, March 1994.

THESIS DIRECTED:

Foley, D.C., LT, USN, "Command and Control in New Nuclear States: Implications for Stability," Master's Thesis, June 1994.

OTHER:

Research in progress - "U.S. Foreign Policy and the Territorial Integrity of the USSR" and "Paramilitary Formations in Russia: Thee Cossacks."

DOD KEY TECHNOLOGY AREA: Other (International Relations)

KEYWORDS: Foreign Policy, Russian Politics, Ukrainian Politicss, U.S. Foreign Policy

LEARNING TO LIVE WITH THE BOMB: THE POLITICS OF NUCLEAR PROLIFERATION IN SOUTH ASIA

P.R. Lavoy, Assistant Professor
Department of National Security Affairs
Sponsor: Naval Postgraduate School

OBJECTIVE: The objective of this two-year project is to examine and report on the evolution of nuclear weapons activities in India and Pakistan.

SUMMARY: The goals of this research project are: (1) to explain the conditions that motivate India and Pakistan to expand or reduce their nuclear weapons capabilities; (2) to assess U.S. and other foreign efforts to influence Indian and Pakistani nuclear decision making; (3) to examine the military and political problems posed by nuclear weapons in South Asia; and (4) to explore arms control and confidence-building solutions for these problems. The project has resulted in several publications and conference presentations.

PUBLICATIONS:

Lavoy, P.R., "Civil-Military Relations, Strategic Conduct, and the Stability of Nuclear Deterrence in South Asia," in Civil-Military Relations and Nuclear Weapons, S. Sagan, ed., Stanford: Center for International Security and Arms Control, 1994.

Lavoy, P.R., "Nuclear Myths and the Causes of Nuclear Proliferation," The Proliferation Puzzle: Theoretical Explorations of Nuclear Proliferation, Z.S. Davis and B. Frankel, eds., London: Frank Cass, 1994.

Lavoy, P.R., "Arms Control in South Asia," Arms Control Toward the Twenty-First Century, J.A. Larsen and G.J. Rattray, eds., Boulder, CO: Lynne Rienner, forthcoming in 1995.

Lavoy, P.R. and Mohan, C.R., "Avoiding Nuclear War: Deterrence, Arms Control and Confidence-Building in South Asia," Confidence-Building Measures in South Asia, Washington, D.C.: H.L. Stimson Center, forthcoming in 1995.

Lavoy, P.R., "Constructive Engagement: The Recent Shift in U.S. Nonproliferation Policy Toward South Asia," Pakistan Journal of American Studies, Islamabad, forthcoming in 1995.

Lavoy, P.R., "Worlds Apart: Indian and U.S. Perspectives on Nonproliferation," (review of Kathleen Bailey, Strengthening Nuclear Nonproliferation and Brahma Chellaney, Nuclear Proliferation: The U.S.-Indian Conflict), Millennium, Vol. 24, No. 1, forthcoming in Spring 1995.

CONFERENCE PRESENTATIONS:

Lavoy, P.R., "Forecasting the Future of Nuclear Proliferation: The Case of South Asia," The Nuclear Nonproliferation Regime: Post-Cold War Perspectives, presented at Marquette University, May 1994.

Lavoy, P.R., "Nuclear Symbolism: Prestige and Legitimacy in Pakistan's Nuclear Weapons Program," presented at the International Studies Association Annual Meeting, Washington, D.C., March 1994.

OTHER:

Lavoy, P.R., "Regional Security: The Neglected Object of Nuclear Diplomacy in South Asia," Nuclear Nonproliferation Issues in South Asia, to be presented to the Islamabad Council of World Affairs and the Hanns Seidel Foundation, Islamabad, Pakistan, April 1995.

"Learning to Live With the Bomb: The Politics of Nuclear Proliferation in South Asia," Ph.D. dissertation, University of California, Berkeley, Department of Political Science, forthcoming in May 1995.

The project involved a two-month research and speaking tour of South Asia. Aside from conferring with governmental and non-governmental experts in India and Pakistan, I took part in two interesting public activities. First, I served as the moderator for Traveling Seminar V: U.S. Foreign Policy in South Asia, an annual confidence-building forum for regional policy experts. The U.S. Information Agency sponsored the seminar which convened in Karachi, Pakistan and in New Delhi, India. Second, I presented a lecture ("Learning to Live With Nuclear Weapons in South Asia") to the following 14 organizations. Both activities increased awareness among influential Indian and Pakistani audiences about the seriousness of the nuclear issue and about the goals of U.S. policies in the region.

Pakistan
Department of International Relations, Sindh University, Hyderabad
Department of International Relations, University of Baluchistan, Quetta
Social Sciences Faculty, Quaid-i-Azam University, Islamabad
Social Sciences Departments, Peshawer University
Political Science Department, Punjab University, Lahore
Pakistan Civil Services Academy, Lahore
American Center, U.S. Consulate, Karachi

India
School of International Studies, Jawaharlal Nehru University, New Delhi
Centre for Policy Research, New Delhi
Institute for Defence Studies and Analyses, New Delhi
Department of Defence and Strategic Studies, Allahabad University, Allahabad
Department of Political Science, Banaras Hindu University, Varanasi
South Asia Studies Centre, University of Rajasthan, Jaipur
Department of Defence and Strategic Studies, Madras University, Madras

THESES DIRECTED:

Parisi, T., LT, "India: Asia's Other Giant," Master's Thesis.

Foley, D., LT, "Command and Control in New Nuclear States," Master's Thesis.

Barretta, M., LT, "Nuclear Proliferation and the Stability-Instability Paradox," Master's Thesis.

DOD KEY TECHNOLOGY AREA: Other (Nuclear Weapons)

KEYWORDS: Nuclear Weapons, Nuclear Proliferation, India, Pakistan

NORTHEAST ASIAN CONFIDENCE BUILDING MEASURES (CBMs): FROM A REGIONAL CONTEXT TO THE ENVIRONMENTAL FRONTIER

E.A. Olsen, Professor
Department of National Security Affairs
Sponsor: Office of Naval Intelligence

OBJECTIVE: To develop new source materials on Japanese, South Korean, and North Korean environmental policies and assess their importance for regional CBMs.

SUMMARY: This study examined the generic roles on Confidence-Building Measures (CBMs) in post-cold war Northeast Asia and the specific functions of economic and environmental CBMs. Special attention was paid to the domestic roots of these CBMs in Japan, South Korea (ROK), and North Korea (DPRK), and their impact on each country's policies regionally. Environmental CBMs are evolving within the context of strategic and economic CBMs in Northeast Asia, but they also possess unique characteristics on the governmental and non-governmental (NGO) levels. The importance of environmental CBMs in the post-cold war era are described and contrasted in this study, and their efficacy is evaluated as instruments to reduce regional tensions.

PUBLICATION:

Olsen, E.A., "Northeast Asian Confidence Building Measures (CBMs): From A Regional Context To The Environmental Frontier," Naval Postgraduate School Technical Report, NPS-NS-94-002, October 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects, Other (Ocean Policy)

KEYWORDS: Environment, Ocean Policy, Japan, South Korea, North Korea

DILEMMAS OF STATES: ISLAMICISM, POLITICAL LIBERALIZATION AND THE ARAB-ISRAELI 'END-GAME'

G.E. Robinson, Assistant Professor
Department of National Security Affairs
Sponsor: United States Institute of Peace and Naval Postgraduate School

OBJECTIVE: To conceptualize how the end of the Arab-Israeli conflict likely will impact domestic Arab politics in the Levant.

SUMMARY: This project links both theoretically and empirically the three most important political phenomena in the post-Cold War Levant: Islamicism (Islamic fundamentalism), political liberalization, and the Arab-Israeli peace negotiations. The geographical focus wa son Jordan, the West Bank/Gaza Strip, and Syria. The major finding is that the inherent tensions between the containment of Islamicism, political liberalization, and the participation in a negotiated settlement with Israel restrict regimes to the pursuit of (at most) two of these policy

goals. The resulting strategic choices have had - and will continue to have - a profound impact both on the stability of the settlement with Israel and on the prospects for sustainable political liberalization - even democratization - in the Arab Levant. Fieldwork for this project was conducted for six weeks in April and May 1994 in the Levant.

CONFERENCE PRESENTATIONS:

Robinson, G.E., "The Islamicist Movements in Jordan and Palestine," United Stats Institute of Peace, Washington, DC, 14 December 1994.

Robinson, G.E., "Dilemmas of States: Islamicism, Liberalization and the Arab-Israeli 'End-Game'," Middle East Studies Association Annual Conference, Phoenix, AZ, November 1994.

Robinson, G.E., "Domestic Arab Politics in the Context of an Arab-Israeli Settlement," al-Urdunn al-Jadid Research Center, Amman, Jordan, 12 April 1994.

Robinson, G.E., "Democratization and the Arab-Israeli 'End-Game'," Center for Strategic Studies, University of Jordan, Amman, 4 April 1994.

OTHER:

The research also contributed to a book manuscript on a related topic, "On the Palestinian uprising and its aftermath," near completion.

Robinson, G.E., "The Islamicist Movements in Jordan and Palestine: A Comparison," United States Institute of Peace, forthcoming.

Robinson, G.E., "The Islamicist Movement in Jordan under Liberalization," in progress in Ahmad Moussalli, Islamicist Movements in the Middle East, University of Florida Press, forthcoming.

Robinson, G.E., "Defensive Democratization in Jordan," currently under review at The Middle East Journal.

DOD KEY TECHNOLOGY AREA: Other (International Stability) (Regionalism)

KEYWORDS: Arab, Israel, Jordan, Syria, Palestinian, Islamic Fundamentalism, Democracy, Liberalization

THE U.S. POLICYMAKING PROCESS IN THE POST-COLD WAR ERA

P.N. Stockton, Assistant Professor
Department of National Security Affairs
Sponsor: Defense Security Assistance Agency

OBJECTIVE: The goal of this project is to produce a book-length manuscript investigating how the end of the Cold War has altered the U.S. defense policymaking process and civil-military relations, and to draw some broader theoretical conclusions concerning the impact of international change on domestic political structures.

SUMMARY: With the advent of the Cold War, the United States made significant organizational changes in defense policymaking institutions, and (compared to earlier periods of U.S. history) kept peacetime forces and defense spending at unprecedented levels. Now, with the breakup of the Soviet Union, what will become of the U.S. institutions and civil-military relations that evolved in response to the Soviet threat? How will this

institutional and domestic political legacy of the Cold War shape the U.S. response to the new security era? The project describes the Cold War-era defense policymaking process and civil-military relationships to provide a baseline for examining subsequent changes. Then, the project examines the history of defense policymaking since the collapse of the Berlin Wall in 1989, and analyzes the underling changes in the policymaking process and civil-military relations that have shaped U.S. decisions on force structure. The project concludes by drawing some broader lessons concerning the impact of international change on domestic-level determinants of state behavior, and contrasting those lessons with the existing theories in the field. The project relies on over 100 interviews conducted by the P.I. of senior DoD officials, Members of Congress and their staffs, and other relevant personnel, as well as original and secondary documents covering the post-cold War period.

PUBLICATION:

Stockton, P.N., "When the Bear Leaves the Woods: Department of Defense Reorganization in the Post-Cold War Era," Change in U.S. Foreign Policy after the Cold War: Processes, Structures, and Decisions, R. Ripley and J. Lindsay, eds., University of Michigan Press, accepted and forthcoming early 1996.

CONFERENCE PRESENTATION:

Stockton, P.N., "When the Bear Leaves the Woods," presented at the U.S. Foreign Policy after the Cold War, the Mershon Center, Ohio State University, Columbus, OH, 20-21 May 1994.

THESES DIRECTED:

Wilson, C.L., USA, and Weingartner, J.L., USAF, "Blame-Proof Policymaking: Congress and Base Closures," Master's Thesis, December 1993.

Schnell, D.A., USN, "Stormy Waters: Technology, Sea Control and Regional Warfare," Master's Thesis, June 1994 (Co-Advisor: Wayne P. Hughes, Jr.).

Dowell, S.B., USN and Bell, J.H., USN, "Power By the Numbers: Congressional Line Item Budgeting," Master's Thesis, June 1994.

DOD KEY TECHNOLOGY AREA: Other (Policy)

KEYWORDS: Cold War, Policy

BRAZIL'S NATIONAL SECURITY STRATEGY: IMPLICATIONS FOR HEMISPHERIC SECURITY

S.D. Tollefson, Assistant Professor
Department of National Security Affairs
Sponsors: US Navy and Office of the Secretary of Defense, Regional Security Affairs, Inter-American Region

OBJECTIVE: The goal of this three-project was to investigate Brazil's national security strategy (development, security, and foreign policies), and the implications of that strategy for Brazilian, Latin American, and U.S. security.

SUMMARY: The research examined key issues in Brazil's national security strategy, including the nuclear programs; arms industry and weapons transfers; ballistic missile program; border projects; and narco-trafficking. The research included extensive travel to Latin America and Washington, D.C. The research was comparative in nature, and included studies on Argentina and Chile.

PUBLICATIONS:

Tollefson, S.D. and English, A.J., "Chile: National Security," Chapter 5 in Chile: A Country (Area Handbook Series), U.S. Government Printing Office, 1994.

Tollefson, S.D., "Brazil: International Relations," Handbook of Latin American Studies/Social Sciences, Vol. 51, Austin: University of Texas Press, 1994.

Tollefson, S.D., "Brazil: International Relations," Chapter 5 in Brazil: A Country Study (Area Handbook Series), to be published in late 1995.

Tollefson, S.D., "Brazil: Science and Technology," Chapter 6 in Brazil: A Country Study (Area Handbook Series), to be published in late 1995.

CONFERENCE PRESENTATION:

Tollefson, S.D., "Brazil's National Security Policy," presented at the First Conference of the Brazilian Studies Association (BRASA), Atlanta, GA, 10 March 1994.

OTHER:

Discussant on panel, "Caso Nacional Brasileño, Seminário Internacional América Latina: Gasto Militar , Actores Claves, Procesos de Decisiones," Sponsored by the Academia Nacional de Estudios Políticos y Estratégicos (ANEPE), and the Facultad Latinoamericana de Ciencias Sociales, 6 January 1994.

PI submitted following reports to sponsor in December 1994:

"Brazil's Nuclear, Space and Missile Programs: An Assessment of Capabilities and Intentions," 33 pages;
"Brazil's National Security: Overview," 85 pages; and
"National Security Policy and Democratization in Brazil," 19 pages.

PI was a visiting researcher at the Facultad Latinoamericana de Ciencias Sociales (FLACSO), Santiago, Chile, August 1993 - April 1994. While in Chile, PI traveled to Brazil, Argentina, Paraguay, and Uraguay.

DOD KEY TECHNOLOGY AREA: Other (Comparative Politics, Security)

KEYWORDS: Brazil, Nuclear, Security, Amazon, Argentina, Chile, Civil-Military Relations

ARMS CONTROL COMPLIANCE: FUTURE ISSUES

J.J. Wirtz, Assistant Professor
Department of National Security Affairs
Sponsor: Navy International Program Office (IPO)

OBJECTIVE: The purpose of this project is to provide support to Navy IPO by responding to a series of research questions related to arms control compliance, verification and implementation.

SUMMARY: This project responds to a series of research questions posed by Navy IPO concerning future issues related to arms control compliance, verification, and implementation. The project itself actually represents several research initiatives, conducted by faculty and students under the supervisions of the PI. In addition to these specified projects, however, it is expected that the research initiative will evolve continuously to better support Navy IPO.

PUBLICATIONS:

Wirtz, J.J., "Allies and Theater Missile Defense: The Benefits of an ASW Approach to Counterforce (U)," Naval Postgraduate Technical Report, NPS-OR-94-007, 1994.

Wirtz, J.J., "Counterforce & Theater Missile Defense: An ASW Approach to the SCUD Hunt," Strategic Studies Institute, U.S. Army War College, forthcoming in 1995.

THESES DIRECTED:

Green, D., LT, USN, "Monitoring Proliferation Markets," Master's Thesis.

Blackburn, D., LT, USN, "The Chemical Weapons Convention Verification Regime: A Model for A New NPT?" Master's Thesis.

Carr, R., CDR, USN, "A U.S.-Russian Nuclear Waste Treaty," Master's Thesis.

Peterson, J., CDR, USN, "Theater Missile Defense: Beyond Patriot," Master's Thesis.

OTHER:

Wirtz, J.J., "Multilateral Deterrence," (Unpublished Manuscript).

DOD KEY TECHNOLOGY AREA: Other (Arms Control)

KEYWORDS: Arms Control, Missile Defense

THE RISKS OF ARM CONTROL

J.J. Wirtz, Assistant Professor
Department of National Security Affairs
Sponsor: USAF Institute of National Security Studies

OBJECTIVE: This project explains (1) the conditions under which states will engage in arms control; and (2) the circumstances under which arms control agreements will either decrease or increase national security.

SUMMARY: The analysis also will provide definitive answers to several related questions. For instance, it can explain why recent executive initiatives have come to replace extended arms control negotiations. Additionally, the analysis can explain why these types of initiatives would be dangerous to replicate in arms control efforts directed toward other states.

To answer these issues, the analysis adopts a unique non-normative view of arms control. Instead of offering better negotiating techniques or new negotiating venues, it uses the empirical record to treat arms control itself as the phenomenon under investigation. It explores arms control in its historical setting and asks an often ignored question: what political and strategic purposes are served by arms control. The analysis treats arms control as a dependent variable and seeks to identify both the necessary and sufficient conditions that underlie the arms-control process. It identifies the conditions that permitted arms control to occur during the Cold War and estimates whether these conditions will emerge in the immediate future. The purpose of this project is to provide support to Navy IPO by responding to a series of research questions related to arms control compliance, verification and implementation.

PUBLICATION:

Wirtz, J.J., "Did Arms Control Succeed," Arms Control Toward the 21st Century: A Primer, J. Larsen and G. Rattray, eds., Lynne Rienner, forthcoming in 1995.

CONFERENCE PRESENTATIONS:

Wirtz, J.J., participant of presentation of Arms Control Toward the 21st Century: A Primer, Preparation Symposium, Institute for National Security Studies, USAF Academy, Colorado Springs, CO, 2 December 1994.

Wirtz, J.J., "Counterproliferation and Deterrence," USAF Institute for National Security Studies, Annual Research Conference, USAF Academy, Colorado Springs, CO, 9-10 November 1994.

Wirtz, J.J., "Multilateral Deterrence," paper delivered at the Conference on Deterrence in the Post-Cold War Era, Airlie House, VA, 26-28 September 1994.

DOD KEY TECHNOLOGY AREA: Other (Arms Control)

KEYWORDS: Arms Control, Strategy

ANALYTICAL TRENDS REGARDING THE MILITARY-TECHNICAL REVOLUTION

D.S. Yost, Professor
Department of National Security Affairs
Sponsors: Under Secretary of Defense for Acquisition and Technology and Director of Net Assessment, Office of the Secretary of Defense

OBJECTIVE: The objective was to advance understanding of French and European security policy developments, especially regarding the strategic implications of the Military-Technical Revolution.

SUMMARY: A Military-Technical Revolution takes place when new technologies are combined with innovative operational concepts and organizational adaptations that fundamentally change the character and conduct of military operations. The key new technologies at the current juncture include information systems to gather, process, and disseminate data; extended-range, advanced conventional munitions; and simulations techniques to prepare and train forces and to develop new types of capabilities and operational concepts. Research regarding French views on this subject was performed in conjunction with the principal investigator's participation in the 1993-1994 session of the French Defense Ministry's Centre des Hautes Études de l'Armement in Paris.

PUBLICATIONS:

Yost, D.S., "La France, les États-Unis et la révolution militaro-technique," L'Armement, No. 42, pp. 135-141, May/June 1994. (L'Armement is a journal published by the Délégation Générale pour l'Armement, part of the French Ministry of Defense).

Yost, D.S., "Nuclear Debates in France," Survival, Vol. 36, pp. 113-139, Winter 1994-1995. (Survival is the quarterly journal of the International Institute for Strategic Studies, London).

CONFERENCE PRESENTATIONS:

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Yost, D.S., "Les nouvelles politiques américaines en matière d'armement nucléaire," (in French), for the U.S. Embassy, Paris, at the request of the U.S. Information Service, 27 January 1994.

Yost, D.S., "France, the Gulf War, and the Military-Technical Revolution," for the John M. Olin Institute for Strategic Studies, Center for International Affairs, Harvard University, Cambridge, MA, 16 February 1994.

Yost, D.S., "France, the Gulf War, and the Military-Technical Revolution," for the Research Program in International Security, Princeton University, Princeton, NJ, 17 February 1994.

Yost, D.S., "Les révolutions militaro-techniques vues des États-Unis," (in French) for the lecture series "les Conférences du Mercredi," sponsored by the Centre des Hautes Études de l'Armement, École Militaire, Paris, 2 March 1994.

Yost, D.S., "Les interprétations américaines de la pensée russe au sujet de l'avenir de la guerre," (in French), Délégation aux Affaires Stratégiques, Ministry of Defense, Paris, 7 June 1994.

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Yost, D.S., "The American Military Presence in Europe: Status and Perspectives," at the conference on

"Transatlantic Relations and International Security," sponsored by the United Nations Institute for Disarmament Research, in Caen, France, 22-23 September 1994.

DOD KEY TECHNOLOGY AREA: Other (Information Systems)(Nuclear Weapons)(Weapons)

KEYWORDS: NATO, Europe, Strategy, Nuclear Deterrence, Military-Technical Revolution, France

EUROPE IN THE NEW POLITICAL-MILITARY ENVIRONMENT

D.S. Yost, Professor
Department of National Security Affairs
Sponsor: Naval Security Group Support Activity

OBJECTIVE: The objective was to advance understanding of West European, and notably French, assessments of the new international political-military environment.

SUMMARY: The research effort emphasized the analysis of primary sources regarding international security issues, including West European views on topics such as the military-technical revolution and possible Western responses to potential crises in Eastern Europe and the former Soviet Union. Special attention was devoted to France, Britain, and Germany, especially with respect to military-technical innovation, nuclear deterrence, the proliferation of weapons of mass destruction, and technology transfer controls. The research was performed in conjunction with the principal investigator's participation in the 1993-1994 session of the French Defense Ministry's Centre des Hautes Études de l'Armement in Paris.

PUBLICATIONS:

Yost, D.S., "France," The Defense Policies of Nations: A Comparative Study, third edition, D.J. Murray and P.R. Viotti, eds., Baltimore and London: The Johns Hopkins University Press, pp. 233-277, 1994.

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Yost, D.S., "European Views on a Comprehensive Test Ban and the Future Role of Nuclear Weapons," at the conference on "The Future Role of U.S. Nuclear Weapons," Massachusetts Institute of Technology, Cambridge, MA, 3-4 February 1994.

Yost, D.S., "Current Trends regarding Nuclear Weapons in France," at the School of Advanced International Studies, Johns Hopkins University, Washington, DC, 15 February 1994.

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Yost, D.S., "La redéfinition des missions de l'OTAN," (in French) for the conference on "L'Alliance Atlantique

et la Sécurité en Europe," sponsored by the Fondation Singer Polignac, Paris, 24 May 1994.

DOD KEY TECHNOLOGY AREA: Other (Nuclear Weapon)

KEYWORDS: Military-Technical Revolution, Proliferation, Europe, France, Technology Transfers, Nuclear Deterrence

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1994
Faculty Publications
and Presentations

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Breemer, J.S., "Out of the Blue: The U.S. Submarine Fleet After the Cold War," Maritime Patrol Aviation, Vol. 3, No. 1, pp. 64-67, September 1994.

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Breemer, J.S., "The End of Naval Strategy: Revolutionary Change and the Future of American Naval Power," Proceedings of the Conference on Maritime Security and Conflict Resolution at Sea in the Post Cold War Era, P. Haydon and A.L. Griffiths, eds., pp. 135-142, Dalhousie University, Halifax, N.S., Canada, 1994.

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CONFERENCE PRESENTATIONS

Arquilla, J., "Information, Deterrence, and National Power," Keynote speech presented at the Worldwide Psychological Operations Conference, September 1994.

Breemer, J.S., "Technological Change an the New Calculus of War: The United States Builds a New Navy," Social Science Research Council-MacArthur Foundation conference on The Politics of Strategic Adjustment: Ideas, Institutions, and Interests, The University of Texas, Austin, TX, 23-24 April 1994.

Breemer, J.S., "Out of the Blue: The U.S. Submarine Fleet After the Cold War," presented at the conference on "Sea Power for the Next Decade," London, U.K., 6 May 1994.

Breemer, J.S., "Home From the Sea: Have We Entered a New Era of Maritime Strategic Thinking?" presented at the 1994 Colloquium on Maritime Forces in Global Security," Dalhousie University, Halifax, N.S., Canada, 24 June 1994.

Breemer, J.S. "The Navy Gets the Gravy and the Army Gets the Helicopters," presented at the Financial Post conference, "The Canadian Defence Industry: Surviving Changing Priorities," Ottawa, Canada, 1 November 1994.

Bruneau, T.C., "The Political and Social Conditions for Successful Macro-Economic Adjustment," panel discussant/presentation, Conference on Latin America: What Kind of Markets? What King of Democracy?, McGill University/Universite de Montreal, 7-8 April 1994.

Bruneau, T.C., presentation in Portuguese on the political process leading to democracy in Portugal on panel "O Processo Revolucionario, a Democratizacao e a Sua Dialectica," Conference on 25 De Abril: 20 Anos, Coloquio

International, Instituto de Historia Contemporanea, Lisbon, 18-20 April 1994.

Bruneau, T.C., presentation and seminar leader on panels at workshop, Security and Defence Issues in Southwest Europe, CINCIBERLANT, Lisbon, 4-6 December 1994.

Looney, R., "Economic Motivations for East Asian Defense Expenditures," Western Economic Association International Pacific Rim Conference Hong Kong, 8-13 January 1994.

Looney, R., "Regional Differences in Manufacturing Efficiency: A Comparison of Public and Private Firms in Pakistan," Western Economic Association Meetings, Vancouver, B.C., 29 June - 3 July 1994.

Lavoy, P.R., "Forecasting the Future of Nuclear Proliferation: The Case of South Asia," The Nuclear Nonproliferation Regime: Post-Cold War Perspectives, presented at Marquette University, May 1994.

Lavoy, P.R., "Nuclear Symbolism: Prestige and Legitimacy in Pakistan's Nuclear Weapons Program," presented at the International Studies Association Annual Meeting, Washington, D.C., March 1994.

Moran, D., "The Fortress Peace: Germany in the Great War," Annual Meeting of the Great War Society, Chicago, IL, September 1994.

Moran, D., "Thinking About War: The Usefulness of War in Western History," Institute for Advanced Study Seminar on Force in History, June 1994.

Robinson, G.E., "The Islamicist Movements in Jordan and Palestine," United Stats Institute of Peace, Washington, DC, 14 December 1994.

Robinson, G.E., "Dilemmas of States: Islamicism, Liberalization and the Arab-Israeli 'End-Game'," Middle East Studies Association Annual Conference, Phoenix, AZ, November 1994.

Robinson, G.E., "Domestic Arab Politics in the Context of an Arab-Israeli Settlement," al-Urdunn al-Jadid Research Center, Amman, Jordan, 12 April 1994.

Robinson, G.E., "Democratization and the Arab-Israeli 'End-Game'," Center for Strategic Studies, University of Jordan, Amman, 4 April 1994.

Stockton, P.N., "When the Bear Leaves the Woods," presented at the U.S. Foreign Policy after the Cold War, the Mershon Center, Ohio State University, Columbus, OH, 20-21 May 1994.

Tollefson, S.D., "Brazil's National Security Policy," presented at the First Conference of the Brazilian Studies Association (BRASA), Atlanta, GA, 10 March 1994.

Wirtz, J.J., participant of presentation of "Arms Control Toward the 21st Century: A Primer," Preparation Symposium, Institute for National Security Studies, USAF Academy, Colorado Springs, CO, 2 December 1994.

Wirtz, J.J., "Counterproliferation and Deterrence," USAF Institute for National Security Studies, Annual Research Conference, USAF Academy, Colorado Springs, CO, 9-10 November 1994.

Wirtz, J.J., "Multilateral Deterrence," Conference on Deterrence in the Post-Cold War Era, Airlie House, VA, 26-28 September 1994.

Yost, D.S., "Nuclear Weapons Issues in France," Monterey Proliferation Seminar, (co-sponsored by the Naval Postgraduate School and the Monterey Institute of International Studies), Monterey, CA, 8 December 1994.

Yost, D.S., "Les révolutions militaro-techniques vues des États-Unis," (in French), for the Centre des Hautes Études de l'Armement, École Militaire, Paris, 25 January 1994; for the lecture series "les Conférences du Mercredi," sponsored by the Centre des Hautes Études de l'Armement, École Militaire, Paris, 2 March 1994.

Yost, D.S., "Les nouvelles politiques américaines en matière d'armement nucléaire," (in French), for the Mission Académique de Formation des Personnels de l'Éducation Nationale, Paris, 21 January 1994; for the U.S. Embassy, Paris, at the request of the U.S. Information Service, 27 January 1994.

Yost, D.S., "France, the Gulf War, and the Military-Technical Revolution," for the John M. Olin Institute for Strategic Studies, Center for International Affairs, Harvard University, Cambridge, MA, 16 February 1994; for the Research Program in International Security, Princeton University, Princeton, NJ, 17 February 1994.

Yost, D.S., "Les interprétations américaines de la pensée russe au sujet de l'avenir de la guerre," (in French), Délégation aux Affaires Stratégiques, Ministry of Defense, Paris, 7 June 1994.

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Yost, D.S., "The American Military Presence in Europe: Status and Perspectives," at the conference on "Transatlantic Relations and International Security," sponsored by the United Nations Institute for Disarmament Research, in Caen, France, 22-23 September 1994.

Yost, D.S., "European Views on a Comprehensive Test Ban and the Future Role of Nuclear Weapons," at the conference on "The Future Role of U.S. Nuclear Weapons," Massachusetts Institute of Technology, Cambridge, MA, 3-4 February 1994.

Yost, D.S., "Current Trends regarding Nuclear Weapons in France," at the School of Advanced International Studies, Johns Hopkins University, Washington, DC, 15 February 1994.

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Department of Oceanography

The Oceanography Department has developed a broad research program focused on physical oceanography to meet the anticipated future needs of the Navy. Our priority 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 and temporal domains. The areas of emphasis include coastal and nearshore ocean dynamics, air-sea interaction phenomena and boundary currents. Regions of interest include the marginal sea ice zone, coastal ocean regions and strategic straits of the world.

Our priority 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 coastal ocean response storms on acoustic propagations and ambient noise and the impact that nearshore processes exert on the wave climate and beach character as pertains to mine/mine countermeasure and amphibious warfare

These research themes require the development of numerical ocean prediction and synoptic oceanography capabilities. They are achieved through employment of modern dynamical and mathematical principles, numerical and statistical methods, computational and graphical facilities, and in-situ and remote sensing observation.

The diverse talents of the faculty of the department are blended by the use of these various techniques to solve problems of common interest. Our students are actively involved in these research programs and participate in research cruises, conference presentations and as co-authors of research reports and papers. Much of our research results, both theoretical and applied, are incorporated into the curricula we support. A summarization of particular research areas follows below.

Coastal and Nearshore Oceanography

Professors C.A. Collins, N. Garfield and **Professor Carter** are making regular RAFOS float measurements of the California Undercurrent. The sponsor for these studies is ONR. **Professors S.R. Ramp, Collins, Garfield** and **L. Rosenfeld** continued analysis of hydrographic and current meter data in the region to the west of the Farallons. These studies were sponsored by the EPA and the Western Division, Naval Engineering Facilities Command. **Professor S.R. Ramp** and **C.A. Collins** continued time series measurements of the current and water mass properties over the continental slope off Pt. Sur to study the long-term seasonal and interannual variability of the flow. **Prof. Ramp** is also investigating the mesoscale variability of weakly nonlinear systems, a five year ONR accelerated research initiative, to study the energy exchanges occurring in eastern boundary currents.

Under sponsorship of ONR, **Professor M.L. Batteen** is using an eddy-resolving, primitive equation coastal model to study the generation, stability, and maintenance of currents and eddies in the California Current System.

Professor J.D. Paduan, with funding from ONR, is using satellite-tracked surface drifters to map the large-scale horizontal surface convergence and eddy statistics in the northeast Atlantic Ocean. He is conducting intensive, single-eddy surveys of two features in the California Current System. With support from NPS and ONR, he is undertaking studies of coastal circulation problems in Monterey Bay using HF radar-derived currents as well as drifting buoys, including newly-developed GPS drifters. Of particular interest are the coastal phenomena of sea breeze-driven currents and topography-generated internal tidal currents.

Professors T.P. Stanton and **E.B. Thornton** are involved in a program to develop a 3-component velocity and sediment flux probe with high temporal and spatial resolution that will provide a unique capability to estimate suspended and bedload sediment fluxes.

Professors E.B. Thornton, T.P. Stanton and **T. Lippmann** are developing models to predict the wave-induced three dimensional velocity field and induced sediment transport over arbitrary bathymetry in the nearshore zone under funding from ONR. Under a separate ONR contract they are evaluating their wave and current surf zone models that have been transitioned to the fleet Tactical Environmental Support System.

Professor T.H.C. Herbers, is investigating the dynamics of ocean surface waves in shallow coastal waters using theory and field observations. Current research projects (funded by the Office of Naval Research) focus on nonlinear wave-wave interactions, shoaling of waves on beaches, the generation of surf beat, and the propagation of waves over a continental shelf.

Professor P.C. Chu, under the sponsorship of Naval Oceanographic Office is conducting a study on the coherence time and length scales that have been found from the complete hydrographic database for the Yellow Sea, which will improve the Navy's Optimum Thermal Interpolation System for the littoral zones.

Acoustical Oceanography

Professors R.H. Bourke, C-S. Chiu and **J.H. Miller** continued their analysis of the data collected during the combined hydrographic-acoustic tomographic experiment in the Barents Sea. Current meter, ADCP, and CTD observations all indicate the importance of tidal forcing in modulating the Barents Sea Polar Front. Tomographic cross-sections of sound speed show boluses of warm water migrating upslope at two hour intervals. ONR is the sponsor of this work.

Professors R.H. Bourke and J.H. Wilson are analyzing bottom backscattering data from shallow water areas with a goal of developing a bottom reverberation algorithm for the AN/SQS-53C sonar when operating in shallow coastal waters. The Sponsor is NAVSEA.

Professors R.H. Bourke and J.H. Wilson analyzed the ambient noise record from three ice-mounted buoys drifting in the Arctic Ocean north of Franz Josef Land. They are particularly interested in the effect of storms generating high noise levels. The sponsor is the Naval Oceanographic Office and the Naval Undersea Warfare Center.

Professors R.H. Bourke and J.H. Wilson are developing a predictive ambient noise model for submarines operating in the Arctic Ocean which will forecast periods of extremely loud (>95th percentile level) and quiet (<5th percentile) noise levels. The sponsor is NPS and the Naval Undersea Warfare Center.

Professors C-S. Chiu and **L.N. Le** are developing and assessing a method to assimilate acoustic tomography data into coastal ocean models for nowcasting purposes. The research is sponsored by ONR.

Professors C-S. Chiu, J.H. Miller, and **A.J. Semtner** are conducting simulation studies of the variability of long-range, low-frequency sound transmission using the output from the Semtner-Chervin global eddy-resolving ocean model. This research, designed to detect signs of global warming, is sponsored by UCSD/ATOC.

Professors J.H. Miller and **C-S. Chiu** are investigating time-domain acoustic signal processing and propagation modeling techniques for the localization of sources of acoustic transient signals. This research is sponsored by NUWC.

Air-Sea Interaction and Ocean Turbulence

Professor T.P. Stanton, participated in the first open ocean iron enrichment experiment under ONR sponsorship by designing a Lagrangian reference frame for the experiment and defining mixed layer processes which

contribute to the dispersion of surface injected tracers. Under NSF sponsorship he participated in the Antarctic ANZFLUX program by deploying three instrument systems which measured anomalously high winter heat fluxes across the ocean mixed layer in the Weddell Sea.

Professor R.W. Garwood, Jr. is sponsored by ONR and NPS to investigate Mediterranean Sea and Labrador Sea deep convection. Submarine observations of polar and sub-polar oceanic convection are compared with computer-simulated convection.

Professor Garwood has received an NSF grant to study the role of turbulent mixing in the Arctic system of ocean-ice-atmosphere interactions. Two forms of conditional instability for deep mixing have been discovered that may explain deep water formation in the polar seas and its impact on the global conveyor belt of deep thermohaline circulation.

Ms. Arlene Guest and Professor Garwood have received a three-year grant from NSF for the project "Equatorial Mixed Layer System". This new project is part of the TOGA Coupled Ocean Atmosphere Response Experiment (COARE), to explain large-scale feedback between the ocean and atmosphere in the Western Pacific.

Numerical Prediction and Data Assimilation

Professor A.J. Semtner, Jr., under National Science Foundation sponsorship, has developed a global eddy-resolving ocean model with 1/4 degree grid size. Comparisons with in-situ and satellite observations show the simulation to be very realistic, hence the model provides a means of improving physical understanding of the ocean and enabling climate change prediction. In another project funded by the Department of Energy, developmental studies are underway to incorporate all the relevant physical processes important to climate predictability and change in his global eddy-resolving ocean models.

Under sponsorship of NSF, **Professor Batteen** is carrying out eddy-resolving, modeling studies of the Leuuwin Current in the coastal region off Western and Southern Australia. Process-oriented studies are being used to explore the roles of thermal and wind forcing, coastline irregularities, and topography in the generation, stability, and maintenance of the currents and eddies in this anomalous eastern boundary current region.

Professor E. Carter continued studies on data assimilation into numerical ocean models with the goal of improving mesoscale ocean forecasts. The sponsors for this work are NPS and ONR.

Under the sponsorship of ONR, **Prof. P.C. Chu** is developing a three dimensional diagnostic/prognostic system for the South China Sea. He found the major effect of monsoon forcing and Kuroshio intrusion on the South China Sea shelf circulation and the upper layer thermal structure. This research is contributing to a recently initiated International South China Sea Monsoon Experiment. He is also sponsored by NPS and ONR to develop a new diagnostic system (P-vector method) for computing 3-D ocean circulation from hydrographic data.

Marine Operations

Mr. P. Jessen, Mr. B. Miller and **Professor R.H. Bourke** managed shipboard support for NPS at-sea research projects off the central California coast. Fifty-one days of operations were carried out on the R/V Pt. Sur. Students and faculty participating in these shipboard projects included the Departments of Oceanography, Meteorology and Physics. The sponsor for this project is the Commander, Naval Oceanography Command. NPS acquired the Point Sur SOSUS array and it is being used in a variety of research projects.

Professor J.R. Clynch, with funding from NISE-West, conducted studies to improve the aircraft landing system in Antarctica using GPS and also evaluated the merging of GPS data with the TACAN system. Dr. Clynch is

also investigating how the Defense Mapping Agency can make use of available DoD GPS receivers in their applications.

EDDY-RESOLVING MODELING STUDIES OF THE LEEUWIN CURRENT

M.L. Batteen, Associate Professor
Department of Oceanography
Sponsor: National Science Foundation

OBJECTIVE: The overall goals of this research are to carry out process-oriented modeling studies to investigate the generation and stability of currents and eddies in the anomalous Leeuwin Current region, and to better describe the contributing forcing mechanisms, and their relative importance. To carry out these goals, we proposed to extend our eddy-resolving, process-oriented modeling studies by adding the following features to the model: (1) wind forcing, (2) extension of the model domain to include the Southern Australia coastal region, and (3) bottom topography. This work is part of a continuing project which began in 1992 and ends in 1995.

SUMMARY: We have added idealized wind forcing, representative of the period of maximum Leeuwin Current flow (austral autumn/austral winter), and have extended the model domain (which was a closed eastern boundary with open borders to the north, west, and south) to include the Southern Australia region. Both an idealized and an irregular coastline were also incorporated into the model.

The results demonstrate the respective roles that thermal forcing, wind forcing, and coastline geometry play in the Leeuwin Current System. The results show that: 1) Although thermal forcing is the dominant forcing mechanism in the Leeuwin Current System and gives rise to the Leeuwin Current and undercurrent, the winds along the irregular coastline act to increase the current baroclinicity via upwelling along the west coast, and produce an intensified current along with a strong temperature front along the south coast. The winds oppose the thermal forcing along the west coast, which effectively decreases the magnitude of the poleward current (and undercurrent). Near Cape Leeuwin, easterly winds enhance the current flow around the cape, 2) The North West Shelf (NWS) water dominates the source region which effectively eliminates regional upwelling. The NWS water contributes to warmer waters advected into the Great Australian Bight and regenerates coastal mesoscale features near the source region. With time the wind forcing effects increase and act to recede the NWS water back towards the source region, 3) Instability mechanisms show that baroclinic (barotropic) instability processes dominate along the west (south) coast, and 4) Eddies propagating westward result in a division of the onshore geostrophic flow. An offshore poleward and a narrow inshore poleward flow reunite at Cape Leeuwin further increasing regional horizontal and vertical shears, which lead to a semi-permanent feature in the vicinity of Cape Leeuwin.

The results are consistent with available observations of the Leeuwin Current from satellite, current meter, and drifting buoy data.

PUBLICATIONS:

Batteen, M.L., McClean, J.L., and Bayler, E.J., "Modeling simulations and comparisons of the California and Leeuwin Current circulations," Transactions of the American Geophysical Union,Vol. 75, p. 133, 1994.

McClean, J.L., Batteen, M.L., and Cook, M., "Visualization of modeling simulations and comparisons of the California and Leeuwin Current circulations," Transactions of the American Geophysical Union, Vol. 75, p. 148, 1994.

Batteen, M.L., Braccio, P.G., and Butler, C.L., "Visualization of the Leeuwin Current from a regional, fine resolution, primitive equation model," Transactions of the American Geophysical Union, Vol. 75, p. 367, 1994.

Butler, C.L. and Batteen, M.L., "Modeling studies of the Leeuwin Current off Western and Southern Australia," Naval Postgraduate School Technical Report, NPS-OC-94-009, 146 pp., 1994.

CONFERENCE PRESENTATIONS:

Batteen, M.L., McClean, J.L., and Bayler, E.J., "Modeling simulations and comparisons of the California and Leeuwin Current circulations," presented at the Ocean Sciences Meeting, San Diego, CA, February 1994.

McClean, J.L., Batteen, M.L., and Cook, M., "Visualization of modeling simulations and comparisons of the California and Leeuwin Current circulations," presented at the Ocean Sciences Meeting, San Diego, CA, February 1994.

Batteen, M.L., Braccio, P.G., and Butler, C.L., "Visualization of the Leeuwin Current from a regional, fine resolution, primitive equation model," presented at the Fall American Geophysical Union Meeting, San Francisco, CA, December 1994.

THESES DIRECTED:

Butler, C.L., LCDR, USN, "Modeling studies of the Leeuwin Current off Western and Southern Australia," Master's Thesis, December 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Coastal Oceanography, Ocean Modeling, Ocean Circulation

COASTAL OCEAN MODELING STUDIES IN THE CCS

M.L. Batteen, Associate Professor
Department of Oceanography
Sponsor: Naval Postgraduate School

OBJECTIVE: The scientific goal of this research is to use a high-resolution, multi-level, primitive equation, regional ocean model to systematically investigate current and eddy structures in the California Current System (CCS). The studies should provide improved physical understanding of the CCS.

SUMMARY: A high-resolution, primitive equation model has been used to isolate the response of the CCS to temporally and spatially varying wind forcing. To study the generation, evolution, and maintenance of features in the CSC, the model was forced with climatological average and yearly winds. For all model runs, a poleward coastal surface current near the start and end of each year, an equatorward surface current, a poleward undercurrent, upwelling, filaments, meanders, and eddies were simulated. Longer simulation times showed that the meanders and eddies can be quasi-permanent features of the CCS. A mixed (baroclinic/barotropic) instability process is shown to be responsible for the generation of the meanders and eddies. The results from these experiments support the hypothesis that temporally and spatially varying wind forcing is an important mechanism for the generation of many of the observed features of the CCS.

PUBLICATIONS:

Batteen, M.L., Collins, C.A., Bacon, J.L., and Nelson, C.S., "The effect of salinity on density in the California Current System," Journal of Geophysical Research, in press.

Batteen, M.L., Hu, C.-P., Bacon, J.L., and Nelson, C.S., "A numerical study of the effects of wind forcing on the Chile Current System," Journal of Oceanography, in press.

Haines, R.T. and Batteen, M.L., "A numerical study of interannual wind forcing effects on the California Current System, 1980-1983," Naval Postgraduate School Technical Report, NPS-OC-94-003, 124 pp., 1994.

Vann, J.R. and Batteen, M.L., "A numerical study of wind forcing effects on the California Current System, Naval Postgraduate School Technical Report, NPS-OC-94-006, 212 pp., 1994.

Hu, C.-P. and Batteen, M.L., "A numerical study of the effects of wind forcing on the Chile Current System, Naval Postgraduate School Technical Report, NPS-OC-94-007, 37 pp., 1994.

Batteen, M.L., "Process-oriented modeling studies of wind forcing effects on the California Current System," Research Activities in Atmospheric and Oceanic Modeling, A. Staniforth, ed., CAS/JSC Working Group on Numerical Experimentation, in press.

CONFERENCE PUBLICATIONS:

Batteen, M.L., McClean, J.L., and Bayler, E.J., "Modeling simulations and comparisons of the California and Leeuwin Current circulations," presented at the Ocean Sciences Meeting, San Diego, CA, February 1994.

McClean, J.L., Batteen, M.L., and Cook, M., "Visualization of modeling simulations and comparisons of the California and Leeuwin Current circulations," presented at the Ocean Sciences Meeting, San Diego, CA, February 1994.

THESES DIRECTED:

Haines, R.T., LT, USCG, "A numerical study of interannual wind forcing effects on the California Current System," Master's Thesis, September 1994.

Hu, C.-P., LCDR, Taiwan Navy, "A numerical study of wind forcing effects on the Chile Current System," Master's Thesis, December 1994.

Vann, J.R., LT, USN, "A numerical study of wind forcing effects on the California Current System," Master's Thesis, September 1994.

OTHER:

Batteen, M.L., "Wind-forced modeling studies of currents, meanders, and eddies in the California Current System," submitted to Journal of Geophysical Research-Oceans.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Coastal Oceanography, Ocean Modeling, Ocean Circulation

DEVELOPMENT OF AN ARCTIC LOW FREQUENCY AMBIENT NOISE MODEL

R.H. Bourke, Professor and Chairman
Department of Oceanography
J.H. Wilson, ONR Arctic Marine Science Chair
Sponsor: Naval Postgraduate School and
Naval Undersea Warfare Center, (Code 01Y) New London, CT

OBJECTIVE: The goal of this project is to develop a low frequency Arctic ambient noise model to predict extremely high and low noise conditions. Arctic ambient noise can vary by 20dB to over 30dB in short time (hours) intervals and currently U.S. submarines operating in the Arctic Ocean have no reliable way to anticipate the occurrence of extremely low or high noise periods. Obviously, the two extremes in noise levels result in significantly different tactical employment of submarine sonar systems.

SUMMARY: Two significant data analysis efforts have been completed that have greatly helped the Arctic noise model development effort. First, analysis of three Naval Oceanographic Office data buoy records, each of one to two years in length, resulted in several important conclusions (Feller, 1994). Specifically, the data exhibited much greater noise levels statistically than the 20 plus years of buoy data from the central Arctic. The long term track of these three buoys started north of Svalbard in the Nansen Basin and drifted south toward the shallow water of the Barents Sea. Based on previous noise analyses near the Greenland Sea, Prof. Bourke had postulated that Arctic ambient noise is increased greatly when the ice is compressed as it moves shoreward. This first analysis of the Nansen Sea noise data supports this important component of ambient noise modeling in the Arctic.

The second data analysis performed this year was a characterization of past major storm events in the deep water central Arctic basin (Fritsch, 1995). This study showed that the contribution from the entire spatial extent of the storm dominated the total ambient noise level measured at low frequency and that the contribution from the local ice surface immediately above the measurement site could not account for the measured low frequency noise level. This analysis also showed that rapid changes in ice speed direction (i.e., large rotation or torquing of the ice field over short time periods), as well as the magnitude of ice speed, contributes significantly to the measured noise level.

Based on these data analyses an Arctic source level spectral density was derived that depends initially on three parameters: ice speed; changes in ice velocity direction; and nearness to land/ice speed toward land. The directional ambient noise estimation (ANDES) model was obtained and analyzed for its possible use to implement the Arctic noise model. ANDES was found to be satisfactory and software is now being developed to implement an Arctic noise model.

THESIS DIRECTED:

Feller, D., LT, USN, "Environmental Forcing of Ambient Noise in the Nansen and Amundsen Basins of the Arctic Ocean," Master's Thesis, September 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Arctic Ocean, Ambient Noise, Storms, Sea Ice

IMPACT OF BOTTOM REVERBERATION ON AN/SQS-53C PERFORMANCE IN SHALLOW WATER

R.H. Bourke, Professor and Chairman
Department of Oceanography
J.H. Wilson, ONR Arctic Marine Science Chair
Sponsor: Commander, Surface Ship ASW Combat System Program
PM0411 Program Executive Office (USW), Department of the Navy

OBJECTIVE: The objective of this effort is to assess the impact of bottom reverberation on AN/SQS-53C active sonar system performance in shallow water. Measured reverberation data collected on this sonar system will be compared to model estimates from a state-of-the-art reverberation model developed for the kiloHertz frequency range.

SUMMARY: Reverberation beam data collected on the AN/SQS-53C sonar system during a recent shallow water exercise south of Long Island is currently being analyzed. Reverberation time series show over 20dB of short term (seconds) variation in reverberation level (RL) and a decreasing level for approximately 20 to 25 seconds. After that the RL remains nearly constant and is assumed to be ambient noise limited at that time. 24 beams of data are available with two types of waveforms each. We have analyzed one run which had a downward refracting sound speed profile and a beam depression angle of -3°. Under these conditions bottom reverberation is expected to be dominant. Two characteristics of the RL data are being investigated by LT Scanlon for his Master's thesis. First, the 20 to 25 seconds of reverberation dominance indicates that many bottom multipaths are contributing to the RL time series. Second, there are no obvious peaks in RL at the time expected for the first bottom bounce 2-way travel time in any of the beam data. This indicates that other scattering mechanisms, other than standard rough bottom interface scattering laws (Lambert, McKenzie, etc.), may be important. Of particular interest is the sub-bottom volume scattering mechanism recently proposed by APL/University of Washington. Also, high angle bottom scattering entering the beam side lobes may be contributing significantly to the RL at earlier times.

To help interpret the RL data a state-of-the-art comprehensive acoustic (kHz frequency) model was obtained from the Naval Undersea Warfare Center (NUWC) New London, CT. with permission of Mr. Ed Chaika of the Advanced Environmental Acoustic Support (AEAS) Program of ONR. The model is currently running at NPS and being used to prepare model estimates of RL time series to compare to the RL data. A detailed geoacoustic model of the exercise area is currently being prepared.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Reverberation, Active Acoustics, Shallow Water, AN/SQS-53C

CHAIR IN ARCTIC MARINE SCIENCE

R.H. Bourke, Professor and Chairman
Department of Oceanography
Sponsor: Office of Naval Research and Naval Postgraduate School

OBJECTIVE: To foster oceanographic research in the Arctic, acquaint naval officer students with Arctic problems, reduce results of pure research to operational usage and publicize Navy interest in the Arctic.

SUMMARY: Professor Bourke served as administrator of the Chair handling such details as selecting Chair candidates, writing IPA's and proposals and setting up visits and seminars for the Chair incumbent. Dr. James H. Wilson, a private consultant, was the Chair incumbent during 1994. He had a particularly busy year at NPS being heavily involved in teaching and research. In addition to lecturing in the polar oceanography course, he taught an ocean acoustics course which he modified to increase the subject matter related to shallow water acoustics. He was the thesis advisor for seven students and significantly assisted the research endeavors of two others. In response to the changing Arctic warfare threat, he conducted an extensive review of the state of knowledge of Arctic shallow water acoustic propagation and ambient noise capability based upon observations and modeling. He also wrote five scholarly publications, each now in the final stages of the review process. He attended several other major conference, presenting papers at each.

CONFERENCE PRESENTATIONS:

Bourke, R.H., Wilson, J.H, and Dien, J. "Wilson Dispersion Phenomena (WDP) in Shallow Water," Navy Symposium on Underwater Acoustics (NSUA) Conference in Washington, D.C., 30 June 1994.

Stewart et al., "Shallow Water Ambient Noise Caused by Breaking Waves in the Surf Zone," Acoustical Society of America Meeting at Austin, TX, 28 November 1994.

THESES DIRECTED:

Davies, J.H., LCDR, British Navy, "An Investigation of Frequency Dispersion in the Shallow Water Waveguide," Master's Thesis, December 1994.

Dien, J., LT, USN, "Wilson Dispersion Phenomena (WDP) in Shallow Water as an Active Classification Technique (S)," Master's Thesis, March 1994.

Duarte, S.P., LT, USN, "A Comparative Study of Acoustic Models in a Range-Independent Shallow Water Environment," Master's Thesis, December 1994.

Feller, D., LT, USN, "Environmental Forcing of Ambient Noise in the Nansen and Amundsen Basins of the Arctic Ocean," Master's Thesis, September 1994.

Stewart, M.S., CDR, USN, "Shallow Water Ambient Noise Caused by Breaking Waves," Master's Thesis, December 1994.

Veenhuis, R.S., LCDR, USN, "Matched Field Processing in Shallow Water Using a Small Aperture Towed Array," Master's Thesis, December 1994.

OTHER:

Fritsch, F.C., LT, USN, "Synoptic Atmospheric Forcing of Arctic Underice Ambient Noise," Master's Thesis, completion March 1995.

Null, J.M., LT, USN, "An Inverse Method to Estimate Geoacoustic Properties of the Bottom in Shallow Water," Master's Thesis, in progress.

Scanlon, G.S., LT, USN, "Impact of Bottom Reverberation on AN/SQS-53C Sonar Performance," Master's Thesis, in progress.

Wilson, J.H. and Buck, B.M., "Buck/Wilson Arctic Transmission Loss Model," resubmitted to Journal of the Acoustical Society of America addressing reviewer's comments of November 1994.

Stewart, M.S., Wilson, O.B., Bourke, R.H., and Wilson, J.H., "Shallow Water Ambient Noise Caused by Breaking Waves in the Surf Zone," submitted to Journal of the Acoustical Society of America.

Wilson, J.H., "Theoretical Applications of Inverse Beamforming," submitted to Journal of the Acoustical Society of America, October 1994.

Wilson, J.H. and Fabre, J.P., "Minimum Detectable Level (MDL) Evaluation of Inverse Beamforming (IBF) using Outpost SUNRISE Data," submitted to Journal of the Acoustical Society of America, October 1994.

Wilson, J.H., Bourke, R.H., and Davies, J.H., "Applications of Frequency Dispersion in Shallow Water for Active Classification of Reflectors from the Water Column and Bottom/Sub-bottoms," in final preparation for submission to Journal of the Acoustical Society of America.

Wilson, J.H. and Veenhuis, R.S., "Matched Field Processing in Shallow Water Using a Small Aperture Towed Array," in final preparation for submission to Journal of the Acoustical Society of America.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Underwater Acoustics, Shallow-water Acoustics, Ambient Noise

GLOBAL ACOUSTIC PATH VARIABILITY STUDY

C.-S. Chiu, Associate Professor
A.J. Semtner, Professor
Department of Oceanography
J.H. Miller, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: UCSD - ATOC Project Office

OBJECTIVE: The objective of this project is to quantify the inherent variability of the cross-basin acoustic transmissions as planned by the Acoustic Thermometry of Ocean Climate (ATOC) Project using numerical models.

SUMMARY: Specifically, the modeling work simulates the influence of ocean fronts, eddies and seasonal cycles on cross-basin acoustic transmissions using the Semtner-Chervin Eddy-Resolving Global General Circulation Model (SCGCM) and the Hamiltonian Acoustic Raytracing Program for the Ocean (HARPO). Acoustic ray paths and signal arrival structures from a planned source site to a planned receiver site were calculated at a 3-day interval over a model year. The simulated time series were analyzed in terms of the stability of the geometry and arrival structure of the multipaths and the variability of the arrival times.

PUBLICATIONS:

Chiu, C.-S., Semtner, A.J., Ort, J.H., and Miller, J.H., "A ray variability analysis of sound transmission form Heard Island to California," Journal of the Acoustical Society of America, Vol. 96, No. 4, pp. 2380-2388, 1994.

Chiu, C.-S., "Downslope Modal Energy Conversion," Journal of the Acoustical Society of America, Vol. 95, No. 3, pp. 1654-1657, 1994.

Baggeroer A.B., Sperry, B., Lashkari, K., Chiu, C.-S., Miller, J.H., Mikhalevsky, P.N., and Von Der Heydt, K., "Vertical array receptions of the Heard Island Feasibility Transmissions," Journal of the Acoustical Society of America, Vol. 96, No. 4, pp. 2395-2413, 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Acoustics, Modeling, Climate, Variability

BARENTS SEA DATA ANALYSIS

C.-S. Chiu, Associate Professor
R.H. Bourke, Professor
Department of Oceanography
J.H. Miller, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Office of Naval Research

OBJECTIVE: In August 1992, an integrated acoustic-oceanographic experiment over the steep northwestern slope of the Bear Island Trough, about 100 km east of Bear Island was conducted. The overall goal of the field study was to characterize the dynamics of the Barents Sea Polar Front using acoustic tomography coupled with traditional physical oceanographic techniques. The analysis of the acoustic and hydrographic data was continued in FY94.

SUMMARY: In the acoustic data analysis, we concentrated on the (1) forward modeling of the modal arrival structure as observed by the vertical hydrophone array in the tomographic transmissions, (2) quantification of the mode energy coupling due to the frontal gradients, (3) development of a least-squares mode filtering technique, and (4) hybrid ray-mode inversion of the signal arrivals for the frontal thermal structure. In parallel to the acoustic work, the oceanographic analysis concentrated on the kinematical and dynamical interpretation of the integrated data set. This extensive data set included temperature-pod, CTD, current-meter, ADCP and transmissivity measurements. Also included were the tomographic maps of the frontal variability. The different

types of measurements were highly complimentary in that they observed the oscillations of the Barents Sea Polar Front at different space and time scales.

PUBLICATIONS:

Chiu, C-S., Miller, J.H., and Lynch, J.F., "Inverse Techniques for Coastal Acoustic Tomography," Environmental Acoustics, D. Lee and M. Schultz (eds.), World Scientific, pp. 917-931, 1994.

Miller, J.H., Chiu, C.-S., and Lynch, J.F., "Signal Processing for Coastal Acoustic Tomography," Environmental Acoustics, D. Lee and M. Schultz (eds.), World Scientific, pp. 899-916, 1994.

Chiu, C-S., Miller, J.H., Denner, W.W., and Lynch, J.F., "A Three-Dimensional, Broadband, Coupled Normal-Mode Sound Propagation Modeling Approach," Full Field Inversion Methods in Ocean and Seismic Acoustics, O. Diachok, A. Caiti, P. Gerstoft and H. Schmidt (eds.), Kluwer Academic Publishers, 1994 (accepted).

Chiu, C-S., Miller, J.H., Denner, W.W., and Lynch, J.F., "Forward Modeling of the Barents Sea Tomography Vertical Line Array Data and Inversion Highlights," Full Field Inversion Methods in Ocean and Seismic Acoustics, O. Diachok, A. Caiti, P. Gerstoft and H. Schmidt (eds.), Kluwer Academic Publishers, 1994 (accepted).

CONFERENCE PRESENTATIONS:

Chiu, C-S., Miller, J.H., Denner, W.W., and Lynch, J.F., "A Three-Dimensional, Broadband, Coupled Normal-Mode Sound Propagation Modeling Approach," NATO Conference, La Spezia, Italy, 1994. (Invited conference presentation.)

Chiu, C.-S., Miller, J.H., Denner, W.W., and Lynch, J.F., "Forward Modeling of the Barents Sea Tomography Vertical Line Array Data and Inversion Highlights," NATO Conference, La Spezia, Italy, 1994. (Invited conference presentation.)

Von Der Heydt, K., Kemp, J., Lynch, J.F., Chiu, C.-S., and Miller, J.H., "Real-time telemetry of acoustic array data for tomography and other applications," 127th Meeting of the Acoustical Society of America, Cambridge, MA, 6-10 June 1994. (Invited conference presentation.)

THESES DIRECTED:

Muggleworth, C.E., LT, "Shallow Water Reverberation and Measurement and Modeling," Master's Thesis, June 1994.

Franken, J., LCDR, "A Tactical Application of Coastal Acoustic Tomography," Master's Thesis, December 1994.

DOD KEY TECHNOLOGY AREA: Sensors, Environmental Effects

KEYWORDS: Frontal Dynamics, Shallow-water Acoustics, Tomography

OCEAN DIAGNOSTIC/PROGNOSTIC SYSTEM

P.C. Chu, Associate Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: Several weaknesses in the coastal models prevent them from operational use. Uncertainty in the initial conditions and unrealistic lateral boundary conditions are the major obstacles. The objective of this research project is to solve these problems by developing a diagnostic/prognostic system.

SUMMARY: In this project, we have developed a new diagnostic model (P-vector method) to compute three dimensional ocean circulation from hydrographic data sets. This model has a great potential for the regional sea modeling.

PUBLICATIONS:

Chu, P.C., "P-vector method for determining North Atlantic Ocean circulations from hydrographic data," Journal of Marine Technology Society, in press.

Chu, P.C., Li, C.C., Ko, D.S., and Mooers, C.N.K., "Response of the south China Sea to seasonal monsoon forcing," Air-Sea Interaction and Meteorology and Oceanography of the Coastal Zone, Vol. 2, pp. 214-215, 1994.

Chu, P.C., "Localized TOGA sea level spectra obtained from the S-transformation," TOGA Notes, Vol. 17, pp. 5-8, 1994.

Chu, P.C., "The South China Sea oceanography," The South China Sea Monsoon Experiment, Science Plan, pp. 31-35, 1994.

CONFERENCE PRESENTATIONS:

Chu, P.C., "Feedback between the South China Sea thermal fields and the Asian monsoon," International Workshop on South China Sea Monsoon Experiment, NASA Goddard Space Flight Center, 10-12 January 1994.

Chu, P.C., Li, C.C., Ko, D.S., and Mooers, C.N.K., "Response of the south China Sea to seasonal monsoon forcing," Second International Conference on Air-Sea Interaction and Meteorology and Oceanography of the Coastal Zone, Lisbon, Portugal, 22-27 September 1994.

Ko, D.S., Chu, P.C. and Mooers, C.N.K., "A South China Sea nowcast/forecast system," Western Pacific Geophysics Meeting, Hong Kong, 25-29 July 1994.

Chu, P.C., "P-vector method for diagnosing three dimensional Southwest Atlantic Ocean circulation," International Workshop on Southwest Atlantic Ocean Circulations, Sao Paolu, Brazil, 28-31 November 1994.

THESIS DIRECTED:

Li, C.-C., "A numerical simulation of seasonal circulation in the South China Sea," Master's Thesis, March 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Turbulence Closure, Ocean Circulation, Ocean Prediction

LITTORAL ZONE NAVAL OCEAN PREDICTION SYSTEM

P.C. Chu, Associate Professor
Department of Oceanography
Sponsor: Naval Oceanographic Office

OBJECTIVE: The goal of this multi-year project was to improve littoral zone naval ocean prediction systems in the southeast Asian regional seas by (1) studying the relationship between the sea surface temperature and subsurface thermal structure, (2) investigating the horizontal coherence length scales, and (3) implementing ocean circulation models.

SUMMARY: The complete database for the Yellow Sea temperature and salinity (approximate 50,000 profiles) has been installed and processed. All the necessary software for the research has been transferred from

NAVOCEANO to NPS as well as built up in NPS. A numerical model for the South China Sea has also been established.

PUBLICATIONS:

Chu, P.C., Fralick, C.R., Haeger, S.D., and Carron, M.J., "A feature model for Yellow Sea thermal structure," EOS Transactions American Geophysical Union, Vol. 75, No. 44, p. 395, 1994.

Chu, P.C., "A feature model for the Arctic upper ocean thermal structure," Polar Meteorology and Oceanography, Vol. 4, in press.

CONFERENCE PRESENTATION:

Chu, P.C., Fralick, C.R., Haeger, S.D., and Carron, M.J., "A feature model for Yellow Sea thermal structure," American Geophysical Union Fall Meeting, San Francisco, CA, 5-9 December 1994.

THESES DIRECTED:

Fralick, C.R., "Yellow Sea thermal structure," Master's Thesis, September 1994.

Wells, S.K., "Temporal and spatial decorrelation scales of the Yellow Sea thermal fields," Master's Thesis, September 1994.

OTHER:

Chu, P.C., Fralick, C.R., Haeger, S.D., and Carron, M.J., "Yellow Sea thermal structure, part 1: a feature model," Continental Shelf Research, (in revision).

Chu, P.C., Fralick, C.R., Haeger, S.D., and Carron, M.J., "Yellow Sea thermal structure, part 2: surface and subsurface correlations, " Continental Shelf Research, (in revision).

Chu, P.C., Wells, S.K., Haeger, S.D., Szczechowski, C., and Carron, M.J., "Yellow Sea thermal structure, part 3: temporal and spatial scales of thermal variability," Continental Shelf Research, (in revision).

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Feature Model, Decorrelation Scales, Auto Correlation

NAVAL OCEAN ANALYSIS AND PREDICTION

P.C. Chu, Associate Professor
Department of Oceanography
Sponsor: Naval Postgraduate School

OBJECTIVE: The goal of this project was to develop a new Ocean Analysis and Prediction System to meet the Navy's requirement of ocean prediction.

SUMMARY: A new system was developed for diagnosing three dimensional ocean circulation from the hydrographic data sets. This method was also used for obtaining realistic initial and lateral open boundary conditions for ocean numerical models.

PUBLICATIONS:

Chu, P.C., "P-vector method for determining absolute velocity from hydrographic data," Ocean Modeling, Vol. 114, pp. 23-26, 1994.

Collins, C.A. and Chu, P.C., "Oceanography," Encyclopedia of Applied Physics, in press.

Chu, P.C., "An integral method for determining North Atlantic circulation from hydrographic data," EOS Transactions, American Geophysical Union, Vol. 75, No. 3, p. 62, 1994.

Chu, P.C., "An observational study on the upper layer thermal structures of the Arctic Ocean," EOS Transactions, American Geophysical Union, Vol. 75, No. 16, p. 211, 1994.

CONFERENCE PRESENTATIONS:

Chu, P.C., "An integral method for determining North Atlantic circulation from hydrographic data," American Geophysical Union Ocean Science Meeting, San Diego, CA, 21-25 February 1994.

Chu, P.C., "An observational study on the upper layer thermal structures of the Arctic Ocean," American Geophysical Union Spring Meeting, Baltimore, MD, 23-27 May 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: P-vector, Diagnostic Model, Ocean Circulation

GPS ANTARCTIC LANDING SYSTEM: ACCURACY AND IONOSPHERIC EFFECTS

J.R. Clynch, Research Professor
Department of Oceanography
Sponsor: Nise-West/Vallejo

OBJECTIVE: The precision landing system used by the US Navy at the US bases in Antarctica must be replaced soon. This effort is evaluating the unique environmental conditions in polar latitudes to determine the feasibility of a Category I GPS landing system in that area. This is the third year of an ongoing project.

SUMMARY: There are three major differences between a GPS landing system in Antarctica and in the United States: at high latitudes the satellites never come overhead leading to a reduced accuracy in the height measurements, the ionosphere may cause disruptions of signals from satellites, and the landing fields are often on ice sheets that move substantially over the course of a week. During this year all of these problems were addressed. Ionospheric scintillation data on GPS satellites from experiments deployed earlier were analyzed and reported. This should not be a significant problem. An accuracy model was developed based on Antarctic test results and tests of five different differential GPS systems on a test range at NPS. This model showed that SCAT I requirements can be met in Antarctica with modern GPS equipment. An experiment in the ice motion was deployed. In addition a flight demonstration using a C-130 was flown into both McMurdo and South Pole Stations and the results analyzed. The results were very favorable. Work continues on ice motion and a more ambitious flight demonstration program.

PUBLICATIONS:

Clynch, J.R., "Comparisons of DGPS Systems in a Dynamic Environment," Proceeding of ION GPS-94, p. 1481, Salt Lake City, UT, 20-23 September 1994.

Clynch, J.R. and Henry, C., "Ionospheric Effects on GPS and DGPS in Polar Regions," Proceedings of ION GPS-94, p. 1579, Salt Lake City, UT, 20-23 September 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Precision Landing Systems, Global Positioning System, Scintillations

CALIFORNIA UNDERCURRENT STUDIES

C.A. Collins, Professor and Chairman
N. Garfield, Research Assistant Professor
E. Carter, Assistant Professor
Department of Oceanography
Sponsor: Naval Postgraduate School
Funding: Office of Naval Research and Naval Postgraduate School

OBJECTIVE: To understand the dynamics and kinematics of the California Undercurrent off Central California. The following questions formed the basis for our investigation. What is the mean pattern of poleward and equatorward flow off Pt. Sur? What are the poleward transports of heat and salt? Is the California Undercurrent continuous along the west coast, or is it a series of discontinuous currents? Is there a reference level that can be used for geostrophic calculations: How can various velocity measuring techniques be used in a consistent manner?

SUMMARY: Past work involved 19 research cruises occupying a transection of CTD and Pegasus stations extending westward from Point Sur. Data from these cruises have been used to define the water mass structure and to determine the current structure between the coast and 200 km offshore. Work is now focused on understanding the dynamics of the California Undercurrent, the subsurface nearshore poleward flowing jet. During the last year 21 RAFOS floats were launched in the eastern Pacific, and 18 floats have surfaced and returned data on their subsurface Lagrangian drift. These data are being analyzed to determine the dynamics of

the Undercurrent and the associated eddy field. This is an ongoing project with a continual schedule of float deployments. We have also undertaken the task of restructuring the float processing software used by many members of the RAFOS community.

PUBLICATIONS:

Garfield, N., Rago, T.A., Schnebele, K.J., and Collins, C.A., "Evidence of a turbidity current in Monterey Submarine Canyon associated with the 1989 Loma Prieta earthquake," Continental Shelf Research, Vol. 14, No. 6, pp. 673-686, 1994.

Rosenfeld, L.K., Schwing, F.B., Garfield, N., and Tracy, D.E., "Bifurcated flow from an upwelling center: a cold water source for Monterey Bay," Continental Shelf Research, Vol. 14, No. 9, pp. 931-964, 1994.

CONFERENCE PRESENTATIONS:

Garfield, N., Carter, E., Rago, T.A., Collins, C.A., and Paquette, R.G., "California Undercurrent RAFOS study," RAFOS float technology workshop, Woods Hole Oceanographic Institution, Woods Hole, MA, 13-14 January 1994.

Garfield, N., Rago, T.A., Spearman, M.G., and Collins, C.A., "Hydrographic and Pegasus Observations at the Mouth of the Gulf of California," 1994 Ocean Sciences Meeting, San Diego, CA, 23 February 1994.

Jessen, P.F., Ramp, S.R., and Garfield, N., "Hydrographic and ADCP Data from May 1993: Initial Conditions for a Mesoscale eddy in the California Current System," 1994 Ocean Sciences Meeting, San Diego, CA, 23 February 1994.

Paduan, J.D. and Garfield, N., "An animation of surface drifters and subsurface float trajectories in the Eastern Boundary Current," Eastern Pacific Oceanic Conference, Timberline, OR, 29 September 1994.

Rago, T.A., Paquette, R.G., Garfield, N., Carter, E., and Collins, C.A., "First results from deployments of RAFOS floats off the Central California Coast," 1994 Ocean Sciences Meeting, San Diego, CA, 24 February 1994.

Steiner, M.T., Garfield, N., and Schwing, F.W., "Net non-tidal transport estimates for the Gulf of the Farallones, 1991-1992," 1994 Fall Meeting, American Geophysical Union, San Francisco, CA, 6 December 1994.

THESIS DIRECTED:

Rischmiller, F.W., LT, USN, "Seasonal Variability of Ocean Currents off Pt. Sur, California from May 1988 to April 1991," Master's Thesis, December 1993.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Ocean Circulation, Absolute velocity measurements, Eastern Pacific Circulation

PLUME TRACKING WITH RAFOS FLOATS

C.A. Collins, Professor and Chairman
N. Garfield, Research Assistant Professor
Department of Oceanography
Sponsor: National Oceanic and Atmospheric Administration

OBJECTIVE: The objective of this research was to provide NOAA/PMEL scientists involved in the North Pacific VENTS program with RAFOS subsurface ocean drifters which could be used to tag and track subsurface ocean thermal plumes emitted from the mid-ocean ridge area.

SUMMARY: Three RAFOS subsurface Lagrangian ocean drifter floats were prepared and ballasted for NOAA/PMEL researchers involved in the VENTS experiment. An August 1993 cruise to the Juan de Fuca Ridge carried these floats with the intent of launching the floats into a subsurface thermal plume. The plume was not encountered, but one of the floats was launched. This float surfaced in July 1994. The data from this float are being analyzed. The other two floats will be carried and deployed on future VENTS cruises.

CONFERENCE PRESENTATION:

Garfield, N., "Lagrangian floats for the VENTS Program," VENTS program science meeting, Seattle, WA, 18 February 1994.

DOD KEY TECHNOLOGY AREA: Sensors, Environmental Effects

KEYWORDS: Deep Ocean Circulation, Oceanic Hydrothermal Plumes

PROCESSING RAFOS FLOATS DEPLOYED OVER THE MID OCEAN RIDGE

C.A. Collins, Professor and Chairman
N. Garfield, Research Assistant Professor
Department of Oceanography
Sponsor: National Science Foundation

OBJECTIVE: The objective of this project was to process and analyze data returned from subsurface Lagrangian RAFOS floats that have been deployed in the northeastern Pacific.

SUMMARY: This project provided the funds to process and analyze the returned data from three RAFOS subsurface Lagrangian drifters that were provided to NOAA/PMEL researchers participating in the VENTS experiment. The intent was to use the floats to tag and track subsurface ocean thermal plumes being emitted from the mid-ocean ridge. The first deployed float surfaced in August 1994.

OTHER:

This work was a quick response proposal to NSF in order to assist NOAA/PMEL researchers in the VENTS program with a way to track oceanic thermal plumes with the Lagrangian drifters that we are using in other projects.

DOD KEY TECHNOLOGY AREA: Sensors, Environmental Effects

KEYWORDS: Deep Ocean Circulation, Oceanic Hydrothermal Plumes

ANALYSIS OF AVHRR SATELLITE IMAGERY FROM THE SOUTHERN CALIFORNIA BIGHT

N. Garfield, Research Assistant Professor
Department of Oceanography
Sponsor: EPA funding to NPS Foundation

OBJECTIVE: This project was an Interagency agreement with EPA through the Cooperative Institute for Research in the Integrated Ocean Sciences (CIRIOS). The objective was to examine a one year data set of AVHRR satellite imagery to determine if these data could be used to monitor upwelling in the Southern California Bight.

SUMMARY: A one year data set of AVHRR imagery for July 1991 to July 1992 was evaluated to determine whether upwelling could be observed at two sites in the Southern California Bight. This work was performed to help EPA designate dredge disposal sites off Los Angeles and San Diego. The data were first evaluated to describe the occurrence of clouds, fog, and other atmospheric contamination. Then, the clear useful imagery were assembled to allow viewing of the evolution of the surface temperature at these two sites. The final recommendation to EPA was that because of the atmospheric contamination (clouds, haze, and fog) in the Southern California Bight satellite AVHRR imagery were not dependable as a routine tool to monitor coastal upwelling.

PUBLICATION:

Garfield, N., "Final Report: Evaluation of AVHRR Satellite Imagery for the Monitoring of Dredge Disposal Sites in the Southern California Bight," prepared by CIRIOS, Monterey, CA for EPA Marine Protection Program (W-7-11).

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Satellite AVHRR Imagery Processing and Analyses

SIMULATION OF LAGRANGIAN DRIFTER RESPONSE TO OCEANIC CONVECTION

R.W. Garwood, Jr., Professor
Department of Oceanography
Sponsor: Office of Naval Research and Naval Postgraduate School

OBJECTIVE: The long-term goal of the Oceanic Planetary Boundary Layer (OPBL) Laboratory is to understand the turbulent boundary layer of the ocean, from the polar seas to the tropical oceans, in order to be able to model the exchange of energy, momentum, and mass between the atmosphere and the upper ocean. The first scientific

objective of this project has been to develop the capability of Large-Eddy Simulation (LES) of ocean turbulence, with partial support by NPS. Now that this goal has been achieved, the project is supported by ONR under a 5-year Accelerated Research Initiative to study Deep Convection in the Labrador Sea. The first-year goal of the OPBL Laboratory in behalf of this initiative is to use LES predictions to understand the response of instrumented Lagrangian drifters and floats in the presence of oceanic convection, with the purpose of determining optimal deployment strategies to best observe the Labrador Sea convection. This technology will have immediate uses in the prediction of tracers, pollutants, suspended sediment and the advection of mines and drifting sensors.

SUMMARY: Several important developments have been made. The methods include development and application of a hierarchy of numerical models, including (i) Large-eddy simulation of three-dimensional small-scale convection; and (ii) Development of mixed layer parameterizations for entrainment and super-penetrative convection for inclusion in primitive equation models for basin- to global-scale circulation. Topographic influences on density-driven circulation over continental shelf and slope showed (Jiang and Garwood, 1994) that baroclinic instability and eddy transport may play roles in transporting mass, heat and salt from across bounding frontal zones, including from the shelf to deep ocean. The interaction between these mesoscale features and small-scale plumes needs to be investigated further. Submarine CTD observations in the Arctic during the winter and late spring have shown evidence of convection and other mesoscale phenomena (Schilling, 1994, Guest et al., 1994).

PUBLICATION:

Guest, A., "Animation of convection: Sequence of three-dimensional LES-predicted ocean plumes on the World Wide Web. OPBL Group home page at http://www.met.nps.navy.mil/~bird/, 1994.

CONFERENCE PRESENTATIONS:

Garwood, Jr., R.W. and Arata, B., "Verification of turbulence closure with ADCP observations and large eddy simulation of deep convection," presented at the Fall Meeting of the American Geophysical Union, San Francisco, CA, December 1994.

Harcourt, R. and Garwood, Jr., R.W., "Large eddy simulation of open ocean deep convection plumes," presented at the Fall Meeting of the American Geophysical Union, San Francisco, CA, December 1994.

THESES DIRECTED:

Arata, B., "Deep convection in the Mediterranean Sea," Master's Thesis, 1994.

Schilling, C., "Submarine observations of convection and mesoscale phenomena in the polar seas (U)," Masters Thesis, 1994. (SECRET document)

OTHER:

Guest, A.B., Garwood, Jr., R.W., and Schilling, C., "Submarine CTD observations in wintertime convection regimes," Naval Postgraduate School Technical Report, in preparation.

Jiang L. and Garwood, R.W., "A numerical study of three-dimensional dense bottom plumes on a southern ocean continental slope," submitted to Journal of Geophysical Research, 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects, Software

KEYWORDS: Lagrangian Drifters, Ocean Turbulence

ENHANCEMENTS TO DEEP OCEANIC CONVECTION IN THE ARCTIC SYSTEM

R.W. Garwood, Jr., Professor
Department of Oceanography
Sponsor: National Science Foundation

OBJECTIVE: The purpose of this program of research was to explore the roles of turbulent mixing processes that had been neglected in traditional mixed layer modeling applied to the arctic systems for ocean-atmosphere-ice interactions.

SUMMARY: Of particular interest were the hypothesized increased importance of nonlinearities in the equation of state and of planetary rotation for the extremely deep penetrative convection found in the arctic. The techniques included application of three-dimensional nonhydrostatic large-eddy simulation (LES) to polar sea deep convection, and improvement of one-dimensional mixed layer models. There were four significant results: 1. Analysis of the enhanced buoyancy flux due to the pressure-augmentation of thermal expansion of sea water. This led to the prediction of a probable mid-depth maximum in the turbulent kinetic energy (TKE) for free oceanic convection in the polar seas whenever the mixed layer depth exceeds about 1 km, 2. Prediction of the existence of a new class of oceanic conditional instability. The instability has two forms: a "parcel instability" and a "layer instability." For these phenomena, the vertical transport of heat and mass in the polar seas are hypothesized to resemble convection in the tropical atmosphere, because of the mathematical similarity with conditional instabilities in the atmosphere. This discovery is significant because it is a possible mechanism for the start of the global thermohaline conveyor belt with deep water formation in the Greenland-Iceland Seas and in the polar southern oceans, 3. Probable identification in satellite imagery of the surface signature of mesoscale oceanic convection cells resembling Rayleigh-Benard cells in the Greenland Sea during winter, and 4. Numerical verification of the earlier predictions of mid-depth maximum in TKE for very deep free convection; numerical verification of the parcel instability mechanism.

PUBLICATIONS:

Garwood, Jr., R.W. and Guest, A.B., "Greenland Sea convection instabilities," World Climate Research Programme Publication Series, in press.

Garwood, Jr., R.W., Isakari, S.M., and Gallacher, P.C., "Thermobaric convection," in The Polar Oceans and Their Role in Shaping the Global Environment, O. Johannessen, R. Muench and J. Overland, Eds., AGU Geophysical Monograph 85, pp. 199-209, 1994.

Paluskiewicz, T., Garwood, Jr., R.W., and Denbo, D.W., "Deep convective plumes in the ocean," Oceanography, Vol. 7, pp. 37-44, 1994.

CONFERENCE PRESENTATION:

Jiang, L. and Garwood, Jr., R.W., "Dense bottom plumes over continental slopes," Fall Annual Meeting of the AGU, San Francisco, CA, 1994.

THESIS DIRECTED:

Schilling, C., "Submarine observations of convection and mesoscale phenomena in the polar seas," Master's Thesis, (SECRET document), 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects, Software

KEYWORDS: Oceanic Convection, Ocean Circulation, Climate

TROPICAL OCEAN TURBULENT BOUNDARY LAYER SYSTEM

R.W. Garwood, Jr., Professor
A.A. Guest, Oceanographer
Department of Oceanography
Sponsor: National Science Foundation

OBJECTIVE: The scientific objective of this NSF-funded three-year TOGA-COARE (Coupled Ocean-Atmosphere Response Experiment) study is to understand the response of the tropical and equatorial ocean turbulent boundary layer system to unsteady atmospheric forcing on time scales from diurnal to annual.

SUMMARY: Although this project has only just begun, there has been significant progress. A suite of numerical models has undergone extensive development and enhancements for application to tropical turbulent boundary layer and air-sea interaction problems in the Oceanic Planetary Boundary Layer (OPBL) Laboratory at the Naval Postgraduate School:

(i) OPBL1D, the NPS bulk turbulence closure oceanic planetary boundary model with a new entrainment zone parameterization;

(ii) OGCM/ML, the embedded ocean general circulation-mixed layer model; and

(iii) LES/OC, the large-eddy simulation model.

A study of westerly wind bursts (Weddle, 1993), which used a wind stress derived from NOGAPS winds to force the three-dimensional ocean general circulation model with embedded mixed layer model, showed the importance of using daily winds, rather than monthly-averaged winds. Monthly-averaged winds interpolated to smooth daily values resulted in a warmer western Pacific and a cooler eastern Pacific compared to a simulation made using the daily winds. The relative warming of the western Pacific using the smoothed winds can be explained by the decrease in turbulent mixing and shallower mixed layer depth. The cooler temperatures in the eastern Pacific are due to increased upwelling caused by more constant easterly winds resulting from a smoothing of the westerly wind bursts.

Long waves in the equatorial Pacific Ocean during the 1991-1993 El Nino event were examined using time series of temperature, currents and winds from a moored buoy array on the equator (Sitler, 1994). Equatorial Kelvin waves, which were generated by westerly wind events, were found in the data, with a period of greatest wave activity between August 1991 to May 1992, during the peak phase of the 1991-1993 El Nino event. Tropical

instability waves and mixed Rossby-gravity waves were also detected using the temperature time series during the El Nino event.

Brainard (1994) examined the diurnal cycle of high-frequency temperature variability attributable to internal waves and turbulence in the upper central equatorial Pacific Ocean. Using moored temperature and velocity data in the upper 250m from (0, 140W) during the period November 1983 to October 1987, isotherm displacement variance was examined under a variety of surface forcing and dynamic stability conditions on time scales from diurnal to seasonal and interannual.

THESES DIRECTED:

Sitler, T.W., LT, USN, "An Observational Study of Long Waves in the Equatorial Pacific Ocean during the 1991-1993 El Nino," Master's Thesis, June 1994.

Weddle, C.A., LT, USN, "The effect of westerly wind bursts on a tropical ocean general circulation model," Master's Thesis, December 1993.

Brainard, R. LCDR, NOAA Corps, "The diurnal cycle of high-frequency internal waves and their relationship to mixing in the central equatorial Pacific," Doctoral Dissertation, June 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects, Software

KEYWORDS: Oceanic Convection, Ocean Circulation, Climate

NONLINEAR INTERACTIONS IN OCEAN SURFACE WAVES

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Department of Oceanography
S. Elgar, Co-Investigator, Washington State University
R.T. Guza, Co-Investigator, Scripps Institution of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: The main objective of this continuing project is to evaluate the importance of nonlinear interactions in naturally occurring ocean surface waves.

SUMMARY: Although sophisticated nonlinear theories for ocean surface waves were developed more than 30 years ago, a detailed verification with field observations has not been reported. In this continuing project extensive ocean wave data sets are compared to nonlinear theory predictions. The generation of weakly attenuated secondary pressure fluctuations in the ocean (an important source of sea floor microseisms) by nonlinear interactions between two wind waves traveling in opposing directions was verified using data from an extensive array of pressure sensors deployed in 13 m depth on the North Carolina shelf. Dramatic increases in pressure energy at double wind-wave frequencies (0.3-0.7 Hz), observed after a sudden large shift in wind direction generated directionally opposing waves, were shown to be in good agreement with second-order nonlinear theory predictions. At about three times the frequency of the dominant wind waves, tertiary waves forced by nonlinear interactions between three wind-wave components are important. Trispectral analysis of data collected during a severe nor'easter (the significant wave height was about 5 m) indicates significant tertiary wave contributions to the bottom pressure field.

PUBLICATIONS:

Elgar, S., Herbers, T.H.C., and Guza, R.T., "Reflection of ocean surface gravity waves from a natural beach," Journal of Physical Oceanography, Vol. 24, No. 7, pp. 1503-1511, 1994.

Herbers, T.H.C. and Guza, R.T., "Nonlinear wave interactions and high-frequency sea floor pressure," Journal of Geophysical Research, Vol. 99, No. C5, pp. 10035-10048, 1994.

Elgar, S., Herbers, T.H.C., Chandran, V., and Guza, R.T., "Higher-order spectral analysis of nonlinear ocean surface gravity waves," Journal of Geophysical Research, in press.

CONFERENCE PRESENTATION:

Herbers, T.H.C., Elgar, S., and Guza, R.T., "Infragravity Waves," invited presentation at the ONR-sponsored Ocean Waves Workshop in Tucson, AZ, 16-18 March 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Ocean Surface Waves, Nonlinear Interactions, Sea Floor Pressure

BOTTOM PRESSURE FLUCTUATIONS ON THE SHELF INDUCED BY SURFACE WAVES

T.H.C. Herbers, Assistant Professor
Department of Oceanography
R.T. Guza, Co-Investigator, Scripps Institution of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: The main objective of this continuing project is to determine the mechanisms by which nearshore infragravity waves are generated.

SUMMARY: Infragravity waves or 'surf beats' are waves with periods of nominally 0.5-5 minutes that are believed to cause changes in beach morphology and drive seiche motions in small harbors. Although the generation of infragravity waves has been linked to shoaling wind waves, the precise mechanisms are not understood. Observations in depths between 8-204 m, near Atlantic and Pacific coasts, were used to show that infragravity waves are a mix of forced waves, locally excited by nonlinear wave-wave interactions, and free waves generated at nearby shores. Although free waves usually dominated the infragravity band, forced wave contributions were significant with large amplitude swells and in very shallow water. Observed forced wave energy levels were shown to be accurately predicted by second-order nonlinear theory. A geometrical optics-based model was developed for the generation and propagation of free infragravity waves. Model predictions are in good agreement with the observations. Free infragravity energy levels are sensitive to the geographic surroundings. Comparisons of observations made on different shelves, suggest that more infragravity energy is generated on broad, sandy beaches than on rocky, cliffed coasts.

PUBLICATIONS:

Herbers, T.H.C., Elgar, S., and Guza, R.T., "Infragravity-frequency (0.005-0.05 Hz) motions on the shelf, Part I: Forced waves," Journal of Physical Oceanography, Vol. 24, No. 5, pp. 917-927, 1994.

Herbers, T.H.C., Elgar, S., Guza, R.T., and O'Reilly, W.C., "Infragravity-frequency (0.005-0.05 Hz) motions on the shelf, Part II: Free waves," Journal of Physical Oceanography, in press.

Herbers, T.H.C., Elgar, S., and Guza, R.T., "Generation and Propagation of Infragravity Waves," Journal of Geophysical Research, in press.

CONFERENCE PRESENTATION:

Herbers, T.H.C., Elgar, S., and Guza, R.T., "Longterm Array Observations of Surface Waves," presented at Coastal Dynamics'94: An International Conference on the Role of Large Scale Experiments in Coastal Research, Barcelona, Spain, 21-25 February 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Ocean Surface Waves, Continental Shelf, Nearshore Processes

SHALLOW WATER WAVE PROCESSES

T.H.C. Herbers, Assistant Professor
Department of Oceanography
Sponsor: Naval Postgraduate School

OBJECTIVE: The overall objective of this research is to predict accurately nearshore wave and surf processes.

SUMMARY: A new method was developed for estimating the reflection of ocean waves from coastal structures (e.g., breakwaters, seawalls) or natural shores (e.g., sand bars, steep foreshores) using a spatial array of instruments located seaward of the reflector. Whereas earlier studies assumed unidirectional waves propagating perpendicular to the reflector, the new technique is applicable to a realistic multi-directional sea. Model tests with simulated array data demonstrate that the gross properties of incident and reflected waves can be accurately estimated for wave incidence angles up to about 30 degrees.

The new method was applied to array data acquired offshore of a permeable, rubble mound breakwater in Monterey Bay, California. The estimated reflection coefficients are only weakly dependent on the wave energy but decrease with increasing wave frequency. The observed fraction of the incident wave energy flux that is transmitted through the breakwater decreases with increasing incident wave energy flux, suggesting that dissipation is enhanced with large amplitude waves.

PUBLICATIONS:

Dickson, W.S., Herbers, T.H.C., and Thornton, E.B., "Wave reflection from breakwater," Journal of Waterway, Port, Coastal and Ocean Engineering, in press.

O'Reilly, W.C., Herbers, T.H.C., Seymour, R.J., and Guza, R.T., "A comparison of directional buoy and fixed platform measurements of pacific swell," Journal of Atmospheric and Oceanic Technology, in press.

THESIS DIRECTED:

Dickson, W.S., LT, USN, "Wave Reflections from Breakwaters," Master's Thesis, June 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Ocean Surface Waves, Coastal Structures, Nearshore Processes

NUMERICAL MODELING OF DENSE PLUMES

L. Jiang, Research Associate
Department of Oceanography
Sponsor: Naval Postgraduate School

OBJECTIVE: The scientific objective of this study is to understand the three-dimensional features of major outflows from marginal seas and deep water production over continental slopes due to outflows. The ultimate goal of this study is to represent the outflows by means of submodels that will handle the descent and adjustment of an outflow to a state of near geostrophy, and then pass the outflow current to large scale models. Once this is done we will be one step closer to understanding how the deep ocean may store and transport trace gases.

SUMMARY: We investigated the three-dimensional features of dense bottom plumes flowing over continental slopes with or without along-slope topographic variations simulating the evolution of a density front at a southern ocean continental shelf break, using a three-dimensional, primitive equation numerical model with a second-order turbulence closure scheme embedded. The focus of our investigation is the role of topography in determining mixing and the offshore transport of dense shelf water during the transient adjustment process of a density front over a continental slope. We compared and discussed the numerical simulations for two cases: a uniform shelf and slope case and a case with a canyon that leads from the coast to the deep ocean crossing the shelf and the slope. The numerical simulations indicate that baroclinic instability, planetary rotation, bottom friction and topography play major roles in determining the surface and bottom plume formation, the growth and penetration depth of the bottom plumes, and the characteristics of water mass on the slope. Mesoscale eddies play a fundamental role in transporting mass, heat and salt from shelf to deep ocean. The effects of the depth and width of the canyon are examined with two more experiments.

The presence of a wide and deep canyon in the continental shelf and slope enhances considerably the drainage of coastal shelf water into the deep ocean.

PUBLICATIONS:

Jiang, L. and LeBlond, P.H., "Three dimensional modeling of tsunami generation due to a submarine mudslide," Journal of Physical Oceanography, Vol. 24, No. 3, pp. 556-571, 1994.

Jiang, L. and Garwood, R.W., "A numerical study of three-dimensional dense bottom plumes on a southern ocean continental slope," Journal Geophysical Research, in press.

CONFERENCE PRESENTATIONS:

Jiang, L. and Garwood, R.W., "Dense bottom currents over a continental slope," ONR workshop, Modeling the dispersion of nuclear contaminations in the Arctic seas, Naval Research Laboratory, Monterey, CA, October 1994.

Jiang, L. and Garwood, R.W., "Three-dimensional bottom plumes over a continental slope," Annual Meeting of American Geophysical Union, San Francisco, CA, December 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Modeling, Climate Change, Variability, Ocean Circulations

AIR-SEA-WAVE INTERACTION THEORY AND MODELING

L.N. Ly, Associate Research Professor
Department of Oceanography
Sponsor: Office of Naval Research (ONR) under Marine Boundary Layer and Waves BAA Programs

OBJECTIVE: The goal of this project which is expanded from the ONR sponsor under Marine Boundary Layer Program "Effects of Ocean Surface Waves on Fluxes and Turbulence and Resulting Impacts on Coupling Modeling." The problem to be solved in this project is one aspect of air-sea-wave interaction modeling, which includes air-sea-wave model development of semi-empirical turbulence theory and application of a new theory, the wave boundary layer (WBL) theory, to air-sea-wave coupling.

SUMMARY: In FY94 we focus on development of air-sea-wave interaction models of semi-empirical turbulence theory for studying energy and momentum transfer in the air-sea-wave system. In FY95 we focus on investigating influences of waves on air-sea fluxes, turbulent structure (including turbulence kinetic energy budget and dissipation distributions), dynamical structure of atmospheric/oceanic boundary layers, and air-sea interaction characteristics by using recently developed air-sea-wave interaction models of semi-empirical turbulence theory by Ly (1994) and Ly and Benilov (1995). The work in FY95 is also focused on validation of numerical model results by comparison to available datasets and development of an algorithm for air-wave coupling using the wave spectrum approach of the wave boundary layer theory.

In FY96 we focus on the evaluation of the developed algorithm and comparison of two approaches (semi-empirical theory of turbulence and wave boundary layer theory) in terms of influences of ocean surface waves on air-sea fluxes, dynamical and turbulent structures, and available observed data. Our work is also focused on coupling the air-sea-wave interaction algorithm with the Navy Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) of Naval Research Laboratory (Monterey, CA), and using this coupled system to investigate wave influences on momentum, heat, and moisture fluxes under realistic inhomogeneous and nonstationary conditions.

A mathematical coupled model of air-sea-wave interaction is developed to study influences of ocean wind waves on dynamical, turbulent structures of the air-sea system and their impacts on coupled modeling. The model equations for both atmospheric and oceanic boundary layers include equations for: (1) momentum, (2) Ly's (1991) k-epsilon turbulence scheme, and (3) stratification in the atmospheric and oceanic boundary layers. The model equations are written in the same form for both the atmosphere and ocean. In this model, wind waves are considered as another source of turbulent energy in the upper layer of the ocean besides turbulent energy from shear production. The dissipation (diss) at the ocean surface is written in the form of a linear combination of terms representing dissipation from mean flow and breaking waves. The dissipation from breaking waves is estimated by using similarity theory and observed data, and is written in terms of wave parameters such as wave phase speed, height, and length, which then are expressed in terms of friction velocity by using similarity theory.

Numerical and computing schemes are developed to solve systems of nonlinear equations for both atmospheric and oceanic boundary layers (AOBL) by using the matrix and simple pivotal-condensation methods. Numerical experiments are designed for various geostrophic winds, wave heights, and wave ages to study the influence of waves on the air-sea system.

The numerical simulations show that the vertical diss profiles for AOBL are similar and agree with the observed profiles of Shay and Gregg (1984). Observations of diss in the oceanic surface zone are much larger than those in the atmospheric surface zone and in the interior of the oceanic boundary layer (OBL). This kind of z^{-4} power law distribution for diss in the near-surface layer of OBL was believed to show the inadequacy of the constant-stress boundary layer theory. The numerical simulations also show that the diss distribution in the OBL is strongly dependent on wave heights resulting from wind speeds and the diffusion term in the diss budget equations.

Overall, our model shows good agreement with measurements and observations on diss distribution, wind stress, roughness length, and geostrophic drag coefficients observed under ocean wave conditions. The model can be coupled to larger scale atmospheric and oceanic models taking wind waves into account in studying ocean surface wave influences on circulation.

PUBLICATIONS:

Ly, L.N. and Tackle, E.S., "A Numerical Study of the Influence of the Air Temperature-Inversion Layer and Seawater Density-Jump Layer on the Structure of Atmospheric and Oceanic Boundary Layers," Journal of Boundary-Layer Meteorology, Vol. 4, No. 67, pp. 327-343, 1994.

Ly, L.N., "A Numerical Coupled Model for Studying Air-Sea-Wave Interaction," Journal of Physics of Fluid, in press.

CONFERENCE PRESENTATION:

Ly, L.N., "A Numerical Model of Air-Sea-Wave Interaction," Ocean Science Meeting, American Geophysical Union, EOS, O41A-19, San Diego, CA, February 1994.

OTHER:

Ly, L.N., Kindle, J.C., Thompson, J.D., Youtsey, W., "Wind Stress from ECMWF (1985-1989) Over the Western Equatorial Pacific and North Atlantic Oceans as Atmospheric Forcing Functions for Ocean Circulation Models," Journal of Boundary-Layer Meteorology, submitted for publication, December 1994.

Ly, L.N., "The Pivotal-Condensation Method Applied to a Mathematical Coupled Model of the Air-Sea-Wave System," Journal of Mathematical and Computer Modelling, submitted for publication.

Ly, L.N., "On the Aerodynamic Roughness Length from below in a Coupled Model Taking Wind Wave Breaking into Account," a journal paper in preparation. Completion is expected end August 1995.

Ly, L.N., "On Dissipation Distribution of the Constant-Stress Boundary Layer Theory in the Upper Oceanic Layer," a journal paper in preparation. Completion is expected end September 1995.

Ly, L.N. and Benilov, A.Y., "A Numerical Study of Wave-Enhanced Turbulence in the Oceanic Upper Layer," a journal paper in preparation. Completion is expected end September 1995.

Ly, L.N. and Benilov, A.Y., "A Theoretical Air-Wave Interaction Model Using the Wave Boundary Layer Theory," NPS Technical Report in preparation. Completion is expected mid October 1995.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Wave Effect, Wave-Fluxes Relation, Surface Fluxes, Air-Sea-Wave Interaction, Air-Sea-Wave Modeling

COASTAL OCEAN MODELING

L.N. Ly, Associate Research Professor
Department of Oceanography
Sponsor: Office of Naval Research (ONR) under the Navy Ocean Modeling and Prediction Program (NOMP)

OBJECTIVE: Research is for the development of a capability to derive analyzed time varying ocean fields in coastal environments based on available data and ocean dynamics. The data is from all sources, such as satellite products and in situ observations, and includes fields for currents, sea surface heights, temperature, salinity, waves, and tides.

The coastal models are developed based on the most recent version of the Princeton Ocean Model (POM, 1994). The models have curvilinear, nearly-orthogonal, coast-following grids, to better simulate regions with complicated coastlines, bathymetry, and boundary conditions. The model has complete thermodynamics and mixed layer physics.

A key component of the research is to perform a system which will produce the 4-D analyzed ocean structure for the Yellow Sea (YS), Monterey Bay (MB), and South China Sea (SCS) as a prototype for a Navy system of coastal environments using available data from all sources, data assimilation technique and coastal ocean models. This capability also allows for the generation of virtual coastal oceans useful for various applied sciences, including undersea acoustic and environmental applications.

SUMMARY:

PROJECT A: THE YELLOW SEA

The three-month project is to apply new technologies to the Navy coastal modeling activities. This includes the application of grid generation, multi-block grid techniques of Computational Fluid Dynamics (CFD) to the Yellow Sea (YS) modeling. The research in FY94 is to develop a coastal ocean system for YS which couples a

state-of-the-art coastal ocean model to a grid package of curvilinear nearly-orthogonal grids to better handle complex coastlines and topography. The research is also to develop a system of capability in producing nowcasts/forecasts based on available data using data assimilation techniques. This is be done in combination with a coastal modeling effort using a state-of-the-art coastal model, the Princeton Ocean Model (POM, 1994), and GGT. This project is continuously joined with NAVOCEANO (Stennis Space Center, MS). The NPS Yellow Sea Model is transferred to NAVOCEANO and is validated for operational activity.

PROJECT B: MONTEREY BAY MODELING

This two-year (FY95-FY96) project is also an application of grid generation, multi-block grid techniques of Computational Fluid Dynamics (CFD) to the MB modeling. The research is to develop a coastal ocean system for the MB which couples a state-of-the-art coastal ocean model to a grid package of curvilinear nearly-orthogonal grids to better handle complex coastlines and topography. The research is also to develop a system of capability in producing nowcasts/forecasts based on available data using data assimilation techniques. This is be done in combination with a coastal modeling effort using a state-of-the-art coastal model, the Princeton Ocean Model (POM, 1994), and GGT. Part one of the project (FY95) emphasizes nowcasts and forecasts will be focused in the Part two of the project (FY96).

PROJECT C: SOUTH CHINA SEA MODELING

The two-year (FY94-FY96) project is to develop a nowcast capable system for the SCS using a state-of-the-art coastal ocean model. The model were developed based on the most recent version of the POM. The SCS model is a curvilinear, nearly-orthogonal, coast-following grids and fully active thermodynamics to better simulate regions with complicated coastlines, bathymetry, and boundary conditions. In FY96 the research will be to model wind-driven circulation in the SCS focusing on monsoon and wind wave effects.

PUBLICATIONS:

Ly, L.N., "A Numerical Study of Sea Level and Current Responses to Hurricane Frederic Using a Coastal Ocean Model for the Gulf of Mexico," Journal of Oceanography, Vol. 50, pp. 599-616, 1994.

Ly, L.N. and Chiu, C.-S., "Coastal Acoustic Tomography Data Constraints Applied to a Coastal Ocean Circulation Model," Naval Postgraduate School Technical Report, NPS-OC-94-001, 1994.

Ly. L.N. and Luong, P., "Application of Grid Generation Techniques to the Yellow Sea Simulations," High-Performance Computing, in press.

CONFERENCE PRESENTATION:

Ly, L.N., Luong, P., O'Connor, W.P., Ezer, T., and Mellor, G.L., "A Numerical Study of Circulation and M2 Tide in the Yellow Sea," European Geophysical Society, XX General Assembly, Hamburg, Germany.

OTHER:

Ly, L.N., Luong, P., Ezer, T., and Mellor, G.L., "Grid Sensitivity Study for the Mediterranean Sea Using Grid Generation Techniques," a journal paper in preparation. Completion is expected mid October 1995.

Ly, L.N, Luong, P., and O'Connor, W.P., "A Numerical Modeling of Wind-Driven Circulation and M2 Tide in the Yellow Sea," a journal paper in preparation. Completion is expected mid October 1995.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Nowcast/Forecast Systems, Data-Model Combination, Coastal Modeling, Wind-Driven Circulation, Grid Generation Technique, Monterey Bay, South China Sea, Yellow Sea

LAGRANGIAN MEASUREMENTS OF EDDY CHARACTERISTICS IN THE CALIFORNIA CURRENT

J.D. Paduan, Assistant Professor
Department of Oceanography
Sponsor: Office of Naval Research and Naval Postgraduate School

OBJECTIVE: The objectives of this continuing program are to describe the mesoscale eddy variability in the California Current System off the west coast of the United States and to relate that variability to narrow jet-like features in the current and to the mean current. The data sets to be collected are position and surface temperature following satellite-tracked surface drifters.

SUMMARY: This program is part of a larger coordinated effort to study the eddy field in an eastern boundary current sponsored by the Office of Naval Research. This past year has seen the completion of the program's field phase. Quarterly deployments of 8 surface drifters were placed along an offshore line at 39.5 degrees north latitude (39.5N). The first instruments were placed at 125 degrees west longitude (125W) with approximately 40 km between subsequent deployment sites. Trajectories from these instruments are providing statistics about the mesoscale eddy field of the California Current as a function of season. The second component of the experiment involved intensive study of a single eddy to expose its flow structure and its growth or decay rate. Two deployments took place. In the first, 13 drifters were placed in a cyclonic eddy but extremely strong wind conditions at that time drove most of the drifters out of the eddy within a few days. In the second deployment, 24 drifters were placed within an anticyclonic and drifters mapped out that feature for up to 14 days. The mean translation velocity of the eddy was (–5.1,–2.4) cm/sec (to the southwest). Typical rotation speeds were 10 to 40 cm/sec with speeds increasing away from the eddy center out to a radius of about 40km. This year we have concentrated on filtering high frequency motions from the eddy trajectories in order to compute more accurate translation and rotation characteristics, including decay rates. We have also concentrated on developing computer-based animations of the entire drifter data base that provide a unique view of the circulation in the California Current.

CONFERENCE PRESENTATIONS:

Kelly, K., Limeburner, R., Caruso, M., Beardsley, R., and Paduan, J., "Comparisons of drifter, altimeter and AVHRR data in the California Current," 41st Eastern Pacific Ocean Conference, Timberline, OR, September 1994.

Paduan, J.D., Garfield, N., and Cook, M.S., "An animation of surface drifter and subsurface float trajectories in the Eastern Boundary Current," 41st Eastern Pacific Ocean Conference, Timberline, OR, September 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Eddies, Currents, Lagrangian Measurements, Air-sea Interaction

ANALYSIS OF RADAR-DERIVED SURFACE CURRENTS IN MONTEREY BAY FROM CODAR

J.D. Paduan, Assistant Professor
Department of Oceanography
Sponsor: Naval Postgraduate School

OBJECTIVE: The objectives of this continuing work are to study ocean surface currents in the coastal environment and to evaluate the ability of HF radar to remotely sense these currents. Coastal currents are influenced by atmospheric forcings in ways similar to those of the deep-ocean environment plus they are influenced by effects of wind, heat flux, and bottom topography that are unique to the coastal area. Land-sea temperature gradients and possible coastal mountain ranges strongly affect the currents in the upper ocean providing for, in general, currents of much shorter length and time scales than their open-ocean counterparts. The long-term goal of research into these coastal currents is to be able to predict surface currents and their variability based on more easily-measurable parameters such as coastal wind, sea level, and sea surface temperature. The benefits of such predictability are many, including support of amphibious landings and search and rescue operations and the prediction of fish or crab stocks whose juvenile stages are transported by near-surface currents.

SUMMARY: This project has worked to set up and operate a network of HF radars around Monterey Bay capable of measuring surface currents out to distances of about 50km from the shore with horizontal resolution of about 2km. Its initial phase collected data from two HF radar sites in March through September 1992. This year two new radar systems have been installed and continuous data collection from the entire network began in August. One old radar system was decommissioned in order to provide parts for the second old system. Hence, data has been collected from August through December from 3 sites around Monterey Bay with overlapping ocean coverage. This is the only such 3-site, long-term data set in existence from HF radar measurements and we have begun to analyze the radar-derived currents for the dual purpose of describing the coastal circulation and characterizing and improving the radar technique. We have computed monthly-averaged currents and tidal-band-filtered currents from the radar data. We have also compared low-passed time series from individual radar bins with moored current meter observations and compared two-dimensional mapped currents from the radar data with arrays of surface drifters deployed within the radar field. Results show that the present radar algorithms do provide reasonable ocean currents when averages of several maps are computed or when harmonic analyses at particular frequencies are conducted. We have now adopted a more case study approach to attempt to correlate errors in individual radar maps with various environmental parameters.

CONFERENCE PRESENTATIONS:

Paduan, J.D., "Remotely sensed surface currents in Monterey Bay from multiple HF radar installations," IEEE, OCEANS-94 Conference, Brest, France, September 1994.

Paduan, J.D., Petruncio, E.T., Rosenfeld, L.K., Cook, M.S., and Foster, M., "Observations of surface currents in Monterey Bay from shore-based HF radars (CODAR)," Fourth Annual Monterey Bay Research Symposium, Monterey, CA, February 1994.

Rosenfeld, L.K. and Paduan, J.D., "Fronts and tides in Monterey Bay," 41st Eastern Pacific Ocean Conference, Timberline, OR, September 1994.

OTHER:

The principal investigator made three invited presentations to local technical groups on Monterey Bay currents derived from this project: Carmel Kiawanas Club-January, Monterey Bay National Marine Sanctuary Research Advisory Panel-October; Marine Technology Society-November. The principal investigator hosted a science and planning meeting for HF radar scientist from several locations around the country in Monterey on 9 December.

DOD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Surface Currents, HF Radar, Air-sea Interaction

LARGE-SCALE MEAN CONVERGENCE IN THE MIXED LAYER OF THE CANARY BASIN AS DETERMINED FROM LAGRANGIAN DRIFTERS

J.D. Paduan, Assistant Professor
Department of Oceanography
Sponsor: Office of Naval Research (expired)

OBJECTIVE: The objective of this continuing project is to obtain statistically-reliable estimates of the mean surface currents and temperatures in the Subduction region of the northeast Atlantic Ocean and to use this information, gathered over years, to describe the mean large-scale horizontal convergence near the surface (~15 m). We hope to be able to expose the relative importance of this large-scale frontal convergence as compared with more localized observations and to compare observed convergence with Ekman convergence estimates in order to partition it into wind-driven and non-wind-driven components.

SUMMARY: The approach being used is to make direct measurements of surface currents and temperatures using satellite-tracked Lagrangian drifters. The deployment pattern that was used was designed to assess the importance of the semi-permanent oceanic front, which occurs south of the Azores Islands, in the north-to-south convergence over the larger Subduction region. Data from 70 drifters has been collected over four years from Navy-sponsored deployments and data is available from an additional 25 instruments deployed by French colleagues.

Velocity statistics have been computed in one degree latitude by two degree longitude boxes over the larger region of interest. The mean location of the Azores Current is apparent in the data set with a suggestion of the expected divergence patterns: convergent flow north of the front and divergent flow south of the front. Work is under way to incorporate satellite-derived SST data to obtain an approximate time history of the frontal location, which will allow a more precise calculation of the divergence patterns relative to the front.

OTHER:

The investigator hosted a two-week visit of a remote sensing technician from the University of Miami in support of LT J. Brown's thesis work on this project. He also attended two working conferences in support of this project in which he made the following presentations:

Paduan, J.D., "Drifter results from the NE Pacific (OCEAN STORMS) and Atlantic (SUBDUCTION)," Subduction/Semaphore Experiment Working Conference, Toulouse, France, September 1994.

Paduan, J.D., Zhou, M., and Niiler, P.P., "Drifter observations in the northeast Atlantic as part of the Subduction Experiment," Subduction Experiment Working Conference, Woods Hole, MA, November 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Currents, Lagrangian Measurements, Eddies, Air-sea Interaction

SATELLITE OCEAN COLOR IN THE LITTORAL ZONE

A. Semtner, Professor
N. Garfield, Research Assistant Professor
Department of Oceanography
Funding: Naval Postgraduate School
Sponsor: NAVOCEANO

OBJECTIVE: The purpose was to prepare for reception of ocean color data from the soon-to-be-launched SeaWiFS sensor in order that these data will be available in the IDEA Laboratory for both teaching and research purposes. The shift in naval strategy toward a force capable of operating in the near shore region demands improved surveillance capabilities. Satellite data from the visible spectrum may prove to be an important tool in developing these capabilities. The work carried out through this proposal will provide NPS students with opportunity to evaluate the potential usefulness of ocean color data and make recommendations concerning the incorporation into TESS(3) capabilities.

SUMMARY: The SMQ/11 satellite receiving antenna and the TeraScan system antenna installed on the roof of Root Hall will allow reception of SeaWiFS ocean color data after the satellite is launched in the summer of 1994. The work carried out here was to ensure the capture and processing of the SeaWiFS data.

DOD KEY TECHNOLOGY AREA: Sensors, Environmental Effects

KEYWORDS: Ocean Color, Littoral Zone

SCIENTIFIC DEVELOPMENT OF A MASSIVELY PARALLEL OCEAN CLIMATE MODEL

A.J. Semtner, Professor
J.L. McClean, Research Associate
Department of Oceanography
Sponsor: US Department of Energy / CHAMMP Program

OBJECTIVE: To develop detailed models of the global ocean circulation with all the relevant physical processes important to climate, as well as to validate the models against existing observations. To understand the physical processes in the ocean that affect climate predictability and climatic change.

SUMMARY: A global ocean model, capable of producing climate forecasts out to the limits of predictability when properly coupled to a valid atmospheric model, should ideally be designed to run on the most advanced supercomputers of the future, which are expected to be of massively parallel design. The present research is moving an eddy-resolving model onto massively parallel computers, for climate studies related to CHAMMP. To guide the proper physical development of a comprehensive model, scientific study in three areas is now underway: (i) investigation of the physics of ocean heat transport; (ii) inclusion of near-surface oceanic processes relevant to climate; (iii) examination of resolution requirements for ocean climate modeling. The final and most important aspect of the research will be the demonstration of feasibility and scalability of a climatically-sound

global ocean model for performing multi-century integrations at a grid spacing as fine as 1/8 degree on massively parallel machines. Recent discussions with other CHAMMP Principal Investigators have resulted in a detailed work plan to conduct and analyze a 100-year run with a coupled atmosphere-ocean model on the Los Alamos CM-5 machine, to be completed by the end of 1995.

PUBLICATIONS:

McClean, J.L. and Klinck, J.M., "Description and Vorticity Analysis of 50-Day Oscillations in the Western Tropical Region of the CME Model," accepted, Journal of Physical Oceanography.

Chervin, R.M., Craig, A.P., and Semtner, A.J., "On the Computation of Meridional Ocean Heat Transport from Hydrographic Sections," Journal of Geophysical Research, in press.

Semtner, A.J., "Very high-resolution estimates of global ocean circulation, suitable for carbon-cycle modeling," Proceedings of the Snowmass Global Change Institute on the Global Carbon Cycle, Office of Interdisciplinary Earth Studies, Boulder, CO, 1994, in press.

CONFERENCE PRESENTATIONS:

McClean, J.L., "Comparisons of Global Statistics from the NPS Quarter-Degree and LANL Sixth-Degree Models and Observations," presented at the U.S. WOCE Working Group on Numerical Modeling Meeting, Los Alamos, NM, September 1994.

McClean, J.L., Semtner, A.J., and Braccio, P., "Northeastern Pacific Interannual and Seasonal Variability from the Los Alamos Sixth-Degree Global Ocean Model," presented at the Eastern Pacific Conference, Mount Hood, OR, September 1994.

"Simulations of global ocean circulation with eddy-resolving models," presented at the following:

NOAA Symposium of Global Climate Change, Steamboat Springs, CO, 13-17 September 1994;
ARPA Teraflop Computing Symposium, Monterey, CA, 18-19 August 1994;
International WOCE Numerical Meeting, Los Alamos, NM, 19-22 September 1994;
Invited Texas A&M Oceanography Seminar, Bryan, TX, 1 December 1994;
NASA Earth Observing System Workshop at MBARI, Monterey, CA, 8-10 March 1994;
CHAMMP Science Team Meeting, Albuquerque, NM, 25-29 April 1994;
Invited Florida State U. Computational Seminar, Tallahassee, FL, 5 May 1994;
NASA Ocean Data Assimilation Workshop, Irvine, CA, 24-27 October 1994;
Reviews of Large DOE Computational Projects, Bethesda, MD, 13 July 1994;
US Global Change Program Symposium, Washington, DC, 1-4 May 1994;
Invited Univ. Calif. Marine Sciences Seminar, Santa Cruz, CA, 16 November 1994.

OTHER:

McClean, J.L. and Semtner, A.J., "Comparisons of Global Statistics from the Semtner-Chervin Quarter-Degree and Los Alamos Sixth-Degree Models and Altimetry," in preparation.

Zlotnicki, V., McClean, J.L., and Semtner, A.J., "Length Scales of Sea Level Variability from Topex/Poseidon and the Semtner-Chervin Quarter-Degree Numerical Model," in preparation.

DOD KEY TECHNOLOGY AREA: Computers, Software, Other (Ocean Circulation Modeling)

KEYWORDS: Model Validation, Numerical Modeling, Altimetry, Ocean Circulation

DEVELOPMENT OF A GLOBAL EDDY-RESOLVING THERMODYNAMIC OCEAN MODEL

A.J. Semtner, Professor
Department of Oceanography
Sponsor: National Science Foundation / Physical Oceanography

OBJECTIVE: The goal is to develop a very realistic numerical model of global three-dimensional ocean circulation, including important strong currents and eddies, in order to improve physical understanding of the ocean and to enable more accurate prediction of climate change.

SUMMARY: A model was developed with a 1/4 x 2/5 degree lat/lon grid and 20 vertical levels, with proper representation of coastlines and depths. The model was used to simulate oceanic conditions of 1985-89, starting from earlier 1/2 x 1/2 degree calculations and applying the observed monthly atmospheric surface forcing. A massive amount of model output was compared with both in-situ and satellite observations and found to be in very good agreement with what actually happened. The agreement of predicted surface height variability with that observed by NASA's new TOPEX satellite altimeter was especially impressive. Analyzed results of these NSF-sponsored global models were published in research journals. Model output was distributed to more than thirty groups worldwide for further analysis and additional scientific uses. Video animations of ocean currents, height, temperature, and salinity were distributed to hundreds of requesting scientists, educators, and others. The model development effort is now widely recognized for its success, including receipt of a national award for Breakthrough Computational Science from the Smithsonian Institution. Most important, an accurate new tool for climate prediction and ocean research is now available.

PUBLICATIONS:

McCann, M.P., Semtner, A.J., and Chervin, R.M., "Volume, heat, and salt budgets and transports of a global ocean model with resolved eddies," Climate Dynamics, Vol. 10, pp. 59-80, 1994.

Semtner, A.J., "Very high-resolution estimates of global ocean circulation, suitable for carbon-cycle modeling," Proceedings of the Snowmass Global Change Institute on the Global Carbon Cycle, Office of Interdisciplinary Earth Studies, Boulder, CO, in press.

CONFERENCE PRESENTATIONS:

"Simulations of global ocean circulation with eddy-resolving models" presented at the following:

NOAA Symposium of Global Climate Change, Steamboat Spr. CO, 13-17 September 1994;
ARPA Teraflop Computing Symposium, Monterey CA, 18-19 August 1994;
International WOCE Numerical Meeting, Los Alamos NM, 19-22 September 1994;
Invited Texas A&M Oceanography Seminar, Bryan TX, 1 December 1994;
NASA Earth Observing System Workshop at MBARI, Monterey CA, 8-10 March 1994;
CHAMMP Science Team Meeting, Albuquerque NM, 25-29 April 1994;
Invited Florida State U. Computational Seminar, Tallahassee FL, 5 May 1994;
NASA Ocean Data Assimilation Workshop, Irvine CA, 24-27 October 1994;
Reviews of Large DOE Computational Projects, Bethedsa MD, 13 July 1994;
US Global Change Program Symposium, Washington DC, 1-4 May 1994;
Invited Univ. Calif. Marine Sciences seminar, Santa Cruz CA, 16 November 1994.

DOD KEY TECHNOLOGY AREA: Computers, Software, Other (Ocean Prediction)

KEYWORDS: Modeling, Simulation, Prediction, Ocean, Circulation

MIXED LAYER TURBULENCE MEASUREMENTS DURING THE ANZONE WINTER FLUX EXPERIMENT: ANZFLUX

T.P. Stanton, Associate Research Professor
Department of Oceanography
Sponsor: National Science Foundation

OBJECTIVE: The objectives of this research are to identify and model physical mechanisms responsible for maintaining anomoulously thin winter ice cover over the central Weddell Sea. As large scale, winter-long polynias intermittently form in this area, the potential exists for massive ocean/atmosphere heat fluxes which can significantly effect the global heat budget and bottom water formation.

SUMMARY: The ANZFLUX program was deployed from the icebreaker N. B. Palmer during July and August 1994. Two, week long ice camps were deployed approximately 500m from the ship on O(30 cm) ice to make direct heat, salt and momentum flux measurements in the ocean mixed layer. Three continuous sampling instrument systems were used: *in situ* temperature, salinity and 3 component velocity instrument clusters spanned the upper 3m; a unique Broad Band Acoustic Doppler Profiler measured velocity, shear, Reynolds stress and Turbulent Kinetic Energy profiles to 20m depth; and an automated microstructure profiler spanned the O(100m) mixed layer into the upper pycnocline to resolve the evolving mixed layer thermohaline structure, turbulent dissipation rates and very small vertical gradients in temperature and salinity.

Preliminary analyses of these data suggest that the frequent, intense winter storms which transit the area every few days in provide sufficient mechanical stirring energy to transport heat across the very deep mixed layer from the underlying warm pycnocline up to the ice/ocean interface. Both direct and dissipation-based heat flux estimates show sustained 100 Wm^{-2} heat fluxes across a 100m deep mixed layer while the surface winds blew in excess of 40 knots, and the ice/water velocity exceeded 80 cms^{-1}. These results are being prepared for publication in Science, and are the topic of two conference presentations.

OTHER:

Stanton, T.P., Stockel, J., and McPhee, M.G., "Turbulent Fluxes Near the Ice/Ocean Interface During Strong Storms in the Weddell Sea," upcoming in IAPSO conference, August 1995.

Stanton, T.P., Stockel, J., McPhee, M.G., Padman, L., and Robertson, R., "Turbulent Heat Fluxes Near the Base of the Mixed Layer in the Weddell Sea," upcoming in IAPSO conference, August 1995.
Convener of an ANZFLUX workshop in March 1995.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Ocean Mixed Layer, Antarctic Ocean Fluxes, Mixed Layer Dynamics

COHERENT ACOUSTIC SEDIMENT FLUX PROBE

T.P. Stanton, Associate Research Professor
E.B. Thornton, Professor
Department of Oceanography
Sponsor: US Army Engineer Waterways Experiment Station

OBJECTIVE: The goal of this research program is to develop a 3 component sediment flux probe with high temporal and spatial resolution for use in wave/sediment transport studies. The simultaneous measurement of the three-component velocity vector, dual-frequency backscatter level, and local beam attenuation will provide a unique capability in the estimation of sediment load and fluxes down to dissipation scales.

SUMMARY: The CASP probe was completed and put through preliminary ocean field tests during FY93. The CASP instrument package consists of three 5.2MHz and one 1.3MHz acoustic transceivers which are rapidly sequenced through bistatic and monostatic measurement cycles 36 times a second. The 1.4 Mbaud data stream from the instrument head is processed in real time by a Digital Signal Processor and 486-based PC which has output formats compatible with our existing back-end data processing and visualization tools. A controlled concentration test tank and calibration facility is being used in three thesis research projects to develop the sediment mass algorithms and quantify the effects of bubbles in the water column.

The CASP instrument was successfully deployed from an instrumented sled during the DUCK-94 nearshore processes program in October 1994, which was also sponsored under the Thornton/Stanton ONR Nearshore Waves Processes Program. The instrument was used over a three week period to determine vertical profiles of sediment flux, sediment load, Reynolds stress and dissipation rates in the context of local wave forcing and morphology. This very rich data set is the subject of several theses, and a paper describing the CASP instrument will be submitted with the final report in October 1995.

PUBLICATION:

Stanton, T.P., Kanhanovich, K., and Thornton, E.B., "Acoustic Measurements of Sediment Fluxes at Duck 94," AGU Fall meeting, December 1994.

THESIS DIRECTED:

Anderson, W., LCDR, USN, "Calibration and Sediment Load Algorithms For an Acoustic Sediment Flux Probe," Master's Thesis, June 1994.

OTHER:

Kanhanovich, K., LCDR, USN, "Sediment Mass Estimates in the Surf Zone Using Acoustic Backscatter Techniques," Master's Thesis in progress.

McIntyre, T.A., LCDR, USN, "Acoustic Backscatter Characteristics of Entrained Air Bubbles in the Surf Zone," Master's Thesis in progress.

Stanton, T.P., "An Acoustic Doppler Sediment Flux Probe," to be submitted to Journal of Atmospheric and Oceanic Technology, May 1995.

Stanton, T.P., "Final Report on the Coherent Acoustic Sediment Flux Probe," to be submitted to the Army Corp of Engineers in March 1995.

DOD KEY TECHNOLOGY AREA: Environmental Effects, Electronic Devices

KEYWORDS: Sediment Transport, Acoustic Doppler, Turbulent Fluxes

OCEAN MIXED LAYER PROCESSES DURING THE IRON ENRICHMENT EXPERIMENT

T.P. Stanton, Associate Research Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: The primary objective of this research is to identify and model the physical processes which contribute to the horizontal and vertical diffusion of areas of open ocean which have had chemical tracers introduced at the surface. A secondary objective was to design and implement a system to permit open ocean seeding and sampling experiments to be performed even in the presence of strong horizontal advection and inertial motions.

SUMMARY: During our participation in the Iron Enrichment Experiment in October 1993, three observation systems were used to measure the atmospheric forcing, mixed layer current response and three dimensional mixed layer structure in the experiment area. A Lagrangian reference frame was established to navigate the pre-survey, iron-enrichment phase, and 10 day patch evolution survey period by deploying a telemetered, GPS navigated buoy in the center of the measurement domain, 300 km south of the Galapagos Island. Real-time analysis methods allowed daily maps of the evolving physical, chemical and biological properties to be made. After 3 days, primary productivity had tripled in the 10 km square iron enriched area, producing a signature observable from concurrent NASA remote sensing flights.

The use of the conserved chemical tracer, SF_6, mixed with the trace iron provided a unique opportunity to measure and model the horizontal and vertical diffusion of the surface injected tracer patch in open ocean conditions. The results of the physical analyses of the mixed layer processes contributing to the diffusion are the subject of two submitted publications.

PUBLICATION:

Martin, J.H., Coale, K.H., Johnson, K.S., Fitzwater, S.E., Gordon, R.M., Tanner, S.J., Hunter, C.N., Elrod, V.A., Nowicki, J.L., Coley, T.L., Barber, R.T., Lindley, S., Watson, A.J., Van Scoy, K., Law, C.S., Liddicoat, M.I., Ling, R., Stanton, T.P., Stockel, J., Collins, C., Anderson, A., Bidgare, R., Ondrusek, M., Latasa, M., Millero, F.J., Lee, K., Yao, W., Zhang, J.R., Friedrich, G., Sakamoto, C., Hoge, F., Swift, R., Jyungel, Turner, S., Nightingale, P., Hatton, A., Liss, P., and Tindale, N.W., "Testing the Iron Hypothesis in Ecosystems of the Equatorial Pacific Ocean," Nature, Vol. 371, 8 September 1994.

CONFERENCE PRESENTATION:

Stanton, T.P. and Watson, A.J., "The Iron Enrichment Experiment: Physical Evolution of the Iron Enriched Patch," Ocean Sciences meeting, paper O32 G-32, San Diego, CA, February 1994.

OTHER:

Stanton, T.P., "Advantages of high temporal/spatial resolution sampling of oceanic systems," Invited talk at MBARI, April 1994.

Stanton T.P. and Watson, A.J., "Physical Evolution of an Open Ocean Surface Tracer Patch," submitted to Deep Sea Research.

Stanton, T.P. and Watson, A.J., "Horizontal Diffusion Processes in Open Ocean Mixed Layers", to be submitted to Journal of Physical Oceanography.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Tracer Dispersion, Ocean Mixed Layer, Ocean Mixing

EVOLUTION OF THE TURBULENT STRUCTURE OF ARCTIC LEADS

T.P. Stanton, Associate Research Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: The objectives of this research program are to provide a description of the dynamics controlling fluxes across the oceanic mixed layer under newly formed Arctic leads. The field program and analyses have been designed to determine the relative contribution to the ocean mixed layer diffusivity due to salinity-driven buoyancy fluxes resulting from rapid ice growth, shear-produced turbulence from the surface boundary layer, and shear-induced turbulence at the mixed layer/pycnocline interface. Effects of the convective buoyancy flux on the pycnocline (for example, penetrative convective events) are also being studied with the LEADEX data set.

SUMMARY: During LEADEX field program in March/April 1992, a loose-tethered microstructure profiler equipped with cm-resolving temperature, conductivity, velocity shear and 5 Mhz acoustic backscatter sensors repeatedly sampled from the lead surface to a depth of 60m every 8 minutes as each sampled lead re-froze. Concurrent Acoustic Doppler Profiler measurements provided current and shear data at each lead site. Analyses of the data set have resulted in two submitted publications. A collaboration with Miles McPhee has combined the very high resolution vertical temperature and salinity gradient measurements made by the microstructure profiler with *in situ* Turbulence Instrument Cluster (TIC) measurements of (u,v,w,T,S)(t) at three levels in the mixed layer, to infer the upper mixed layer diffusivity over a 24 hour period. These co-located measurements have also provided a high quality comparison between direct correlation estimates of heat flux made by the TIC's, <w'T'>, estimates, and those based on the thermal dissipation rate and mean vertical gradient. In a second paper the micro-structure based heat flux profiles are used to estimate mixed layer diffusivity profiles as three leads evolve from open water to O20cm) ice cover. Both a high current lead, with significant shear produced turbulence, and a two low mean current lead are considered in this analysis, quantifying the role of pycnocline shear on the lead mixed layer diffusivity. The effects of diurnal reversals of mixed layer surface heat flux due to the absorption of solar radiation are discussed using two profile timeseries from the main lead experiment, and one late spring lead sampled during the LEADEX pilot program.

OTHER:

Stanton, T.P., "The Turbulent Structure of the Ocean Mixed Layer Under Refreezing Arctic Leads," submitted to Journal Geophysical Research.

McPhee, M.G. and Stanton, T.P., "Observations of Heat, Salt and Momentum Fluxes in Arctic Lead Mixed Layers," submitted to Journal of Physical Oceanography.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Weddell Sea, Ocean Turbulence and Mixing, Ocean Mixed Layer

SURF AND NEARSHORE CURRENT PREDICTION

E.B. Thornton, Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: Develop models to predict the evolution of waves across the surf zone, the currents in the NEARSHORE due to waves, wind and tidal influences, and the changes in the bathymetry, and apply these models to improve the predictive capability of the U.S. Navy Tactical Environmental Support System (TESS) Surf Model.

SUMMARY: Surf prediction models are tested, validated and improved utilizing wave and longshore current data acquired during large -scale field experiments. These experiments include NSTS at Torrey Pines and Santa Barbara, California, and a series of experiments (SUPERDUCK, DELILAH and DUCK94) held at the U.S. Army Field Research Facility in Duck, North Carolina. These combined data provide a wide range of wave conditions from the long period, low steepness Pacific swell to steeper Atlantic storm waves. The experiments were conducted over various bottom profiles including both near-planar and barred beaches.

(1) The wave transformation model has been re-derived to include the effects of a surface roller describing breaking waves and dissipation (Lippmann, et al, 1994). Resulting formulation also has two parameters to be specified, the steepness of the breaking wave face, S, and the ratio of rms wave height to local depth, B. The model was run for various cases of near planar (Torrey Pines and Santa Barbara) and barred (DELILAH) profiles. It was found that the model is insensitive to S, and moderate to weakly sensitive to B. The average rms error between observed and calculated wave heights for all runs is less than 7%. The modifications result in a single parameter (B) model, with the functional relationship of B weakly constrained by bottom slope.

(2) By modeling the breaking process, predictions of wave energy gradients can be made, allowing estimation of mean cross-shore and alongshore currents. Although this modeling has worked well on plane beaches, data and models do not always agree on barred profiles where there often are large currents in the trough of the bar. One mechanism to account for the momentum deficit has been suggested (Roelvink and Stive, 1989) to be associated with a lag in the dissipation of turbulent energy from its genesis. In this work (Lippmann and Thornton, 1994) we investigate the affect of wave rollers on the spatial distribution of turbulent kinetic energy (TKE) across a naturally barred profile. The model is formulated from the energy flux balance, in which the total energy of the waves is separated into wave and roller components after Svendsen (1984). The energy loss of the roller is formulated following Deigaard (1993), where the total energy balance in the roller is due to the exchange of water across the wave/roller interface. Production of turbulence at the wave/roller interface occurs through the shear stress exerted by the roller on the water column. The roller area is described by the model of Engelund (1981), with slight modification to allow for variable characteristics of the roller geometry. The roller model is found to depend on the ratio f/e where f is the wave frequency and e is a measure of the asymmetry of the wave form. It is found that the horizontal propagation scales depend on e. Since there are no known appropriate measurements of TKE in the surf zone, the model is indirectly evaluated using percentages of wave breaking obtained from video measurements. For long crested, narrow banded incident waves during the 1990 DELILAH experiment, the percentages of wave rollers predicted by the model gives an excellent fit to field measurements.

PUBLICATION:

Church, J.C., Thornton, E.B., and Oltman-Shay, J., "Mixing by shear instabilities of the longshore current," Coastal Dynamic '94 Conference, pp. 376-390, Barcelona, Spain, 1994.

CONFERENCE PRESENTATIONS:

Lippmann, T. and Thornton, E.B., "The spatial distribution of wave rollers and turbulent kinetic energy on a barred beach," Coastal Dynamics '94, Barcelona, Spain, 1994.

Thornton, E.B. and Lippmann, T.C., "Longshore currents measured in the field," Coastal Dynamics '94, Barcelona, Spain, 1994.

Church, J.C., Thornton, E.B., and Oltman-Shay, J., "Mixing by shear instabilities of the longshore current," Coastal Dynamic '94, Barcelona, Spain, 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Nearshore, Waves, Surf

WAVE TRANSFORMATION AND REFLECTION FROM THE MONTEREY BREAKWATER

E.B. Thornton, Professor
Department of Oceanography
Sponsor: U.S. Army Corps of Engineers, San Francisco District

OBJECTIVE: Waves are measured on both sides of the Monterey breakwater using an array of pressure sensors to determine the transmitted and reflected wave energy spectra. Conditions before and after repair of the breakwater are compared to determine the improved characteristics of wave protection by the breakwater.

SUMMARY: A six element array of pressure sensors as installed on the ocean side and a single pressure sensor inside of the Monterey breakwater to determine the reflected and transmitted wave energy spectra. Conditions before and after repair of the breakwater are compared to determine the improved characteristics of wave protection by the breakwater. A generalized methodology for determined the spectral reflection characteristics has been derived. This procedure was tested with a wide variety of wave conditions acquired to examine the robustness of the methodology and the amount of nonlinearity of the transmission processes.

THESIS DIRECTED:

Dickson, W.S., "Wave reflection from a breakwater," Master's Thesis, September 1994.

OTHER:

Dickson, W.S., Herbers, T.H.C., and Thornton, E.B., "Wave reflection from a breakwater," accepted in Journal of Waterway, Port, Coastal and Ocean Engineering.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Waves, Breakwater, Reflected Waves

NEARSHORE PROCESSES

E.B. Thornton, Professor
T.P. Stanton, Associate Research Professor
Department of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: The long-term goals are to predict the wave-induced three-dimensional velocity field and induced sediment transport over arbitrary bathymetry in the near shore.

SUMMARY: We participated in both the August and October phases of the Duck94 near shore experiment, performing three separate tasks. New instrumentation utilizing doppler acoustics, stereo-video and multi-scale bottom surveying technologies were developed and successfully deployed to make unique measurements of sediment transport, turbulence, breaking waves and small-scale morphology. A moveable sled was used as a platform from which direct measurements were made of suspended and bedload sediment flux, stress, and dissipation over the vertical, small-scale morphology including ripples and mega-ripples, breaking wave characteristics, and the vertical structure of mean currents. The small-scale morphology was also observed using a 500KHz side-scan sonar mounted rigidly to the CRAB along with a 1MHz sonic altimeter. Two-dimensional spectra of the incident-band waves were measured using an array of pressure sensors and stereo video. The breaking wave field was sampled using both mono-wide-angle and stereo-video methods.

The Bowen/Bailard sediment cross-shore transport model was tested using the cross-shore array of velocity measurements acquired during the Delilah experiment. Velocity moments averaged over 90 minutes were used to predict sediment flux, which was then integrated over 10 days to obtain a prediction of changes in bathymetry (Thornton, Humiston and Birkemeier 1994). The model qualitatively predicted the growth of the bar due to two storms occurring in the ten day interval. Based on the model, the dominant mechanisms mobilizing the sediments were the longshore current within the surf zone and the skewness of the wind-wave band of frequencies. The model response to the velocity inputs showed that the tidal modulation of breaker depth over the bar was a primary cause of temporal variability of sediment flux.

The longshore currents maximum observed in the trough of the barred beach during DELILAH is not predicted by present theory. The simplest longshore current models balance cross-shore changes in the alongshore wave momentum (radiation stress) with the alongshore bottom shear stress. Waves break over the bar, reform in the trough and again break on the foreshore. Wave breaking results in changes in the radiation stress predicting two jets, one over the bar and one at the foreshore (base state), which does not agree with the observed current maximum in the trough. The predictions suggest that a transfer of momentum is required to fill the current deficit in the trough. The momentum deficit may be associated with a lag in the dissipation of turbulent energy from its genesis. Lippmann and Thornton (1994) investigated the affect of wave rollers on the spatial distribution of turbulent kinetic energy (TKE) across a naturally barred profile. The model is formulated from the energy flux balance, in which the total energy of the waves is separated into wave and roller components after Svendsen (1984). The energy loss of the roller is formulated following Deigaard (1993), where the total energy balance in the roller is due to the exchange of water across the wave/roller interface. Production of turbulence at the wave/roller interface occurs through the shear stress exerted by the roller on the water column. The roller area is described by the model of Engelund (1981), with slight modification to allow for variable characteristics of the roller geometry. The roller model is found to depend on the ratio f/e where f is the wave frequency and e is a measure of the asymmetry of the wave form. It is found that the horizontal propagation scales depend on e. Since there are no known appropriate measurements of TKE in the surf zone, the model is indirectly evaluated using percentages of wave breaking obtained from video measurements. For long crested, narrow banded incident waves during the 1990 DELILAH experiment, the percentages of wave rollers predicted by the model gives an excellent fit to field measurements.

CONFERENCE PRESENTATIONS:

Church, J.C., Thornton, E.B., and Oltman-Shay, J., "Mixing by shear instabilities of the longshore current," Coastal Dynamics '94, pp. 376-390, 1994.

Birkemeier, W.A. and Thornton, E.B., "The Duck94 Near shore Field Experiment," Coastal Dynamics '94, pp. 815-821, 1994.

Lippmann, T. and Thornton, E.B., "The Spatial Distribution of Wave Rollers and Turbulent Kinetic Energy on a Barred Beach," Coastal Dynamics '94, 1994.

Thornton, E.B., "Overview of the DUCK94 near shore experiment," Small-scale Granular Fluids Conference, 1994.

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Dickson, W.S., "Wave reflection from a breakwater," Master's Thesis, September 1994.

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Church, J.C., Thornton, E.B., Oltman-Shay, J., "Mixing by shear instabilities of the longshore current," submitted to Journal of Geophysical Research.

Church, J.C., Thornton, E.B., and Guza, R.T., "Vertical Profiles of Longshore Currents," submitted to Journal of Geophysical Research.

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Lippmann, T., Thornton, E.B., and Brookins, H., "Breaking Wave Transformation using a Roller Model," submitted to Journal of Coastal Engineering.

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DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Nearshore, Waves, Longshore currents, Surf

DEPARTMENT OF OCEANOGRAPHY

1994
Faculty Publications and Presentations

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Batteen, M.L., Braccio, P.G., and Butler, C.L., "Visualization of the Leeuwin Current from a regional, fine resolution, primitive equation model," Fall American Geophysical Union Meeting, San Francisco, CA, December 1994.

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Chiu, C.-S., Miller, J.H., Denner, W.W., and Lynch, J.F., invited presentation, "Forward Modeling of the Barents Sea Tomography Vertical Line Array Data and Inversion Highlights," NATO Conference, La Spezia, Italy, 1994.

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Chu, P.C., "An integral method for determining North Atlantic circulation from hydrographic data," American Geophysical Union Ocean Science Meeting, San Diego, CA, 21-25 February 1994.

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Garwood, Jr., R.W. and Arata, B., "Verification of turbulence closure with ADCP observations and large eddy simulation of deep convection," presented at the Fall Meeting of the American Geophysical Union, San Francisco, CA, December 1994.

Harcourt, R. and Garwood, Jr., R.W., "Large eddy simulation of open ocean deep convection plumes," presented at the Fall Meeting of the American Geophysical Union, San Francisco, CA, December 1994.

Herbers, T.H.C., Elgar, S., and Guza, R.T., "Infragravity Waves," invited presentation at the ONR-sponsored Ocean Waves Workshop in Tucson, AZ, 16-18 March 1994.

Herbers, T.H.C., Elgar, S., and Guza, R.T., "Longterm Array Observations of Surface Waves," presented at Coastal Dynamics'94: An International Conference on the Role of Large Scale Experiments in Coastal Research, Barcelona, Spain, 21-25 February 1994.

Jessen, P.F., Ramp, S.R., and Garfield, N., "Hydrographic and ADCP Data from May 1993: Initial Conditions for a Mesoscale eddy in the California Current System," 1994 Ocean Sciences Meeting, San Diego, CA, 23 February 1994.

Jiang, L. and Garwood, R.W., "Dense bottom currents over a continental slope," ONR workshop, Modeling the dispersion of nuclear contaminations in the Arctic seas, Naval Research Laboratory, Monterey, CA, October 1994.

Jiang, L. and Garwood, R.W., "Three-dimensional bottom plumes over a continental slope," Annual Meeting of American Geophysical Union, San Francisco, CA, December 1994.

Jiang, L. and Garwood, Jr., R.W., "Dense bottom plumes over continental slopes," Fall Annual Meeting of the AGU, San Francisco, CA, 1994.

Kelly, K., Limeburner, R., Caruso, M., Beardsley, R., and Paduan, J., "Comparisons of drifter, altimeter and AVHRR data in the California Current," 41st Eastern Pacific Ocean Conference, Timberline, OR, September 1994.

Ko, D.S., Chu, P.C. and Mooers, C.N.K., "A South China Sea nowcast/forecast system," Western Pacific Geophysics Meeting, Hong Kong, 25-29 July 1994.

Lippmann, T. and Thornton, E.B., "The spatial distribution of wave rollers and turbulent kinetic energy on a barred beach," Coastal Dynamics '94, Barcelona, Spain, 1994.

Ly, L.N., "A Numerical Model of Air-Sea-Wave Interaction," Ocean Science Meeting, American Geophysical Union, EOS, O41A-19, San Diego, CA, February 1994.

Ly, L.N., Luong, P., O'Connor, W.P., Ezer, T., and Mellor, G.L., "A Numerical Study of Circulation and M2 Tide in the Yellow Sea," European Geophysical Society, XX General Assembly, Hamburg, Germany.

McClean, J.L., Batteen, M.L., and Cook, M., "Visualization of modeling simulations and comparisons of the California and Leeuwin Current circulations," Ocean Sciences Meeting, San Diego, CA, February 1994.

McClean, J.L., "Comparisons of Global Statistics from the NPS Quarter-Degree and LANL Sixth-Degree Models and Observations," presented at the U.S. WOCE Working Group on Numerical Modeling Meeting, Los Alamos, NM, September 1994.

McClean, J.L., Semtner, A.J., and Braccio, P., "Northeastern Pacific Interannual and Seasonal Variability from the Los Alamos Sixth-Degree Global Ocean Model," presented at The Eastern Pacific Conference, Mount Hood, OR, September 1994.

Paduan, J.D. and Garfield, N., "An animation of surface drifters and subsurface float trajectories in the Eastern Boundary Current," Eastern Pacific Oceanic Conference, Timberline, OR, 29 September 1994.

Paduan, J.D., Garfield, N., and Cook, M.S., "An animation of surface drifter and subsurface float trajectories in the Eastern Boundary Current," 41st Eastern Pacific Ocean Conference, Timberline, OR, September 1994.

Paduan, J.D. and Cook, M.S., "Remotely-sensed, two-dimensional surface currents in Monterey Bay from HF radar (CODAR) and satellite-tracked drifting buoys," EOS Transactions, AGU, Vol. 75, p. 180, February 1994.

Paduan, J.D., "Remotely sensed surface currents in Monterey Bay from multiple HF radar installations," IEEE, OCEANS-94 Conference, Brest, France, September 1994.

Paduan, J.D., Petruncio, E.T., Rosenfeld, L.K., Cook, M.S., and Foster, M., "Observations of surface currents in Monterey Bay from shore-based HF radars (CODAR)," Fourth Annual Monterey Bay Research Symposium, Monterey, CA, February 1994.

Paduan, J.D., "Drifter results from the NE Pacific (OCEAN STORMS) and Atlantic (SUBDUCTION)," Subduction/Semaphore Experiment Working Conference, Toulouse, France, September 1994.

Paduan, J.D., Zhou, M., and Niiler, P.P., "Drifter observations in the northeast Atlantic as part of the Subduction Experiment," Subduction Experiment Working Conference, Woods Hole, MA, November 1994.

Petruncio, E.T., Paduan, J.D., and Rosenfeld, L.K., "Characterization of tidal currents in Monterey Bay from remote and in-situ measurements," EOS Transactions, AGU, Vo. 75, p. 180, February 1994.

Petruncio, E.T., Paduan, J.D., and Rosenfeld, L.K., "Baroclinic tidal currents in Monterey Bay submarine canyon," EOS Transactions, AGU, Vo. 75, p. 336, December 1994.

Rago, T.A., Paquette, R.G., Garfield, N., Carter, E., and Collins, C.A., "First results from deployments of RAFOS floats off the Central California Coast," 1994 Ocean Sciences Meeting, San Diego, CA, 24 February 1994.

Rosenfeld, L.K. and Paduan, J.D., "Fronts and tides in Monterey Bay," 41st Eastern Pacific Ocean Conference, Timberline, OR, September 1994.

Semtner, A.J., "Simulations of global ocean circulation with eddy-resolving models," NOAA Symposium of Global Climate Change, Steamboat Springs, CO, 13-17 September 1994; ARPA Teraflop Computing Symposium, Monterey CA, 18-19 August 1994; International WOCE Numerical Meeting, Los Alamos NM, 19-22 September 1994; Invited Texas A&M Oceanography Seminar, Bryan TX, 1 December 1994; NASA Earth Observing System Workshop at MBARI, Monterey CA, 8-10 March 1994; CHAMMP Science Team Meeting, Albuquerque NM, 25-29 April 1994; Invited Florida State U. Computational Seminar, Tallahassee FL, 5 May 1994; NASA Ocean Data Assimilation Workshop, Irvine CA, 24-27 October 1994; Reviews of Large DOE Computational Projects, Bethedsa MD, 13 July 1994; US Global Change Program Symposium, Washington DC, 1-4 May 1994; Invited Univ. Calif. Marine Sciences seminar, Santa Cruz CA, 16 November 1994.

Stanton, T.P., "Advantages of high temporal/spatial resolution sampling of oceanic systems," Invited talk at MBARI, April 1994.

Steiner, M.T., Garfield, N., and Schwing, F.W., "Net non-tidal transport estimates for the Gulf of the Farallones, 1991-1992," 1994 Fall Meeting, American Geophysical Union, San Francisco, CA, 6 December 1994.

Stewart et al., "Shallow Water Ambient Noise Caused by Breaking Waves in the Surf Zone," Acoustical Society of America Meeting at Austin, TX, 28 November 1994.

Thornton, E.B. and Lippmann, T.C., "Longshore currents measured in the field," Coastal Dynamics '94, Barcelona, Spain, 1994.

Thornton, E.B., "Overview of the DUCK94 near shore experiment," Small-scale Granular Fluids Conference, 1994.

Von Der Heydt, K., Kemp, J., Lynch, J.F., Chiu, C.-S., and Miller, J.H., invited presentation, "Real-time telemetry of acoustic array data for tomography and other applications," 127th Meeting of the Acoustical Society of America, Cambridge, MA, 6-10 June 1994.

Zlotnicki, V., McClean, J.L., and Semtner, A.J., "Length Scales of Sea Level Variability from Topex/Poseidon and the NPS 1/4 Numerical Model," EOS Transactions, AGU, Vol. 75, No. 44, November 1994.

BOOK CONTRIBUTIONS

Chiu, C-S., Miller, J.H., and Lynch, J.F., "Inverse Techniques for Coastal Acoustic Tomography," Environmental Acoustics, D. Lee and M. Schultz (eds.), World Scientific, pp. 917-931, 1994.

Chiu, C.-S. and Ehret, L.L., "Three-dimensional acoustic mode propagation through the Gulf Stream," in Oceanography and Acoustics: Coupled Prediction and Propagation Models, Robinson and Lee, eds., American Institute of Physics, 1994.

Garwood, R.W., Jr., Isakari, S.M., and Gallacher, P.C., "Thermobaric convection," in The Polar Oceans and Their Role in Shaping the Global Environment, O. Johannessen, R. Muench and J. Overland, Eds., AGU Geophysical Monograph 85, 199-209, 1994.

Lynch, J.F., Newhall, A.E., Chiu, C.-S., and Miller, J.H., "Three-dimensional ray acoustics in a realistic ocean," in Oceanography and Acoustics: Coupled Prediction and Propagation Models, Robinson and Lee, eds., American Institute of Physics, 1994.

Miller, J.H., Chiu, C.-S., and Lynch, J.F., "Signal Processing for Coastal Acoustic Tomography," Environmental Acoustics, D. Lee and M. Schultz (eds.), World Scientific, pp. 899-916, 1994.

TECHNICAL REPORTS

Butler, C.L. and Batteen, M.L., "Modeling studies of the Leeuwin Current off Western and Southern Australia," Naval Postgraduate School Technical Report, NPS-OC-94-009, 1994.

Clynch, J.R., "High Latitude Aspects of a Differential GPS Aircraft Landing System," Naval Postgraduate School Technical Report, NPS-OC-94-004, July 1994.

Garfield, N., "Final Report: Evaluation of AVHRR Satellite Imagery for the Monitoring of Dredge Disposal Sites in the Southern California Bight," prepared by CIRIOS, Monterey, CA for EPA Marine Protection Program (W-7-11), 1994.

Haines, R.T. and Batteen, M.L., "A numerical study of interannual wind forcing effects on the California Current System, 1980-1983," Naval Postgraduate School Technical Report, NPS-OC-94-003, 1994.

Hu, C.-P. and Batteen, M.L., "A numerical study of the effects of wind forcing on the Chile Current System, Naval Postgraduate School Technical Report, NPS-OC-94-007, 1994.

Ly, L.N. and Chiu, C.-S., "Coastal Acoustic Tomography Data Constraints Applied to a Coastal Ocean Circulation Model," Naval Postgraduate School Technical Report, NPS-OC-94-001, 1994.

Vann, J.R. and Batteen, M.L., "A numerical study of wind forcing effects on the California Current System, Naval Postgraduate School Technical Report, NPS-OC-94-006, 1994.

OTHER

McClean, J.L., "Comparisons of Global Statistics from the NPS Quarter-Degree and LANL Sixth-Degree Models and Altimetry Data," CSIRO, Division of Fisheries and Oceanography, Tasmania, Australia, December 1994. **(seminar presentation)**

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Department of Operations Research

The research program in the department of Operations Research seeks to advance the field's state of knowledge in areas important to the Department of Navy, Department of Defense, and military planning. The study of operational problems often involves the structuring and integration of a number of interdisciplinary components, and the result is a very rich collection of applications. In many instances the methodologies developed are of general interest extending well beyond the problems that spawned them. In these cases our researchers will generalize their work and seek broader recognition.

This report contains the research summaries submitted by the department faculty for the calendar year 1994. For the convenience of the reader, a "summary of the summaries" appears in this cover statement. It is organized according to academic content, and the descriptions are largely in terms of the applied problems treated. Authors are identified in parentheses, and upon occasion, names of collaborators outside of our department are also identified. The specific areas currently represented are optimization, stochastic models and simulation, statistics and data analysis, combat modelling and war gaming. Sponsors are not immediately identified, but can be located in the individual summaries.

Tangible output appears in the form of student theses, reports to sponsors, conference presentations, Naval Postgraduate School technical reports, and refereed articles in the open professional literature. The research summaries of department faculty whose efforts involved projects sponsored outside of the department are reported by the department of the principal investigator. Also, research involving security classified matters are not identified here.

Optimization

Research continues into the development of theory and algorithms for the solution of large-scale optimization models; techniques were developed for the automatic exploitation of special structure in linear programs and in branch-and-bound solutions of integer programs (Bradley, Brown, Wood). These workers are also developing techniques to treat the network interdiction problems in illegal drugs moving through the air corridors of Latin America and the Caribbean. Large scale mixed integer linear programming models are under investigation (Wood). The HEAVY ATTACK modeling suite has received continuing attention (Brown, Hallwachs). Research into cost effective decision support methods for selecting combinations of anti-armor systems has been initiated (Brown, Dell).

Research continues on the optimization based decision tools developed for the analysis of Army base realignment and closure (Dell, Parry, Rosenthal). Previously developed models to aid in decisions relating to the consolidation and relocation of Army Recruiting stations have been modified to include additional constraints (Lawphongpanich). The optimization of the Army's recruiting advertising budget is receiving continued study (Sohn, Webb).

Stochastic Modeling and Simulation

Research and modeling into adaptive logistics and repair systems, etc. has been initiated (Gaver, Jacobs). Models of organic cell response to toxins continues (Gaver, Jacobs). Work has begun on the interactions between PBPK compartment models, dose-response models, and risk analysis (Gaver). Previous work on the reliability requirements of major caliber ammunition has led to the development of simulation supported analysis for use by the Gun Weapon System interaction group (Bailey). Work continues on the optimization of Coast Guard law enforcement assets (Dell, Bailey).

Computerized forecasting methods have been constructed to help anticipate the behavior of individual recruits participating in the Army's Delayed Entry Program (Milch, Whitaker). Other computerized management tools have been developed to facilitate the computation of loss rates from this program (Milch).

Statistics and Data Analysis

Analytical support of Navy operational test and evaluation continues (Gaver). Work has begun on the operational suitability of tactical unmanned ground vehicles (Gaver). Study continues on issues relating to confidence assessments for simulation models used by the Strategic Defense Initiative office (Kemple, Bailey, Sovereign, Purdue). Study of stratigraphic correlations in geological data continues (Kemple, Sadler, Droser, Strauss).

Models for forecasting recruiter productivity are under development (Larson). Research into the Army's Recruiting resource incentive systems is underway (Larson, Read, Keller). An analysis of bonus payments is receiving special attention (Larson). Technical analysis into the Navy's Troubled Systems Process for weapons systems is being performed (Woods). Work has begun on the generation and adaptation of algorithms for the Multi String Rearranging Memory (Read). Research into the fairness of the Schieffelin Award process has returned due to the appearance of data anomalies (Read).

Wargaming and Combat Analysis

Work has continued on the stochastic hierarchical modeling of theater combat, (Gaver, Jacobs, Parry). Work on the battle group logistics support system continues (Schrady, Owings). Measures of effectiveness for training for mission essential tasks are under study (Parry). Improved target acquisition algorithms have been developed for the TRADOC Janus(A) combat simulation model (Driels, Lind).

The chair of emerging technologies (Marshall) continues its activities. The modeling of aspects of Theater Missile Defense receives current attention series. The military worth of staying power is under continued study (Hughes).

RELIABILITY GOAL DETERMINATION FOR MAJOR CALIBER AMMUNITION

M.P. Bailey, Associate Professor
Department of Operations Research
Sponsor: Naval Surface Warfare Center, Crane Division

OBJECTIVE: To build an extensible object class library to facilitate heterogeneous modeling by members of the Gun Weapon System (GWS) Interaction Group, and to educate members of the group in the employment of this toolkit.

SUMMARY: Previous successful efforts to establish and evaluate reliability thresholds for major-caliber ammunition components have demonstrated to the GWS Interaction Group that a simulation-supported analysis was desirable. Other GWS component experts saw this approach as attractive, and are sponsoring the construction of the Naval Gun Weapon System Toolbox. This toolkit can provide a low fidelity representation of each GWS component: gun mount and loading system; fire control sensors; fire control computer; ammunition components; airborne and surface targets; and environmental conditions.

The utility of this model is tied directly to the extendibility of each component's model. Thus, the toolkit submodels must be low fidelity, but with data interfaces which can accommodate high fidelity models.

The GWS Interaction Group received several briefs during the construction of the model, especially during the design phase. The Group will receive software, training, documentation, and demonstrations of the toolkit. The precise nature of the documentation and training will be determined as the project develops.

PUBLICATION:

Bailey, M., Bowden, J., and Callahan, A., "Managing Ship Performance of Naval Gunfire Support Using Statistical Process Control," Military Operations Research, Vol. 1, pp. 5-12, 1994.

OTHER:

The investigator is preparing the software described above for release in 1995.

DOD KEY TECHNOLOGY AREA: Other (Reliability)

KEYWORDS: Shelf Life, Operations Support, Ammunition

INCORPORATING PERSISTENCE IN LARGE-SCALE OPTIMIZATION MODELS

G.H. Bradley, Professor
G.G. Brown, Professor
R.K. Wood, Associate Professor
Department of Operations Research
Sponsor: Air Force Office of Scientific Research

OBJECTIVE: This continuing research program develops theory and algorithms for detecting and exploiting special structure in large-scale optimization models.

SUMMARY: Techniques were developed for automatic exploitation of special structure in linear programs and in branch-and-bound solutions of integer programming problems. The X-System linear/non-linear/integer optimizer was successfully married with the GAMS algebraic modeling system to make this state-of-the-art optimizer more widely available to users, especially in the DoD.

PUBLICATIONS:

Brown, G., Coulter, D., and Washburn, A., "Sortie Optimization and Munitions Planning," Military Operations Research, Vol. 1, pp. 13-18, 1994.

Bradley, G. and Oliveira, H., "NETWORK ASSISTANT to Construct, Test and Analyze Graph and Network Algorithms," Computational Support for Discrete Mathematics, N. Dean and G. Shannon (eds.), American Mathematical Society, pp. 75-84, 1994.

Brown, G. and Olson, M., "Dynamic Factorization in Large-Scale Optimization," Mathematical Programming, Vol. 64, pp. 17-51, 1994.

Brown, G., Lawphongpanich, S., and Podolak-Thurman, K., "Optimizing Ship Berthing," Naval Research Logistics, Vol. 41, pp. 1-15, 1994.

Bradley, G., "Using the Graph Coloring Workbench for Final Exam Scheduling," Technical Note, May 30 1994.

CONFERENCE PRESENTATIONS:

Brown, G., Arntzen, B., Harrison, T., and Trafton, L., "Global Supply Chain Management at Digital Equipment Corporation," 35 minute videotape of 1994 International Management Science Achievement Award Competition, ORSA/TIMS Joint National Meeting, Boston, MA, 24-27 April 1994, College on the Practice of Management Science, Copyright 1994 and distributed by The Institute of Management Sciences, Providence, RI.

Brown, G., Artnzen, B., Harrison, T., and Trafton, L., "Global Supply Chain Management at Digital Equipment Corporation," TIMS/CPMS Prize Competition, ORSA/TIMS Joint National Meeting, Boston, MA, 24-27 April 1994.

Wood, K. and Brown, G., "Solving Large-Scale Multicommodity Network Flow Problems by Dual Decomposition," ORSA/TIMS Joint National Meeting, Boston, MA, 24-27 April 1994.

Wood, K., Brown, G., and Sweeny, K., "Optimally Allocating Marine Corps Officers to Peacetime Billets," ORSA/TIMS Joint National Meeting, Boston, MA, 24-27 April 1994.

Wood, K., Brown, G., and Justice, B., "A Model for Scheduling Courses at the Marine Corps Communications-Electronics School," ORSA/TIMS Joint National Meeting, Boston, MA, 24-27 April 1994.

Brown, G., Artnzen, B., and Harrison, T., "Integrated Production and Distribution Decisions in a Global Manufacturing Environment," ORSA/TIMS Joint National Meeting, Boston, MA, 24-27 April 1994.

Bradley, G. and Golmayo, P., "Final Examination Scheduling Heuristic and Graph Coloring," ORSA/TIMS Joint National Meeting, Detroit, MI, 23-26 October 1994.

THESES DIRECTED:

Wu, H., "A Prototypic Model for Scheduling Courses at the Naval Postgraduate School," Master's Thesis, December 1993.

Boerman, D., "Finding an Optimal Path Through a Mapped Minefield," Master's Thesis, March 1994.

Nieto, J., "Multigrid Methods in Network Optimization: Overview and Appraisal," Master's Thesis, March 1994.

Golmayo, P., "A Computer Assisted Final Exam Scheduling System for the Naval Postgraduate School," Master's Thesis, March 1994.

OTHER:

Brown, G, Arntzen, B., Harrison, T., and Trafton, L., "Global Supply Chain Management at Digital Equipment Corporation," to appear in INTERFACES, Vol. 25, January-February 1995. (Nominated for the 1994 International Management Science Achievement Award).

Wood, K. and Washburn, A., "Two Person Zero-Sum Games for Network Interdiction," to appear in Operations Research, Vol. 43, March-April 1995.

Brown, G, Bausch, D., and Ronen, D., "Consolidating and Dispatching Truck Shipments of Mobil Heavy Petroleum Products," to appear in INTERFACES, Vol. 25, March-April 1995.

Wood, K., Cormican, K., and Morton, D., "Stochastic Network Interdiction," manuscript in progress.

Wood, K. and Morton, D., "Solving Stochastic Network Capacity Expansion Problem," manuscript in progress.

Brown, G., Dell, R., and Farmer, R., "Scheduling Coast Guard District Cutters," manuscript in progress.

Brown, G., Cormican, K., Lawphongpanich, S., and Widdis, D., "Optimizing Submarine Berthing," manuscript in progress.

DOD KEY TECHNOLOGY AREA: Design Automation, Software, Other (Optimization)

KEYWORDS: Large-scale Optimization, Scheduling, Modeling Language

LARGE-SCALE OPTIMIZATION

G.H. Bradley, Professor
G.G. Brown, Professor
R.K. Wood, Associate Professor
Department of Operations Research
Sponsor: Office of Naval Research

OBJECTIVE: This continuing research program develops theory and algorithms for solution of large-scale optimization models.

SUMMARY: Techniques were developed for game theoretic modeling and methods to solve network interdiction problems for the optimal allocation of airborne assets to the interdiction of illegal drugs moving through air corridors of the Caribbean and Latin America. Separately, a system of portable C program modules has been developed to support the construction of efficient graph and network algorithms with capabilities to generate large-scale structured random graphs and networks and analyze test results.

PUBLICATIONS:

Brown, G., Coulter, D., and Washburn, A., "Sortie Optimization and Munitions Planning," Military Operations Research, Vol. 1, pp. 13-18, 1994.

Bradley, G. and Oliveira, H., "NETWORK ASSISTANT to Construct, Test and Analyze Graph and Network Algorithms," Computational Support for Discrete Mathematics, N. Dean and G. Shannon (eds.), American Mathematical Society, pp. 75-84, 1994.

Brown, G. and Olson, M., "Dynamic Factorization in Large-Scale Optimization," Mathematical Programming, Vol. 64, pp. 17-51, 1994.

Brown, G., Lawphongpanich, S., and Podolak-Thurman, K., "Optimizing Ship Berthing," Naval Research Logistics, Vol. 41, pp. 1-15, 1994.

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Brown, G., Artnzen, B., Harrison, T., and Trafton, L., "Global Supply Chain Management at Digital Equipment Corporation," TIMS/CPMS Prize Competition, ORSA/TIMS Joint National Meeting, Boston, MA, 24-27 April 1994.

Wood, K. and Brown, G., "Solving Large-Scale Multicommodity Network Flow Problems by Dual Decomposition," ORSA/TIMS Joint National Meeting, Boston, MA, 24-27 April 1994.

Wood, K., Brown, G., and Sweeny, K., "Optimally Allocating Marine Corps Officers to Peacetime Billets," ORSA/TIMS Joint National Meeting, Boston, MA, 24-27 April 1994.

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Boerman, D., "Finding an Optimal Path Through a Mapped Minefield," Master's Thesis, March 1994.

Nieto, J., "Multigrid Methods in Network Optimization: Overview and Appraisal," Master's Thesis, March 1994.

Golmayo, P., "A Computer Assisted Final Exam Scheduling System for the Naval Postgraduate School," Master's Thesis, March 1994.

OTHER:

Brown, G, Arntzen, B., Harrison, T., and Trafton, L., "Global Supply Chain Management at Digital Equipment Corporation," to appear in INTERFACES, Vol. 25, January-February 1995. (Nominated for the 1994 International Management Science Achievement Award).

Wood, K. and Washburn, A., "Two Person Zero-Sum Games for Network Interdiction," to appear in Operations Research, Vol. 43, March-April 1995.

Brown, G, Bausch, D., and Ronen, D., "Consolidating and Dispatching Truck Shipments of Mobil Heavy Petroleum Products," to appear in INTERFACES, Vol. 25, March-April 1995.

Wood, K., Cormican, K., and Morton, D., "Stochastic Network Interdiction," manuscript in progress.

Wood, K. and Morton, D., "Solving Stochastic Network Capacity Expansion Problem," manuscript in progress.

Brown, G., Dell, R., and Farmer, R., "Scheduling Coast Guard District Cutters," manuscript in progress.

Brown, G., Cormican, K., Lawphongpanich, S., and Widdis, D., "Optimizing Submarine Berthing," manuscript in progress.

DOD KEY TECHNOLOGY AREA: Design Automation, Software, Other (Optimization)

KEYWORDS: Large-scale Optimization, Scheduling, Modeling Language

MODELING RESOURCE ALLOCATION IN WEAPON SYSTEMS ACQUISITION

G.G. Brown, Professor
R.F. Dell, Assistant Professor
Department of Operations Research
Sponsor: Office of the Secretary of Defense, Program Analysis & Evaluation, Land Forces Division

OBJECTIVE: This research provided optimization-based decision support for selecting combinations of antiarmor systems to provide the greatest effectiveness given budget limitations through the year 2010.

SUMMARY: The investigators have provided consultation, research, support, and development of optimization models and supporting data for long-term capital budgeting referred to by the sponsor as: Resource Allocation in Weapon Systems Acquisition. The models identify optimal combinations of weapons systems which provide the greatest effectiveness given budget limitations over a future planning horizon. Initial general model design and implementation of a proof prototype have been completed. The models have been refined for use with emergent issues in multi-service acquisition of alternate antiarmor weapons systems.

OTHER:

"An Optimization Model for Antiarmor Weapon System Acquisition," A. Idhe, Master's Thesis in Operations Research, due March 1995 (R. Dell advisor).

"Weapon System Acquisition Optimizer," (R. Dell with G. Brown), 15 November 1994, a portable decision support system expressed in the algebraic modeling language GAMS.

DOD KEY TECHNOLOGY AREA: Other (Optimization)

KEYWORDS: Optimization, Capital Budgeting, Software Prototype

OPTIMIZATION OF MUNITIONS MODELING

G.G. Brown, Professor
T.E. Halwachs, Lecturer
Department of Operations Research
Sponsor: Headquarters, United States Air Force, USAF/XOFW, The Pentagon

OBJECTIVE: This research provides continuing support for Air Force munitions planning.

SUMMARY: The HEAVY ATTACK modeling suite has received continued research, support, and development: HEAVY ATTACK supported a $2 billion purchase request this year. The embedded nonlinear optimization models have been linked with graphical user interfaces. A technical question from House Appropriations Committee staff was answered. Considerable analysis has been performed for comparing the alternate mathematical formulations of a set of related USAF munitions and aircraft planning models.

PUBLICATIONS:

Brown, G., Coulter, D., and Washburn, A., "Sortie Optimization and Munitions Planning," Military Operations Research, Vol. 1, pp. 13-18, 1994.

Brown, G. and Olson, M., "Dynamic Factorization in Large-Scale Optimization," Mathematical Programming, Vol. 64, pp. 17-51, 1994.

DOD KEY TECHNOLOGY AREA: Other (Optimization)

KEYWORDS: Nonlinear Optimization, Munitions Procurements, Graphical User Interface

CAPACITY PLANNING AND BOTTLENECK MANAGEMENT

A.H. Buss, Visiting Assistant Professor
Department of Operations Research
Sponsor: Unfunded

OBJECTIVE: This research studied optimal and heuristic capacity acquisition in stochastic production environments. Operational and economic impacts, and their interactions, were considered.

SUMMARY: The management of capacity and its interaction with shop-floor performance in realistic (i.e. stochastic) settings was studied with emphasis on financial/economic measures of performance. The economic bottleneck concept, which we introduced, provided the ideal indicator for capacity acquisition. The research has moved in the study of the capacity decision in an international setting (a firm with plants in several countries). We showed that for such a firm the use of excess capacity is more effective as a hedge against currency fluctuations than directly taking positions in the currency markets.

PUBLICATIONS:

Buss, A.H., Lawrence, S.R., and Kropp, D.H., "Volume and Capacity Interaction in Facility Design," IIE Transactions, Vol. 26, No. 4, pp. 36-49, 1994.

Lawrence, S.R. and Buss, A.H., "Shifting Production Bottlenecks: Causes, Cures, and Conundrums," Production and Operations Management, Vol. 3, No. 1, pp.21-37, 1994.

Lawrence, S.R. and Buss, A.H., "Economic Analysis of Production Bottlenecks," to appear in Mathematical Problems in Engineering.

CONFERENCE PRESENTATIONS:

Buss, A.H. and Lawrence, S.R., "Use of the Economic Bottleneck in Capacity Planning and Facilities Design," presented at the 1994 Workshop on Capacity Planning and Management, University of Florida, April 1994.

Lawrence, S.R. and Buss, A.H., "Excess Capacity and International Production Arbitrage," presented at the 1994 Workshop on Capacity Planning and Management, University of Florida, April 1994.

Buss, A.H. and Lawrence, S.R., "Economic Bottlenecks and Economic Balance," presented at ORSA/TIMS Joint National Meeting, Detroit, MI, October 1994.

OTHER:

Buss, A.H. and Lawrence, S.R., "Use of Capacity as a Hedge Against Currency Fluctuations," Naval Postgraduate School Technical Report, in preparation.

DOD KEY TECHNOLOGY AREA: Other (Stochastic Production)

KEYWORDS: Monte Carlo Simulation, Capacity Analysis, Bottlenecks

STOCHASTIC PROJECT MANAGEMENT

A.H. Buss, Visiting Assistant Professor
Department of Operations Research
Sponsor: Naval Postgraduate School

OBJECTIVE: This research develops optimal and heuristic methods for scheduling activities in projects in which the duration is random. The emphasis is on economic criteria, particularly expected net present value (ENPV).

SUMMARY: This was the only research of which we are aware on optimal economic decisions for stochastic project networks. Careful consideration of the decisions under a project manager's control for random-duration projects involved defining the delay of an activity as the amount of time after its earliest start time an activity is initiated, given the realization of its predecessor activities' durations. Using ENPV criterion, we first determined the optimal delay in a Markov Project Network (MAN). Then, to study the robustness of the solution, a simulation model was constructed to numerically solve non-Markov projects. The work is continuing with extensions of the method to incorporate penalties, deadlines, and other constraints.

PUBLICATIONS:

Buss, A.H. and Rosenblatt, M.J., "Activity Delay in Stochastic Project Networks," to appear in Operations Research.

Buss, A.H. and Rosenblatt, M.J., "Maximizing Expected Present Value in Projects with Stochastic Activity Durations: The Impact of Various Probability Distributions," Working Paper, 1994.

OTHER:
Buss, A.H. and Rosenblatt, M.J., "Crashing Activities in Stochastic Project Networks," Naval Postgraduate School Technical Report, in preparation.

DOD KEY TECHNOLOGY AREA: Other (Networks)

KEYWORDS: Project Management, Mauhou Processes, Monte Carlo Simulation

MARKETING/OPERATIONS INTERFACE

A.H. Buss, Visiting Assistant Professor
Department of Operations Research
Sponsor: Unfunded

OBJECTIVE: This research investigated the joint use of Marketing and Operations decisions with the goal of improving profitability.

SUMMARY: Optimal retailer decisions for items under trade promotion were determined, taking into account the inherent randomness in consumer response through demand elasticities, operational factors such as holding costs, and length of promotion. The first paper dealt with a single brand, with the retailer maximizing promotional profits for that brand. The second extended the model to include multiple brands within a category, with demand cross-elasticities playing a major role.

PUBLICATION:

Buss, A.H. and Armstrong, M.K., "Retail Response to Trade Promotions: Maximizing Category Profits under Stochastic Demand," Working paper.

CONFERENCE PRESENTATION:

Armstrong, M.K. and Buss, A.H., "Retail Response to Trade Promotions: Maximizing Category Profits under Stochastic Demand," presented at the 1994 Marketing Science Conference, Tucson, AZ, March 1994.

OTHER:

Armstrong, M.K. and Buss, A.H., "Retail Response to Trade Promotion under Stochastic Demand," under revision for Management Science.

DOD KEY TECHNOLOGY AREA: Other (Marketing)

KEYWORDS: Promotion, Decision Analysis, Pricing

INTERACTIVE SIMULATION AND OPTIMIZATION FOR SELECTING COAST GUARD LAW ENFORCEMENT ASSETS

R.F. Dell, Assistant Professor
M.P. Bailey, Associate Professor
Department of Operations Research
Sponsor: United States Coast Guard Research and Development Center, Systems Analysis Branch

OBJECTIVE: The goal of this multi-year research project is to aid in the development of LESIM: Law Enforcement Simulation. LESIM is an on-going United States Coast Guard (USCG) research effort to develop a simulation model capable of assisting with decisions concerning USCG resource allocation, resource scheduling, and tactics.

SUMMARY: The second year of this multi-year project was completed in 1994. The investigators conducted basic research related to the LESIM model and provided continued support to the sponsor. Support was primarily related to products delivered during the first year which include: an optimization model to schedule both Coast Guard district assests and Atlantic Area assests operating within the seventh and eighth Coast Guard districts and a simulation model to test and validate the LESIM model. The investigators also participated in a command brief by the sponsor at Coast Guard Headquarters.

PUBLICATION:

Bailey, M.P., Dell, R.F., and Glazebrook, K.D., "Simulation-Based Dynamic Optimization: Planning United States Coast Guard Law Enforcement Patrols," Proceedings of the 1994 Winter Simulation Conference, J.D. Tew, S. Manivannan, D.A. Sadowski, and A.F. Seila (eds.), 1994.

CONFERENCE PRESENTATION:

Bailey, M.P., Dell, R.F., and Glazebrook, K.D., "Simulation-Based Dynamic Optimization: Planning United States Coast Guard Law Enforcement Patrols," The International Society for Computer Simulation 1994 Winter Simulation Conference, 11-14 December 1994.

OTHER:

Paper Submitted: Brown, G.G., Dell, R.F., and Farmer, R.A., "Scheduling Coast Guard District Cutters," submitted to Interfaces, May 1994.

DOD KEY TECHNOLOGY AREA: Other (Simulation and Optimization)

KEYWORDS: Interactive Simulation and Optimization

OPTIMALLY STATIONING UNITS TO BASES (OSUB): A MODEL FOR BASE CLOSURE

R.F. Dell, Assistant Professor
S.H. Parry, Professor
R.E. Rosenthal, Professor
Department of Operations Research
Sponsor: Office Chief of Staff of the Army, DACS-DM(TABS)

OBJECTIVE: The goal of this multi-year research project is to provide optimization based decision making tools for the analysis of Army base realignment and closure.

SUMMARY: During the third year (1994) of this multi-year project, the investigators have supported the sponsor's use of an optimization model delivered during the first year of the project. The optimization model (referred to as OSUB) is specifically designed to generate realignment and closure recommendations for maneuver and training installations. The investigators have also developed and supported an optimization model for scheduling base realignment and closure actions.

PUBLICATION:

Dell, R.F., Fletcher, C., Parry, S.H., and Rosenthal, R.E., "Modeling Army Maneuver and Training Base Realignment and Closure," Naval Postgraduate School Technical Report, NPS-OR-94-002, January 1994.

THESES DIRECTED:

Free, E.J., "An Optimization Model for Scheduling Army Base Realignment and Closure Actions," Master's Thesis, September 1994.

Holmes, R.D., "A Multi-Commodity Network Design for the Defense Logistics Agency," Master's Thesis, June 1994.

OTHER:

Software: Optimization model developed to schedule Army Base Realignment and Closure Actions.

DOD KEY TECHNOLOGY AREA: Other (Optimization)

KEYWORDS: Optimization Modeling of Base Realignment and Closure

THE MILITARY WORTH OF STAYING POWER

W.P. Hughes, Jr., Senior Lecturer
Department of Operations Research
Sponsor: Naval Surface Warfare Center, Carderock

OBJECTIVE: To evaluate the military worth of a contemporary warship's ability to continue fighting after taking one or more hits, which is its "staying power." Emphasis is on missile hits.

SUMMARY: The research was completed first in unclassified form and a draft delivered to the sponsor in September 1993. After a review, the sponsor decided that the study would be more useful if a version using classified information were developed. The classified study was delivered in May 1994.

The principal conclusions of the study are:

In missile combat the two most important advantages a force can have are:

- first detection and targeting such that all enemy units posing a threat are put out of action before they can reply.
- survivability through defense in depth.

These two advantages cannot be depended on in joint littoral warfare operations because of compressed battle space. In an exchange of missile salvoes, highly capable surface warships with weak staying power are liable to suffer severe losses to a qualitatively inferior enemy who conducts a bold attack.

Contemporary designs of multipurpose surface combatants such as the CG-47 and DDG-51 are out of balance, in the sense that they have strong offensive and defensive firepower but weak staying power. The result is an unstable situation in littoral operations.

Combat stability will be restored by a balanced design: i.e., one with greater staying power. The benefits from enhancing staying power are to sustain all other attributes of a warship, preserve its deliverable fighting power, and help to assure that a superior force will consistently prevail over a nominally inferior one.

PUBLICATIONS:

Hughes, W.P., Jr., "A Salvo Model of Warships in Missile Combat Used to Evaluate Their Staying Power," Naval Research Logistics, accepted for Publication, Fall 1994.

Hughes, W.P., Jr., "The Military Worth of Staying Power," Naval Postgraduate School Technical Report, NPS-OR-94-008, May 1994.

THESES DIRECTED:

Poulos, A., LT, Hellenic Navy, "An Anti-aircraft Warfare Study for a Small Size Navy," Master's Thesis, March 1994.

Schulte, J., LT, USN, "An Analysis of the Historical Effectiveness of ASCMs in Littoral Warfare," Master's Thesis, September 1994.

Jarek, M., LT, USN, "Vertical Launch System Loadout Model," Master's Thesis, September 1994.

DOD KEY TECHNOLOGY AREA: Other (Naval Combat)

KEYWORDS: Naval Combat, Survivability, Vulnerability, Warship

VARIABLE RESOLUTION COMBAT SIMULATION

W.G. Kemple, Assistant Professor
M.P. Bailey, Assistant Professor
M.G. Sovereign, Professor
P. Purdue, Professor and Chairman
Department of Operations Research
Sponsor: Strategic Defense Initiative Office (SDIO), Washington, D.C.

OBJECTIVE: The objectives of this two year project were threefold: to participate in the development and refinement of procedures to be used in performing confidence assessments on simulation models nominated for inclusion in the SDIO Analytical Tool Box (ATB); to participate in confidence assessment teams formed to evaluate models nominated for inclusion in the ATB; and to develop a taxonomy of model dimensionality and resolution to be used in confidence assessments.

SUMMARY: Funding for the ATB was eliminated for FY94, and all confidence assessments were cancelled. The ATB Project Officer and the P.I. negotiated the return of all carryover funding not already programmed. The only activity for FY94 was to complete a student thesis, developing the taxonomy of model dimensionality and resolution that was to be used in confidence assessments.

THESIS DIRECTED:

Vaseghi, G.H., "Model Resolution Taxonomy," Master's Thesis, September 1994.

DOD KEY TECHNOLOGY AREA: Software

KEYWORDS: Simulation, Confidence Assessment, Theater Missile Defense

STRATIGRAPHIC CORRELATION AS CONSTRAINED OPTIMIZATION: EXTENDING GRAPHICAL CORRELATION TO N DIMENSIONS

W.G. Kemple, Assistant Professor
Department of Operations Research
Collaborative research with:
Peter M. Sadler, Professor
Mary L. Droser, Assistant Professor
David Strauss, Professor
University of California, Riverside
Sponsor: National Science Foundation, Washington, D.C.

OBJECTIVE: An ongoing research program to solve the stratigraphic correlation problem (fusing geological data to develop a time scale for rocks based on fossils they contain) by combining expert knowledge with techniques from operations research.

SUMMARY: Three colleagues at University of California, Riverside and I were awarded parallel two-year grants by the NSF for collaborative research to continue development of our methodology and apply it to fossil data from the mid-Ordovician period, from the Great Basin of California, Nevada, and Utah. Kemple has completed and delivered to the researchers at Riverside a new, greatly enhanced FORTRAN program that reduces solution times by approximately 1.5 orders of magnitude. Graphics have been developed by Sadler and added to the new program to aid in tuning the solution algorithm and to allow the paleontologists to monitor the solution as it develops. The paleontologists on the team, along with graduate students, have collected fossil data from key sections and the literature, and are preparing the data for analysis with the new program. Sadler and Kemple gave an invited presentation at an SEPM (Society For Sedimentary Geology) research conference, and Kemple participated in a three day geological filed trip to examine and collect data from several K/T boundary sections along the Brazos River and Middle Albian, Fredricksburg
Sequence sections in central Texas.

PUBLICATION:

Kemple, W., Sadler, P., and Strauss, D., "Extending Graphic Correlation to Many Dimensions: Stratigraphic Correlation as Constrained Optimization," SEPM Special Publication #52 (Graphic Correlation: the Method and its Application), in press.

CONFERENCE PRESENTATION:

Sadler, P. and Kemple, W., "Extending Graphical Correlation to Many Dimensions," presented at the SEPM Research Conference on Graphical Correlation and the Composite Standard: the Methods and their Application, Houston, TX, November-December 1994.

DOD KEY TECHNOLOGY AREA: Software

KEYWORDS: Graphical Correlation, Stratigraphic Correlation, Combinatorial Optimization, Simulated Annealing

ANALYSIS OF RECRUITING RESOURCE PLANNING SYSTEM

H.J. Larson, Professor
C. Keller, Assistant Professor
R.R. Read, Professor
Department of Operations Research
Sponsor: USAREC

OBJECTIVE: The original goal was to reconcile and explain outputs produced by two different resource planning systems used by the Army Recruiting Command. This was later amended to estimate the elasticities of the enlistment bonus and educational benefit incentives employed in one of these models.

SUMMARY: Background work includes familiarization with the Forecasting and Allocation of Army Recruiting Resources Study (FAARRS) and the Sequential Hierarchical Allocation of Resource Elements (SHARE) model as well as the Job performance Measures/ Cost Performance Tradeoff (JPM/CPT). The outputs of the former two models were initially found to found to differ substantially from those of the latter, based upon the same inputs. Subsequent to the start of the work on this effort, a new study re-estimated the elasticities used in the JPM/CPT model, and these brought the outputs more in line with each other. It is thought that the elasticities for the enlistment bonuses and educational benefits from this new study are still not very accurate. The current focus of this project is the accurate estimation of these two elasticities. Some review of previous modelling efforts has been accomplished. A family of new models is being considered. Data requirements are being identified. Relevant recent data is being sought.

DOD KEY TECHNOLOGY AREA: Othe (Cost Benefit Analysis)

KEYWORDS: Econometrics, Elasticity, Multi-equation Regression

ANALYSIS OF RECRUITING BONUS PAYMENTS

H.J. Larson, Professor
Department of Operations Research
Sponsor: US Army Recruiting Command, Fort Knox, KY

OBJECTIVE: Among other incentives, the Army is authorized to offer enlistment bonuses for certain Occupational Specialties to help influence the numbers of recruits entering these fields. The amounts offered have varied over recent years, as have the time periods over which they were available. This study investigated the bonus amounts offered and the resulting numbers of enlistments produced to identify "best" bonus amounts to offer.

SUMMARY: The United States Army Recruiting Command (USAREC) provided the number of enlistment contracts signed, by high school graduates in categories I through IIIa (high quality), for fiscal years 1988 through 1993. Enlistment bonuses are offered to attract these individuals to the Army, and to aid in channeling them into specific Military Occupational Specialties (MOSs). The bonus amounts offered, and the particular MOSs with which they were associated, varied over the period studied in rather arbitrary fashion.

This study analyzed the numbers of contracts signed in 8 different MOS categories over these 6 fiscal years, seeking to identify the "best" enlistment bonus to offer for each such MOS. Linear spline models with one knot were used for each MOS; weighted least squares was used to estimate the parameters of the spline, including the location of the knot. Available data on unemployment rates were also used and found to have minimal effect on the resulting knot location. The estimated knot locations may then be used to identify the enlistment bonuses to offer for those MOS categories.

OTHER:

Larson, H.J., "Analysis of Recruiting Bonus Payments," Naval Postgraduate School Technical Report, in progress.

Larson, H.J., "Analysis of Recruiting Bonus Payments," to be presented at ORSA/TIMS conference, April 1995.

DOD KEY TECHNOLOGY AREA: Other (Manpower)

KEYWORDS: Enlistment Bonus, Splines, Military Benefits

MODELS FOR MANAGING RECRUITING PRODUCTION

H. Larson, Professor
S. Lawphongpanich, Associate Professor
Department of Operations Research
Sponsor: Navy Recruiting Command

OBJECTIVE: To develop models for forecasting recruiter productivity and contract production from 'Grad' and Will-Grad' markets.

SUMMARY: This project will address two problems in recruiting. One is the problem of forecasting recruiter productivity and the other is the modeling of 'Grad' and 'Will Grad' markets. The first problem is to determine the appropriate probability distribution that describes the number of enlistment contracts a recruiter can produce in a given time period, e.g., a month. The second problem is to identify whether or not there is a relationship between the enlistment data from each market and factors such as unemployment rate, time of year, current military pay and level of advertising. This project was started in September 1994. Some data were collected and preliminary analyses were made prior to this report.

DOD KEY TECHNOLOGY AREA: Other (Manpower)

KEYWORDS: Recruiter Productivity, Recruiter Goals, Poisson Regression

OPTIMAL REALIGNMENT OF THE U.S. ARMY RECRUITING STATIONS

S. Lawphongpanich, Associate Professor
Department of Operations Research
Sponsor: U.S. Army Recruiting Command

OBJECTIVE: To develop an optimization based tool for realigning Army Recruiting stations

SUMMARY: The decision to close, consolidate and relocate recruiting stations has a profound impact on the Army's recruiting efforts. During the past year, the command has gone through another reorganization of its recruiting stations. Models previously developed were modified to include additional constraints concerning the span of control and minimum station size. In addition, models were extended to include recruiting for Army Reserve and student nurses as well.

CONFERENCE PRESENTATION:

Lawphongpanich, S., "Models for Recruiting Station Realignment," Joint Marketing, Analysis, and Research Committee, 12 October 1994.

THESES DIRECTED:

Teague, M.J., CPT, USA, "An Optimal Allocation of Army Recruiting Stations with Active and Reserve Recruiters," Master's Thesis, June 1994.

Matuszewski, D.F., CPT, USA, "Optimization Models for Placing Nurse Recruiters," Master's Thesis, September 1994.

DOD KEY TECHNOLOGY AREA: Computers

KEYWORDS: Optimization, Location Analysis, Recruiting

MODEL FOR TERRITORY REALIGNMENT

S. Lawphongpanich, Associate Professor
T. Halwachs, Adjunct Professor
Department of Operations Research
Sponsor: Navy Recruiting Command

OBJECTIVE: To study the effects of distance measures on Optimal Realignment Models.

SUMMARY: This is a continuation of the project titled 'Optimal Recruiting Structure' that proposed an optimization model for realigning Naval recruiting stations. The model assumes that distances between any two points can be approximated using the great circle distance, i.e., the straight-line distance with adjustment for earth's curvature. In this project, distances between two points were calculated by finding a shortest path between the points using road network information from a database called MAPINFO. The results from the model using the two distance measures, great circle and shortest path, are similar suggesting that the great circle distance can be used to approximate distances in realigning Navy recruiting stations.

CONFERENCE PRESENTATION:

Lawphongpanich, S., "Models for Recruiting Station Realignment," Joint Marketing, Analysis, and Research Committee, 12 October 1994.

OTHER:

Lawphongpanich, S. and Halwachs, T., "Effects of Distance Measures of Models of Recruiting Station Realignment," Naval Postgraduate School Technical Report, in preparation.

DOD KEY TECHNOLOGY AREA: Computers

KEYWORDS: Optimization, Location Analysis, Recruiting

IMPROVED TARGET ACQUISITION ALGORITHMS FOR JANUS (A)

J. Lind, Adjunct Professor
Department of Operations Research
M. Driels, Professor
Department of Mechanical Engineering
Sponsor: TRAC Monterey

OBJECTIVE: The goal of this project is to enhance the TRADOC Analysis Command *Janus (A)* combat simulation model by incorporating new algorithms and data that more closely approximate real-world target acquisition performance.

SUMMARY: In FY-1994 the project explored two avenues for improving target acquisition predictions in *Janus (A)*. First, a new 1-meter-resolution database for Ft. Hunter-Liggett terrain was reviewed and data organization was analyzed. Possible effects of using such precise data for target acquisition modeling were determined. Based on the terrain database, new algorithms were written to model more precisely the line of sight between a sensor and a target, and a technique for visually presenting the results was developed. Second, several hundred factors reported in the literature to affect the human's ability to detect and recognize a target were reviewed and evaluated for possible inclusion in *Janus (A)* programs. Of these, 37 factors were identified as candidates, and a programmable model was proposed for each. A fuzzy logic program was prepared to model six of these factors. Work is continuing on this project in FY-1995 to evaluate existing target acquisition models and to improve the modeling of human performance.

PUBLICATION:

Lind, J.H., "Target Acquisition Models for Janus (A)," Naval Air Warfare Center Weapons Division Technical Memorandum 7811, in press.

THESES DIRECTED:

Dau, F.W., LT, USN, "Improving Detection and Acquisition in Janus (A) Using the Pegasus Database," Master's Thesis, March 1994.

Miller, M.L., LT, USN, "Improvement of Janus Target Acquisition Using a Fuzzy Logic Human Factors Model," Master's Thesis, March 1994.

OTHER:

This project has generated an additional FY-1995 NPS study for TRAC Monterey: *Prototype Line-of-Sight and Target Acquisition Software for Janus (A) Very-High-Resolution Terrain Database.*

DOD KEY TECHNOLOGY AREA: Software, Human-System Interfaces

KEYWORDS: Target Acquisition, Janus (A), Combat Simulation, Line-of-sight, Human Factors, Human Performance

BMDO RESEARCH SUPPORT

K.T. Marshall, Professor
Department of Operations Research
Sponsor: Ballistic Missile Defense Office

OBJECTIVE: This is in support of the Theater Missile Defense (TMD) Group within BMDO. It is based on the adaptation of Anti-Submarine Warfare (ASW) philosophy, tactics and systems, to land-based search and detection.

SUMMARY: Funding for this project started in September 1993. Two quarters were devoted to this project in FY94. Principal activities in the Operations Research Department included completion of a technical report on quantifying counterforce and active defense in countering theater ballistic missiles (TBM's). It has been shown that effective counterforce will be a necessary part of TMD. Effort is now concentrated on how to achieve effective counterforce. Progress has been made on modeling searching along roads, placing of unattended ground sensors to monitor traffic on road networks, and the role of unmanned air vehicles. Principal activities in the National Security Affairs Department included showing how the philosophy that influenced ASW operations can be used to guide counterforce attacks against mobile missiles. Support was given in the last quarter of 1994 to the Physics Department for investigating the use of satellites in counterforce. Support was also given in the last quarter of 1994 to the Aeronautical Engineering Department for work on propulsion for a rocket to be fired from a UAV.

PUBLICATIONS:

Marshall, K.T., "The Roles of Counterforce and Active Defense in Countering Theater Ballistic Missiles," Naval Postgraduate School Technical Report, NPS-OR-94-012, September 1994, (to appear in Military Operations Research).

"Allies and Theater Missile Defense: The Benefits of an ASW Approach to Counterforce," Naval Postgraduate School Technical Report, NPS-OR-94-007, September 1994, (to be published by the U.S. Army War College Strategic Studies Institute).

THESIS DIRECTED:

Soutter,, P.A., LT, USN, "On the use of Unmanned Aerial Vehicles to Search for Tactical Ballistic Missile Transporter Erector Launchers," Master's Thesis, March 1994.

DOD KEY TECHNOLOGY AREA: Other (Operations Research)

KEYWORDS: Search Analysis, Stochastic, Modeling, Sensor Applications

FORECASTING THE CONDITIONAL DEP LOSS PROBABILITIES FOR THE OPTIMAL MISSIONING MODEL

P.R. Milch, Professor
L.R. Whitaker, Associate Professor
Department of Operations Research
Sponsor: U.S. Army Recruiting Command

OBJECTIVE: The goal of this project is to devise a method of estimation of the number of losses (and accessions) from the Delayed Entry Program (DEP) in order to assist the U.S. Army Recruiting Command (USAREC) with its missioning task.

SUMMARY: Computer programs have been constructed in the computer language APL to accomplish two tasks:

(i) to estimate from a substantial portion of the data file, the *conditional* probability of accession/loss of individuals in the DEP by categories of mission box and contracted DEP length, given various lengths of stay in the DEP already;

(ii) to count the number of individuals in the DEP, on a certain date, by categories of mission box and contracted DEP length, whose record is still open (i.e., have *not* yet become either accessed or lost from the DEP).

Using the above two quantities another program has been created to combine them to produce estimates of the number of accessions/losses, by categories of mission box and contracted DEP length, that will occur in the near future (i.e., 1, 2, ..., 12 months after the specific data chosen) among the individuals with the open records. These estimates are then being checked against the *actual* number of accessions/losses by categories of mission box and DEP length, that occurred from among the individuals with open records in order to evaluate the accuracy of this estimation procedure.

In addition, a more involved ordinal response model has been developed to estimate DEP loss probabilities as a function of time in DEP so far, length of DEP, mission box, brigade and a few other explanatory variables. Also to support missioning, a methodology along with the corresponding Pascal code has been developed to predict numbers of contracts written from the current pool of candidates who have already taken the ASVAB test. This model is currently being refined at USAREC. Finally a study of the relationship between first term attrition mission box and time in DEP was conducted.

THESES DIRECTED:

Vales, J.S., LT, USNR, "US Army's Delay Entry Program: A Survival Study," Master's Thesis, June 1994.

Roesler, S.G., CPT, USA, "A Production Early Warning System (PEWS) Model Which Predicts Future USAREC Mission Accomplishment (U)," Master's Thesis, September 1994.

DOD KEY TECHNOLOGY AREA: Other (Operations Research)

KEYWORDS: Delayed Entry Program, Recruiting, Missioning

THE DELAYED ENTRY PROGRAM MANAGEMENT OVERVIEW MODEL (DEPMOM)

P.R. Milch, Professor
Department of Operations Research
Sponsor: U.S. Army Recruiting Command

OBJECTIVE: The goal of this project was the construction of a user-friendly computer model to facilitate the computation of lossrates from the Delayed Entry Program (DEP) by the U.S. Army Recruiting Command (USAREC) staff.

SUMMARY: Two PC-based computer models were constructed in the APL language. The model DEPMOM computes lossrates from the DEP by a menu-driven user-friendly procedure that permits the operator to select periods of contract months, one or more categories of mission box (which define such criteria as level of education, mental category, gender, and prior service) and one or more choices of contracted DEP-length. Because DEPMOM presumes a specially prepared and sorted data file (in order to improve its speed) a second model,

education, mental category, gender, and prior service) and one or more choices of contracted DEP-length. Because DEPMOM presumes a specially prepared and sorted data file (in order to improve its speed) a second model, called CONVERT, was also constructed. CONVERT was designed to be used only when new DEP data becomes available (at most once a month) and provides a user-friendly method for converting the USAREC-prepared ASCII data file into a specially designed APL data file that is directly accessible by the model DEPMOM.

PUBLICATION:

Milch, P.R., "The Delayed Entry Program Management Overview Model (DEPMOM)," Naval Postgraduate School Technical Report, NPS-OR-94-010-PR, July 1994.

DOD KEY TECHNOLOGY AREA: Software

KEYWORDS: Delayed Entry Program, Lossrates

DEVELOPMENT OF MOEs FOR JOINT MISSION ESSENTIAL TASKS

S.H. Parry, Professor
Department of Operations Research
Sponsor: Defense Manpower Data Center

OBJECTIVE: This research effort will develop and validate measures of effectiveness for six USCENTCOM objectives to measure the level to which a staff function or individual has been trained to meet each objective. Automated data collection procedures will be implemented to collect these MOE's.

SUMMARY: The Joint Training Program defined within the Chairman Joint Chiefs of Staff Memorandum of Policy 26 (MOP 26) establishes a program for carrying out the joint training responsibilities of the CJCS, CINCS, and the CINCs' component staffs. The resulting compiled task list is called the Joint Mission Essential Task List (JMETL). Very little work has been accomplished in addressing the issue of measuring the success of training or measuring the level of competence of a staff to perform the essential mission tasks after participating in a computer aided exercise. This research is an attempt to fill that void. The research contract was initiated in October 1994, with the majority of the effort focused during CY 1995.

CONFERENCE PRESENTATION:

Parry, S., "Objectives and Milestones for MOE Development in Support of JMETL," Joint Theater Level Simulation Advisory Group, Rolands and Associates Corp., Monterey, CA, 8 December 1994.

DOD KEY TECHNOLOGY AREA: Software

KEYWORDS: Joint Missions, Measures, Training Evaluation

SCHIEFFELIN AWARD PROCEDURE MODIFICATIONS

R.R. Read, Professor
Department of Operations Research
Sponsor: Unfunded

OBJECTIVE: The goal is to find procedural rules that will insure the fairness of the Schieffelin Award selection method.

SUMMARY: On three occasions since the awards inception in 1970 I have been asked to return to the committee in order to treat problems that have arisen in the generation of data. The most recent problem is not really a new one, but its presence has become increasingly conspicuous. The distribution of the scoring summaries for Aviation Safety and DRMI have become quite different from those of the regular academic departments. On several occasions the award committee, after considerable deliberation, has requested that these two groups be eliminated from consideration in the process. The administration has always denied the request. As an alternative, I have been trying to study the effect of restricting the mailout of ballots to the alumni of these groups. These two groups, because of their very abbreviated curricula, generate alumni at a much more rapid rate than is done by the regular departments. Ordinarily, ballots are mailed to all alumni that are in their first two years that follow graduation. (The purpose of this is to enhance the voter franchise base and reduce irregularities.) This rule ordinarily captures about four to six classes of recent graduates. However a dozen or more such classes are included by this rule for Aviation Safety and DRMI. A study of the issue requires that records be kept of the number of ballots sent and returned for each department and group. We require this both for the students on board and the alumni. Partial data are available for 1991 and 1992, but not for 1993. These limited data show that the two groups are indeed outliers. However more information is needed in order to relate such material to the scoring summaries and to validate whether these adjustments can provide sufficient relief.

OTHER:

I have taken time this year to gather the previous anomalies and their resolution into a case study on the selection of a winner among diverse candidates using a polling of a partitioned set of heterogeneous judges. The article will appear in Naval Research Logistics sometime in 1995.

DOD KEY TECHNOLOGY AREA: Other (Scoring Systems)

KEYWORDS: Ballot Data Processing, Survey Scoring

ALGORITHMS FOR SPECIAL MEMORIES

R.R. Read, Professor
Department of Operations Research
Sponsor: Unfunded

OBJECTIVE: The goal is to generate a computational philosophy for special computer memories that rearrange data automatically and dynamically according to some problem inspired ordering rule.

SUMMARY: The Multi String Rearranging Memory (MSRM) is a memory system that rearranges information dynamically during the read-in cycle of the RAM storage process. Because of this it can sort, search, skim, and insert records in linear time. It is far less expensive than other computer systems that have comparable capabilities in these areas. Because of its properties it has a specialized (albeit simple) instruction set whose exploitation requires some revision or replacement of existing algorithms. The common statistical operations of forming order statistics, ranks, trimmed data, histograms, etc. are conducted in the amount of time that it takes to read the data. The current research develops a special algorithm that performs isotonic regression very

efficiently. It is a substantial improvement to the pool-adjacent-violators-algorithm that is described in the textbooks on the subject.

CONFERENCE PRESENTATION:

Armstrong, P.N. and Read, R. R., "The Multi-String Rearranging Memory and its Use in Statistical Computing," presented at Interface 94, held at the Research Triangle, NC, 15-18 June 1994.

OTHER:

The paper presented at the conference will appear in the conference proceedings.

DOD KEY TECHNOLOGY AREA: Software

KEYWORDS: Data Rearrangement, Isotonic Regression, Sorting

OPTIMIZATION MODELING FOR AIRLIFT MOBILITY

R.E. Rosenthal, Professor
D.P. Morton, Visiting Assistant Professor
Department of Operations Research
Sponsor: Department of the Air Force

OBJECTIVE: The objective of this multi-year research project is to help the Air Force improve logistical efficiency through optimization modeling technology.

SUMMARY: We have developed a multi-period optimization model, implemented in GAMS, to determine the maximum on-time throughput of air cargo and passengers that can be transported with a given fleet over a given network, subject to appropriate physical and policy constraints. The model has been delivered to the Air Force Studies and Analysis Agency, which can use it to help answer questions about selecting airlift assets and about investing or divesting in airfield infrastructure.

THESIS DIRECTED:

Weng, L.T., "Strategic Airlift Assets Optimization Model," Master's Thesis, September 1994.

OTHER:

Weng, L.T., Morton, D.P., and Rosenthal, R.E., "Optimization Modeling for Airlift Mobility," Naval Postgraduate School Technical Report in progress.

Software delivered to Air Force Studies and Analysis Agency.

The following two technical reports were prepared and delivered to Naval Warfare Assessment Division, Corona, California:

1. Impact of TNA/TNC actions on the TSP Roll-up Algorithm, April 15, 1994.
2. Comments on the Meaning of the Derived EOC using the TSP Roll-up Algorithm, December, 1994.

The following self-study learning modules were developed for the Defense Acquisition University short course, SYS201 Systems Planning, Research, Development and Engineering:

1. Reliability and Maintainability Allocations and Predictions
2. Modeling the Impact of Contagious Failures on System Reliability
3. Discrete Reliability Growth in the Test, Analyze and Fix Function
4. Performing Technical Risk Assessment using the Methods and Metrics for Product Success Guide Manual
5. Introduction to the Program Managers Workstation.

The following self-study learning modules were developed for the Defense Acquisition University SYS201-OSL SPRDE short course:

1. No Wearout--A Potentially Conservative And Costly Assumption In Reliability Modeling
2. No Wearout--A Conservative And Costly Assumption In Reliability Demonstration Testing
3. A Quick And Accurate Confidence Interval Formula For Mechanical Reliability
4. Why Worst Case Analysis Is Important In Stress-Strength Reliability Analysis
5. The Classical Interpretation Of Bayesian Reliability Analysis
6. A Potential Trap In Bayesian Reliability Analysis That Can Lead To Highly Optimistic Results.

DOD KEY TECHNOLOGY AREA: Other (Optimization)

KEYWORDS: Optimization Modeling for Airlift Mobility

THEATER LOGISTICS SUPPORT SYSTEM

D.A. Schrady, Professor
D. Hartman, CDR, USN, Instructor
Department of Operations Research
Sponsor: Chief of Naval Operations (N4)
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this research is to expand the prediction of sustainability inherent in the Tactical Logistics Support System (TACLOGS) to encompass the theater of operations. Whereas the TACLOGS client is the battle group/force commander, the client for this work is the Naval force component commander.

SUMMARY: After this work was initiated, it was realized that the scope should be expanded with the goal of providing the Naval force component commander with a full logistics planning and execution system. Elsewhere such work is being pursued under the title of Combatant Logistics Command and Control. Initial work has centered on identifying the information requirements of such a system, whether the information exists in some form, and any needed information shortfalls. While many of the constructs employed in TACLOGS would be useful, the nature of the theater problem requires new ways to display and use logistics information. In exploring this, a surge and sustainment simulation has been constructed and used in understanding the surge closure times and sustainment levels of theater logistics.

THESIS DIRECTED:

Halvorson, T., LT, USN, "Surge and Sustainment Simulation: Version 2.0," Master's Thesis, September 1994.

DOD KEY TECHNOLOGY AREA: Other (Decision Support Systems)

KEYWORDS: Operational Logistics, Sustainability Prediction, Naval Afloat Logistics

TACLOGS
TACTICAL LOGISTICS SUPPORT SYSTEM

D.A. Schrady, Professor
Department of Operations Research
S. Owings, Computer Research Assistant
Office of the Director Academic & Admin Computing
Sponsor: Chief of Naval Operations (N6)
Funding: Chief of Naval Operations and Naval Postgraduate School

OBJECTIVE: The objective of this project is the creation of a tactical logistics support system for a battle group or battle force and to incorporate the support system in the Navy Tactical Command System - Afloat (NTCS-A) within the Joint Maritime Command Information System (JMCIS).

SUMMARY: Building from a stand-alone, PC-based prototype system which was successfully employed in a number of Commander Second Fleet exercises, development has restructured and extended the ideas in the prototype for operation with the Navy standard DTC2 or TAC3 workstations. Initial development was completed in CY95. In so doing, all standards of the JMCIS Common Operating Environment have been observed. A comprehensive TACLOGS User's Guide was written and published. In December 1994, at NRaD San Diego, the JMCIS Software Support Agency, TACLOGS was successfully submitted to JMCIS. Beta test of the TACLOGS software is being planned in cooperation with Commander Third Fleet.

PUBLICATION:

Schrady, D.A. and Owings, S., "User's Guide for TACLOGS: Battle Group Tactical Logistics Support System," Naval Postgraduate School Technical Report, NPS-OR-94-015, December 1994.

PRESENTATION:

Schrady, D.A., TACLOGS briefings and demonstrations (five in total) in the period 26-28 September 1994, in the SPAWAR JMCIS Laboratory to 17 persons from N-62, N-41, N-42, SPAWAR PD-70, PMW-171, PMW-174, and NRaD Detachment Philadelphia.

DOD KEY TECHNOLOGY AREA: Other (Decision Support Systems)

KEYWORDS: Operational Logistics, Sustainability Prediction, Naval Afloat Logistics

OPTIMAL LEVEL OF THE U.S. ARMY ADVERTISING BUDGET

N.J. Webb, Assistant Professor
Defense Resource Management Institute
S.Y. Sohn, Assistant Professor
Department of Operations Research
Sponsor: U.S. Army Recruiting Command

OBJECTIVE: The goal of this project was to provide USAREC with tools to find efficient allocation for advertising expenditures.

SUMMARY: The United States Army Recruiting Command (USAREC) is responsible for attracting high-quality recruits (enlistments) to the U.S. Armed forces, both active and reserves. The purpose of this study was to analyze the problem of allocation of advertising resources faced by USAREC. National advertising data by media type (radio, print, broadcast, direct mail, and local advertising) were evaluated, and relationships between advertising and contracts signed were investigated. The study was to examine advertising effects by examining geographical data using advertising, contract information, and related socio-economic variables. Findings of the study were to provide information to USAREC planners to help accurately predict advertising budget requirements that support the contract mission of USAREC with an appropriate level of advertising funding. Due to data limitations, the findings of this study were limited. The main focus of this report is to outline suggestions for future work, and to suggest data collection methods to provide more informative data and analyses to planners at USAREC in future years.

PUBLICATION:

Webb, N.J. and Sohn, S.Y., "Recommendations for Analysis of U.S. Army Budget Requirement and Efficient Resource Allocation for Advertising Expenditures," Final Report to U.S. Army Recruiting Command, December 1994.

DOD KEY TECHNOLOGY AREA: Other (Resource Allocation)

KEYWORDS: Advertising Elasticity, Translog Cost Function, Budget Allocation, GRP, Contract Mission

LARGE-SCALE MIXED INTEGER PROGRAMMING

R.K. Wood, Associate Professor
Department of Operations Research
Sponsor: Joint Warfare Analysis Center, Dahlgren, VA

OBJECTIVE: This research investigates large-scale mixed integer linear programming models with special structure, and algorithms and software for solving them.

SUMMARY: (Classified - Available from sponsor only)

DOD KEY TECHNOLOGY AREA: Other (Optimization)

KEYWORDS: Optimization

TROUBLED SYSTEMS PROCESS

W.M. Woods, Professor
Department of Operations Research
Sponsor: Naval Warfare Analysis Division, (NWAD), Corona, CA

OBJECTIVE: The goal of this effort was to provide technical analysis support to the Troubled Systems Process (TSP) which is a joint CINCPACFLT/CINCLANTFLT program and serve on the TSP Technical Advisory Group (TAG) to the TSP Board.

SUMMARY: Attended one TAG meeting at NWAD, Corona, California, a TAG working group meeting on shipboard EMI at NAVSEACENPAC, San Diego, California, hosted a TAG working group meeting on shipboard

EMI at NPS, Monterey, California, and developed three reports on TSP problems assigned to me as a TAG member.

OTHER:

The following are technical reports were submitted to NWAD during 1994:

1. Comments on Proposed Strawman for Prioritizing Fleet Troubled Combat Systems, January 12, 1994.
2. Impact of TNA/TNC Actions on the TSP Roll-up, April 15, 1994.
3. Comments on the Meaning of the Derived EOC Using the TSP Roll-up Algorithm, December 22, 1994.

DOD KEY TECHNOLOGY AREA: Other (Systems Engineering)

KEYWORDS: Weapons Effectiveness, Equipment Operational Capability, Troubled Systems Process

SYS201 SYSTEMS PLANNING RESEARCH DEVELOPMENT AND ENGINEERING (SPRDE)

W.M. Woods, Professor
Department of Operations Research
Sponsor: Defense Acquisition University, Washington D.C.

OBJECTIVE: To develop learning modules for the SYS201 SPRDE and SYS201-OSL SPRDE short courses.

SUMMARY: Attended numerous planning sessions for the SPRDE SYS201 course at NPS with other DAU consortium representatives (Army Management Engineering College, Naval Warfare Assessment Division). Held a workshop on the development of PSI courses for NWAD personnel at NPS. Visited the Army APACHE/COMANCHE Helicopter Program offices in St. Louis, Missouri, to collect information to use in the SPRDE 201 case study. Developed five learning modules for the SYS201 SPRDE course and six learning modules for the SYS201-OSL SPRDE courses.

OTHER:

Developed the following five learning modules for SYS201 SPRDE course:

1. Reliability and Maintainability Allocations and Predictions
2. Modeling the Impact of Contagious Failures on System Reliability
3. Discrete Reliability Growth in the Test, Analyze and Fix Function
4. Performing Technical Risk Assessment using the Methods and Metrics for Product Success Guide Manual
5. Introduction to the Program Managers Workstation

Developed the following learning modules for the SYS201-OSL SPRDE Course:

1. No Wearout--A Conservative And Costly Assumption In Reliability Modeling
2. No Wearout--A Conservative And Costly Assumption In Reliability Demonstration Testing
3. A Quick And Accurate Confidence Interval Formula For Mechanical Reliability
4. Why Worst Case Analysis Is Important In Stress-Strength Reliability Analysis
5. The Classical Equivalent Interpretation Of Bayesian Reliability Analysis
6. A Potential Trap In Bayesian Reliability Analysis That Can Lead To Highly Optimistic Results

DOD KEY TECHNOLOGY AREA: Other (Systems Engineering)

KEYWORDS: Systems Reliability, Design Reliability, Reliability Growth

DEPARTMENT
OF
OPERATIONS RESEARCH

1994
Faculty Publications
and Presentations

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Bailey, M., Bowden, J., and Callahan, A., "Managing Ship Performance of Naval Gunfire Support Using Statistical Process Control," Military Operations Research, Vol. 1, pp. 5-12, 1994.

Bailey, M., Kemple, W., West, M., and Chase, C., "Object-Oriented Modelling of Military Communications Networks," Journal of Operational Society, Vol. 45, No. 10, pp. 1108-1122, 1994.

Bradley, G. and Oliveira, H., "NETWORK ASSISTANT to Construct, Test and Analyze Graph and Network Algorithms," Computational Support for Discrete Mathematics, N. Dean and G. Shannon (eds.), American Mathematical Society, pp. 75-84, 1994.

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Brown, G. and Olson, M., "Dynamic Factorization in Large-Scale Optimization," Mathematical Programming, Vol. 64, pp. 17-51, 1994.

Brown, G., Lawphongpanich, S., and Podolak-Thurman, K., "Optimizing Ship Berthing," Naval Research Logistics, Vol. 41, pp. 1-15, 1994.

Buss, A.H., Lawrence, S.R., and Kropp, D.H., "Volume and Capacity Interaction in Facility Design," IIE Transactions, Vol. 26, No. 4, pp. 36-49, 1994.

Lawrence, S.R. and Buss, A.H., "Shifting Production Bottlenecks: Causes, Cures, and Conundrums," Production and Operations Management, Vol. 3, No. 1, pp.21-37, 1994.

Sohn, S.Y., "Monitoring Declining Quality of Ammunition Stockpile under Step-Stress," Naval Research Logistics, Vol. 41, pp. 7070-718, 1994.

Sohn, S.Y., "An Investigation of the Statistical Relationship between the 345 kv Transmission Line Length and the Outage Rate," International Journal of Reliability, Quality and Safety Engineering, Vol. 1, pp. 85-94, 1994.

Sohn, S.Y., "A Comparative Study of Four Estimators for Analyzing the Random Event Rate of Poisson Process," Journal of Statistical Computation and Simulation, Vol. 49, pp. 1-10, 1994.

Sovereign, M., Kemple, W., and Metzger, J., "C3IEW Measures Workshop II," PHALANX, March 1994.

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Bailey, M.P., Dell, R.F., and Glazebrook, K.D., "Simulation-Based Dynamic Optimization: Planning United States Coast Guard Law Enforcement Patrols," Proceedings of the 1994 Winter Simulation Conference, J.D. Tew, S. Manivannan, D.A. Sadowski, and A.F. Seila (eds.), 1994.

Gaver, D.P. and Jacobs, P.A., "Modeling and statistical analysis of medaka bioassay data," (with appendices 1 and 2), Compendium of the FY1990 and FY1992 Research Reviews for the Research Methods Branch, Technical Report 9404, US Army Biomedical Research & Development Laboratory, Fort Detrick, Frederick, MD, pp. 297-324, September 1994.

Serfaty, D., Entin, E., Sovereign, M., Kemple, W., and Green, L., "Team Adaptation and Coordination Training,

Extended Summary," Proceedings of the Technology Panel for C3 of the Joint Directors of Laboratories 1994 Symposium on Command and Control Research and Decision Aids, Monterey, CA, June 1994.

Sohn, S.Y., "Assessing the Shelf-Life of Ammunition Stockpile under Step-Stress," 1993 American Statistical Association Proceedings, Section on Quality and Productivity, pp. 83-88, 1994.

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Armstrong, M.K. and Buss, A.H., "Retail Response to Trade Promotions: Maximizing Category Profits under Stochastic Demand," 1994 Marketing Science Conference, Tucson, AZ, March 1994.

Armstrong, P.N. and Read, R. R., "The Multi-String Rearranging Memory and its Use in Statistical Computing," Interface 94, Research Triangle, NC, 15-18 June 1994.

Bradley, G. and Golmayo, P., "Final Examination Scheduling Heuristic and Graph Coloring," ORSA/TIMS Joint National Meeting, Detroit, MI, 23-26 October 1994.

Bailey, M.P., Dell, R.F., and Glazebrook, K.D., "Simulation-Based Dynamic Optimization: Planning United States Coast Guard Law Enforcement Patrols," The International Society for Computer Simulation 1994 Winter Simulation Conference, 11-14 December 1994.

Brown, G., Artnzen, B., Harrison, T., and Trafton, L., "Global Supply Chain Management at Digital Equipment Corporation," TIMS/CPMS Prize Competition, ORSA/TIMS Joint National Meeting, Boston, MA, 24-27 April 1994.

Brown, G., Artnzen, B., and Harrison, T., "Integrated Production and Distribution Decisions in a Global Manufacturing Environment," ORSA/TIMS Joint National Meeting, Boston, MA, 24-27 April 1994.

Buss, A.H. and Lawrence, S.R., "Use of the Economic Bottleneck in Capacity Planning and Facilities Design," presented at the 1994 Workshop on Capacity Planning and Management, University of Florida, April 1994.

Buss, A.H. and Lawrence, S.R., "Economic Bottlenecks and Economic Balance," presented at ORSA/TIMS Joint National Meeting, Detroit, MI, October 1994.

Dell, R.F., Eagle, J.N., Martins, G.H., and Santos, A.G., "Using Multiple Searchers to Locate a Moving Target," National Meeting of the Operations Research Society of America and The Institute of Management Science, Boston, MA, 24-27 April 1994.

Gaver, D.P., Jacobs, P.A., and Carpenter, R.L., "A biologically motivated stochastic model of cell toxicity," 33rd Annual Meeting of the Society of Toxicology, Dallas, TX, 13-17 March 1994.

Gaver, D.P. and Jacobs, P.A., "Modeling and statistical analysis of bioassay data: medaka cell proliferation under DEN and TCE," Army Biomedical Research and Development Project Review, 20-22 September 1994.

Gaver, D.P., Jacobs, P.A., and Ellis, N., "Transitory queues in telephone response to a survey," TIMS XXXII, Anchorage, AK, 12-15 June 1994.

Gaver, D.P., "Identifying research needs and problem-solving tools for test and evaluation," MORS/ITEA Mini-Symposium: How much testing is enough?, Williamsburg, VA, 28 February - 3 March 1994.

Gaver, D.P., Jacobs, P.A., Parry, S.H., and Youngren, M., "The future theater-level model: a research project

update," Winter Simulation Conference, Orlando, FL, 11-14 December 1994.

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Kemple, W., Jones, C., and Egge, D., "C3 Systems Evaluation & Acquisition at a Temporal Process," 62nd MORS Symposium, Colorado Springs, CA, June 1994.

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Lawphongpanich, S., "Models for Recruiting Station Realignment," Joint Marketing, Analysis, and Research Committee, 12 October 1994.

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Mansager, B. and Kemple, W., "C3 Pre-Test Modeling of the Javelin Antitank System," 62nd MORS Symposium, Colorado Springs, CO, June 1994.

Parry, S., "Objectives and Milestones for MOE Development in Support of JMETL," Joint Theater Level Simulation Advisory Group, Rolands and Associates Corp., Monterey, CA, 8 December 1994.

Sadler, P. and Kemple, W., "Extending Graphical Correlation to Many Dimensions," presented at the SEPM Research Conference on Graphical Correlation and the Composite Standard: the Methods and their Application, Houston, TX, November-December 1994.

Santos, A.G., Dell, R.F., Eagle, J.N., and Martins, G.H., "Using Multiple Searchers in Constrained-Path Moving-Target Search Problems," 26th Simposio Sociegade Brasileira de Pesquisa Operacional, Florianopolis, Brazil, 30 November - 2 December 1994.

Serfaty, D., Entin, E., Sovereign, M., Kemple, W., and Green, L., "Team Adaptation and Coordination Training," Joint Directors of Laboratories 1994 Symposium on Command and Control Research and Decision Aids, Monterey, CA, June 1994.

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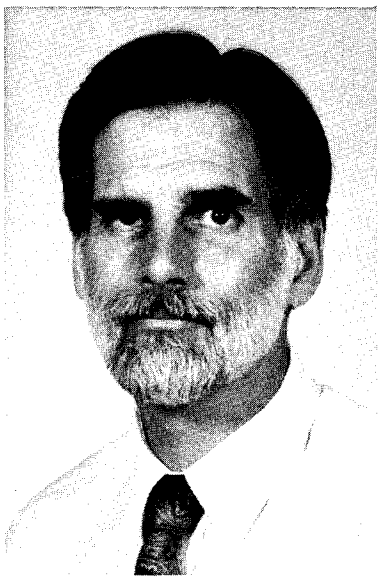
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Buss, A.H. and Rosenblatt, M.J., "Maximizing Expected Present Value in Projects with Stochastic Activity Durations: The Impact of Various Probability Distributions," 1994. **(working paper)**

Kemple, W., "STRATA94," new set of FORTRAN programs developed as part of an NSF project. The programs accept stratigraphic data from several locations and optional expert geological assessments as input, and fuse the data to estimate the true temporal sequence of historical events as well as the locations within the rock columns that correspond to these events. Delevered to Peter Sadler at UC Riverside, December 1994. **(computer programs)**

Schrady, D.A., TACLOGS briefings and demonstrations (five in total) in the period 26-28 September 1994, in the SPAWAR JMCIS Laboratory to 17 persons from N-62, N-41, N-42, SPAWAR PD-70, PMW-171, PMW-174, and NRaD Detachment Philadelphia. **(briefings/demonstrations)**

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Department of Physics

During FY 1994, 19 Physics Department faculty members participated in approximately 37 different research projects. Although the scope of these projects is quite broad, the research in the Physics Department can be grouped, for the purposes of this summary, into four general areas: 1) electromagnetic propagation and remote sensing; 2) acoustics and wave dynamics, including air-ocean interactions; 3) electromagnetic radiation and particle beam technology, and 4) weapons and combat systems technology. An overview of research activities in each of these areas are as follows:

Electromagnetic Propagation and Remote Sensing

Research activities in this category can be subdivided into four areas: 1) optical propagation through turbulence, 2) infrared multispectral imaging, 3) infrared technology development, and 4) remote sensing.

Professor **Donald Walter** is involved in understanding optical propagation through a turbulent atmosphere. The goal of Professor Walter's project is to develop and collect balloon measurements of the stratospheric microthermal fluctuations critical to resolving optical propagation limits imposed on the USAF Airborne Laser Program. To date, two successful balloon launches have occurred, and two more development, test launches are scheduled before the actual ABEL- ACE mission tests.

Professor **Scott Davis** is continuing a project which has as its primary goal the development of a prototype instrument capable of recording fully multiplexed images and multispectral images at long infrared wavelengths, where efficient focal plane array technology is not available. The major activity to which the year was devoted was the detailed design of unique reflecting and transmitting spatial encoding mask systems based upon orthogonal Walsh function patterns mapped into Cartesian and non-Cartesian coordinate systems.

Professor **Alf Cooper** is working in a number of areas related to the application of infrared technology to the Navy. One project is to evaluate experimentally techniques of passive ranging and target discrimination against background and to obtain horizontally and vertically polarized images of small boats in the littoral environment. In addition, Professor Cooper is trying to improve the prediction of detection range for infrared signatures through: evaluation of environmentally modified ship signatures; and experimental evaluation of criteria for detection and recognition. Another project involves the development of instrumentation and techniques for measurement of environmental factors needed for prediction, analysis and modeling of infrared sensor performance in the marine boundary layer. Professor Cooper is also involved with a project to evaluate the performance improvement to be gained by incorporation of IRST in the AEGIS combat system and to provide support to the AEGIS program office in the area of Cost and Operational Effectiveness Analysis.

Professor **David Cleary** is working in the area of remote sensing of the ionosphere. The objective of his research is to develop a passive technique for remote sensing the ionospheric electron density profile on a global basis. Specifically, he wants to determine if the electron density can be inferred from the ultraviolet signature of the positive ions in the ionosphere. In March 1994, his group conducted a sounding rocket experiment. During this experiment two ultraviolet spectrographs measured the UV spectrum of the Earth's ionosphere between 100 and 320 km. This experiment was conducted over the Poker Flat Missile Range in Alaska during and intense geomagnetic storm. The purpose of this experiment to investigate the effects of auroral electron precipitation on the UV spectrum of the ionosphere. Analysis of the data obtained from this experiment is ongoing. In addition, Professor Cleary and his coworkers made significant progress on the development of a new instrument for ionospheric remote sensing. This instrument is an All-Reflection Michelson interferometer. During FY 1994, they successfully demonstrated the operation of this instrument in the UV using the Mercury 2537-Å emission.

Professor **Chris Olsen** is also working in the area of remote sensing. His research addresses the application of multispectral and hyperspectral imaging to Naval needs. The objectives are to identify target signatures, and other features of interest in land and littoral scenes. He is also involved with a project to determine the effectiveness of existing algorithms for the determination of wind speed from the DMSP microwave sensor, SSM/I. Professor Olsen also supported the PMG-Delta flight experiment, working with ground radar observations.

Acoustics and Wave Dynamics

Research activities in this area include 1) thermoacoustics, 2) sonar array performance prediction, 2) wave turbulence and soliton dynamics, 4) bubble generated aerosols, and 5) fiber optic hydrophone development.

The largest effort in acoustics is devoted to thermoacoustic heat engine research. Professors Atchley, Garrett, Hofler, and Keolian are working in this area. The objectives of Professor **Anthony Atchley**'s work is to investigate mechanisms that place fundamental limitations on the high amplitude performance of thermoacoustic engines. Previous work has aimed their efforts to look for velocity effects at other than acoustic time scales, to study the possible effects of acoustic streaming and turbulence on heat transport in thermoacoustic heat engines. Since this heat transport effect is generated by acoustic fields with high acoustic pressure amplitudes, the influence of streaming and resulting turbulence may be important. Specific objectives include investigation of velocity fields in thermoacoustic engines using Laser Doppler Anemometry and investigation of heat exchanger performance in thermoacoustic prime movers.

Professor **Steven Garrett**'s research is directed at the fabrication and testing of a thermoacoustic cooling engine which is capable of providing cooling for a CV-2095 Radar Azimuth Converter on surface ship radar system. A computerized instrumentation system was developed which was capable of accurately measuring electrical, thermal, and acoustical power flows and acoustical parameters within the engine and the associated internal and external heat exchanger components. Adaptation of the thermoacoustic cooler and measurement system for use on a navy surface ship was begun with the goal of testing the chiller at sea in April, 1995, as a cooler for an essential radar system component.

Professor **Thomas Hofler** is performing basic research on thermoacoustic cooling processes for applications requiring high cooling power and a small temperature span. Such applications could include cooling onboard Navy ships. He is also involved with a project to construct third generation prototypes of thermoacoustic refrigerators (TARIII) suitable for use in spacecraft, for the purpose of cooling electronics and sensors to cryogenic temperatures. The goal of this research is to improve the refrigerator performance and design on a fundamental level, so as to increase the temperature span with acceptable efficiency.

The primary objective of Professor **Robert Keolian**'s research is to construct and test "pin stacks," a new thermoacoustic stack geometry. It is expected that the pin stack will improve the efficiency of thermoacoustically based refrigerators, heat pumps, and acoustic sources. A conventional stack can be thought of as a stack of separated flat plates, with sound passing through a fluid in the gaps between the plates. In a pin stack, an array of thousands of wires aligned along the acoustic axis in the fluid is used instead. By removing essentially unnecessary material from the stack, viscous losses can be reduced while keeping optimal thermal contact between the stack and the fluid. Secondary objectives include the exploration of the desirability and practicality of fractal heat exchanger designs and of parametric sound sources.

Professor **Steven Baker** is working with Professors Canright and Scandrett from the NPS Mathematics Department to develop an efficient means to compute the performance of an arbitrarily densely packed, randomly distributed, three-dimensional array of sonar projectors. Present methods of analysis fail to include the effect on the distribution of the radiation of one source due to the presence of another, i.e. the distortion of the nearfield. For this application they are pursuing a combination of analytical and numerical methods. Professor Baker is also trying to experimentally validate a theory developed by scientists at the Naval Coastal Systems Station for the

scattering of underwater sound from a porous solid sphere. The theory has potential application to the detection of mine-like objects buried in sediment.

Professors **Andres Larraza** and **Robert Keolian** are working on a project that deals with experimental and theoretical studies of nonlinear random surface waves driven far off equilibrium. Investigations of the self focusing mechanisms of nonlinear waves were also considered. Professor Larraza also conducted experimental and theoretical investigations of nonlinear dispersive waveguide modes in an acoustic duct. They made preliminary observations of a localized envelope that splits into two disturbances moving with two different velocities of propagation. As a consequence, they predicted that if a signal is amplitude modulated at the source, spatial beating between the two disturbances will occur, and at periodic positions in space the signal will become frequency modulated. These results can have applications in an all-optical AM-FM conversion and in high data rate fiber optic communications.

Professor **Donald Spiel** is working the role that bubble generated aerosols play in processes including air-sea dynamics, global climate, gas exchange, and ocean background acoustic noise. The purpose of this continuing work is to understand the physics of individual bursting bubbles as it relates to the oceanic aerosol source function. The work included the measurements of the number and size of jet drops produced by collapsing bubbles with radii from 350 to 1500 micrometers. In addition, the speeds of ejection, the times of ejection and the heights above the surface at which the droplets separate from the ascending jet, the so-called jet drop birth parameters, were also completed.

Electromagnetic Radiation and Particle Beam Technology

Professor **Fred Schwirzke** is working to understand the high voltage breakdown process and the process of plasma formation on the surfaces of electrodes of a vacuum diode. Electrical breakdown and formation of cathode spots are basic processes in many areas of high voltage engineering and pulsed power technology. A self-consistent physical model of the breakdown process has been developed. Experimental results obtained with the NPS Flash X-Ray and Electron Accelerator System confirm the new breakdown model.

Weapons and Combat Systems Technology

Professor **Steven Baker** is involved with a project to develop and validate through laboratory and field measurements a numerical computer model of the PHALANX gun which can be used to quantify of the effects of design changes and/or modifications on its performance. The PHALANX close-in weapon system (CIWS) provides close-in ship defense against incoming missiles. Reducing the PHALANX gun dispersion can significantly increase its ability to destroy targets at long range.

Professor **Joseph Sternberg** is working on a project is to develop and experiment with a unique wargame designed to assess the value of TRAP information to the mission success of a carrier battle group. The development of the software support system for handling the basic functions of the TRAP information flow, the background message traffic, the preparations for offensive and defensive operations, and the evaluations of the outcomes of those operations has been completed and extensively tested. Since the prime objective of the wargame is to show how, or whether, the differences between the player's intelligence picture and "ground truth" affects mission success in a contingency scenario, the software has been designed to keep separate the player's perception of the status of enemy weapon systems and activity, used in decision making, and the corresponding "ground truth", which is used in evaluating engagement outcomes.

Professor **Michael Melich** is working Project Gusty Oriole. The goal of this research has been the understanding of the properties of complex sensor systems and their interactions with one another and the military units that make use of their measurements. This is a continuation of a multi-year, multi-person research effort.. This year

they have investigated the operational characteristics of existing systems. The goal has been to determine how the information that these systems generate is complementary to that available from other sensor systems. He is also working on SEALAR, HTSSE, STAR Space Technology. This year was the last year of a multi-year effort and was devoted to documenting a portion of the previously conducted research.

BASIC RESEARCH IN THERMOACOUSTIC HEAT TRANSPORT

A.A. Atchley, Associate Professor
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: The overall objective of this research is to investigate mechanisms that place fundamental limitations on the high amplitude performance of thermoacoustic engines. Specific objectives include investigation of velocity fields in thermoacoustic engines and investigation of heat exchanger performance in thermoacoustic prime movers.

SUMMARY: Previous work in the area of velocity measurements concentrated on detecting perturbations in the velocity waveform. The main finding was that within the accessible parameter range, no significant perturbations in the velocity waveforms (averaged over many cycles) were observed. These results have aimed our efforts to look for velocity effects at other than acoustic time scales, to study the possible effects of acoustic streaming and turbulence on heat transport in thermoacoustic heat engines. Since this heat transport effect is generated by acoustic fields with high acoustic pressure amplitudes, the influence of streaming and resulting turbulence may be important. Results to date indicate that streaming inside the stack is relatively small in magnitude (a few cm/s) and uniform in nature. However, just outside the stack, the streaming is much faster (approximately 1 m/s) and not uniform. Jetlike structures have been found.

We also conducted an experiment to test heat exchanger performance. The results have raised a number of questions and analysis is ongoing. However, the overall results can be summarized as follows. 1) Acoustic pressure amplitudes as high as 29% of mean gas pressure were generated in the prime mover. 2) Short heat exchangers performed better than might have expected from simple, boundary layer arguments. 3) Peak-to-peak displacement amplitudes as much as 10 times the heat exchanger length were achieved. 4) Peak-to-peak displacement amplitudes equal to the stack length (2.5 cm) were achieve. 5) Radial temperature differences as high as 30° C were observed in the heat exchangers.

PUBLICATIONS:

Atchley, A.A. and Kuo, F.M., "Stability curves for a thermoacoustic prime mover," Journal of the Acoustical Society of America, Vol. 95, pp. 1401-1404, 1994.

Atchley, A.A., "Analysis of the initial buildup of oscillations in a thermoacoustic prime mover," Journal of the Acoustical Society of America, Vol. 95, pp. 1661-1664, 1994.

CONFERENCE PRESENTATION:

Gaitan, D.F., Gopinath, A., and Atchley, A.A., "Experimental study of acoustic turbulence and streaming in a thermoacoustic stack," 128th Meeting of the Acoustical Society of America, Austin, TX, November 1994, Journal of the Acoustical Society of America, Vol. 96, No. 5, Pt. 2, 3220(A), 1994.

THESES DIRECTED:

Castro, N., LT, USN, "Experimental Heat Exchanger Performance in a Thermacoustic Prime Mover," Master's Thesis, December 1993.

Corrigan, T., LT, USN, "A Preliminary Investigation of High Amplitude Standing Waves with Laser Doppler Anemometry," Master's Thesis, December 1993.

Gamaletsos, A., LTJG, Greek Navy, "Computer Implementation of Arnott's Formulation of Thermoacoustics Using MATLAB," Master's Thesis, December 1993.

DOD KEY TECHNOLOGY AREA: Other (Basic Research)

KEYWORDS: Thermoacoustics, Heat Engine, Refrigeration, Prime Mover, Heat Exchanger

EXPERIMENTAL INVESTIGATION OF THE SCATTERING OF UNDERWATER SOUND FROM A POROUS SOLID SPHERE

S.R. Baker, Associate Professor
Department of Physics
Sponsor: Naval Postgraduate School

OBJECTIVE: The objective is to experimentally validate a theory developed by scientists at the Naval Coastal Systems Station for the scattering of underwater sound from a porous solid sphere.

SUMMARY: Drs. Raymond Lim and Steve Kargl (formerly) of the Naval Coastal Systems Station have developed a theory for the scattering of elastic waves from a fluid-filled porous solid obstacle embedded in a fluid-filled porous solid host. Their theory employs the Biot theory for the propagation of elastic waves in a fluid-filled porous solid and the T-matrix method for the multiple scattering of waves. The theory has potential application to the detection of mine-like objects buried in sediment.

Professor Baker initiated a project in FY93 to experimentally validate Lim and Kargl's theory. Experimental measurements of the scattering of underwater sound from a porous solid sphere were compared to prediction s of Lim and Kargl's theory. Measurements were made on two porous solid sphere samples of nominal diameter 2 inches composed of nominal 100- and 500-micron diameter bonded glass beads, respectively. Physical properties such as porosity, permeability, and shear modulus were measured for cylindrical samples manufactured at the same time as the spherical samples. The values obtained for the cylindrical samples were assumed for the spherical samples in calculating the expected acoustic scattering. Bistatic underwater acoustic scattering measurements were made on the spherical samples as a function of angle and frequency in the underwater acoustic tanks at NPS. The range of frequency covered was approximately 30 kHz to 150 kHz. Results obtained by student LT Ted Huskey in FY93 were in rough order-of-magnitude agreement with the theoretical predictions, but showed practically none of the lobe structure as a function of angle predicted by the theory. Refined scattering measurements were conducted by student LT Martin Pace in FY94. LT Pace also obtained a new, greater aspect ratio, cylindrical sample, and measured both its Young's and shear modulus (The smaller aspect ratio of LT Huskey's cylindrical samples prevented him from measuring the Young's modulus, and so a value was assumed which gave the Poisson's ration of glass, 0.2.). LT Pace measured an unusually small value of 0.14 for the Poisson's ratio of the cylindrical sample. Reasonably good agreement was found between LT Pace's experimental and theoretical results for the 100-micron sphere, especially at the lower frequencies, except for a consistent deficit in the measured backscatter. Agreement between the results for the 500-micron sphere was poor, probably due to sample inhomogeneity.

CONFERENCE PRESENTATION:

Commander, K.W., Lim, R., Huskey, T.W.L., Baker, S.R., and Kargl, S.G., "Acoustic form function for porous solid spheres: comparison between theory and experiments," Journal of the Acoustical Society of America, Vol. 96, No. 5, Pt. 2, 3264, 1994.

THESIS DIRECTED:

Pace, M., LT, "Further investigation of the scattering of underwater sound from a porous solid sphere," Master's Thesis, December 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Underwater Acoustics, Porous Media Acoustics, Biot Theory, T-matrix

STRUCTURAL DYNAMICS OF THE PHALANX GUN

S.R. Baker, Associate Professor
Department of Physics
Sponsor: NSWC, Port Hueneme Detachment

OBJECTIVE: The goal of this project is to develop and validate through laboratory and field measurements a numerical computer model of the PHALANX gun which can be used to quantify of the effects of design changes and/or modifications on its performance.

SUMMARY: The PHALANX close-in weapon system (CIWS) provides close-in ship defense against incoming missiles. The CIWS attempts to destroy a sea-skimming missile at a range where missile fragments are not likely to damage the ship. Reducing the PHALANX gun dispersion can significantly increase its ability to destroy targets at long range.

Using finite-element modeling, it was shown in FY93 by Professor William Colson and students LTs MacNeil and Peterschmidt and colleague Mr. Mike Hatch that the dynamical oscillations of the rotating six-barrel system can be an important contribution to dispersion. In FY94, Professor Baker and students LT David Cela and MAJ Robert Hansberry conducted field and laboratory vibration measurements on a PHALANX gun. Field vibration measurements on a firing PHALANX gun were made on two occasions at Naval Weapons Station, China Lake, in May 1994. Accelerometer data were collected from seven locations on the gun. Estimated vertical and horizontal barrel-tip displacement were derived by time-integrating the acceleration data. These were compared with bullet dispersion data measured at the same time. A large drift in the derived displacement data was observed, most likely due to thermal effects in the accelerometer response. Methods to correct for this drift are being investigated; a cubic spline method appears to be the most promising.

Forced harmonic vibration measurements were made in the laboratory on a PHALANX gun subassembly for frequencies up to 500 Hz. A shaker was used to apply a vertical or horizontal force to a barrel tip, and the resulting acceleration response was measured at five locations along a barrel. Measurements were made for configurations with and without static barrel loading to simulate that in a firing state, and with and without the production muzzle restraint installed. Essentially no difference was observed in the modal structure with and without a static load applied. The effect of the muzzle restraint was to raise the modal frequencies of the lowest few modes, up to approximately 125 Hz, but to lower the modal frequencies and to increase the density of modes above 125 Hz.

THESES DIRECTED:

Cela, D., LT, "Correlation of bullet dispersion and transverse barrel tip displacement on a firing PHALANX gun system," Master's Thesis, December 1994.

Hansberry, R., MAJ, "Modal analysis of the PHALANX M61A1 Close-In Weapons System," Master's Thesis, December 1994.

DOD KEY TECHNOLOGY AREA: Other (Weapons)

KEYWORDS: PHALANX, Close-In Weapons System (CIWS), Structural Dynamics, Vibration, Modal Analysis

SONAR TRANSDUCER AND ARRAY TECHNOLOGY

S.R. Baker, Associate Professor
Department of Physics
D.R. Canright, Associate Professor
C.L. Scandrett, Associate Professor
Department of Mathematics
Sponsor: Naval Postgraduate School

OBJECTIVE: The objective of this research is to develop an efficient means to compute the performance of an arbitrarily densely packed, randomly distributed, three-dimensional array of sonar projectors. Present methods of analysis fail to include the effect on the distribution of the radiation of one source due to the presence of another, i.e. the distortion of the nearfield. For this application we are pursuing a combination of analytical and numerical methods.

SUMMARY: For application to a sonar array, we have extended the so-called transition-matrix, or "T-matrix" method, which was developed to compute the far-field scattering of an incident plane wave from arbitrary collection of scatterers, to the case that the source of the incident radiation is within the cloud of scatterers themselves. This method requires the radiation and scattering characteristics be known for a single projector in an otherwise free-field environment. An eigenfunction expansion is used to represent the radiation field. The T-matrix coefficients relate the components of the incident and scattered fields in terms of these eigenfunctions. Given the locations of and the T-matrix coefficients for each transducer, the field at any location can be computed.

In previous years, Professor Scandrett and Professor David Canright have applied the T-matrix method to a linear array of three identical piezoelectric thin-shell sonar projectors. The radiation and scattering characteristics of each shell were obtained analytically using thin-shell theory. Ultimately, it is desired to model a real sonar array, in which case the radiation and scattering characteristics will have to be computed using a finite-element model of the projector. To this end, in FY93 Professor Baker and student LCDR Rogerio Pinto developed a three-dimensional finite-element model of a Sparton ring-shell flextensional sonar projector for use with the ATILA finite-element code. In FY94, Professors Baker and Scandrett and student LCDR Arthur Ruiz began a series of validation computer experiments using the ATILA code to compute the T-matrix elements for a piezoelectric thin-shell projector. The results showed that roundoff error in the procedure that was employed to extract the T-matrix elements from the ATILA scattering calculations is too severe. An alternative procedure is being explored in FY95.

THESIS DIRECTED:

Ruiz, A., LCDR, Brazilian Navy, "Calculation of the transition matrix for the scattering of acoustic waves from a thin elastic spherical shell using the ATILA finite element code," Master's Thesis, March 1994.

DOD KEY TECHNOLOGY AREA: Other (Sonar Projector)

KEYWORDS: Underwater Acoustic(s), Sonar, Array, Low Frequency Active (LFA), Finite-element Modeling, T-matrix, Acoustic Scattering

FIBER OPTIC SENSOR TECHNOLOGY TRANSFER

D.A. Brown, Research Assistant Professor
Department of Physics
Sponsor: PEO, Undersea Warfare, Advanced Systems and Technology Office

OBJECTIVE: The objective of this project was to transfer the fiber optic sensor and system technology developed at NPS into the sponsors laboratory at NUWC with the air of getting this critic al technology into the fleet. The second objective was to develop fiber optic Bragg grating diffraction technology for Naval applications.

SUMMARY: The principal investigator worked closely with NUWC employees in developing or improving fiver optic acoustic sensor systems including Low Cost Planar Arrays (LCPA), Thin Optical Towed Arrays (TOTA), and new program effort involving development of fiber optic Conformal Acoustic Velocity Sensor (CA VES) for larger conformal hull-mounted sonar arrays. The principal investigator (D.A. Brown, NPS) and NRC Postdoctoral fellow (Q. Zhang, NPS) worked in conjunction with the Laboratory for Lightwave Technology at BROWN University. NPS Physics Department, and NUWC Submarine Sonar to develop Bragg grating technology in support of sonar systems. This research collaboration is covered under a pending CRADA to support new multiplexing concepts for interferometric sensors, new concepts for sensing, and new techniques for dispersion cancellation. In this past year we patented a new #X# coupler based optical subcarrier multiplexing scheme which increase the number of sensors and decrease the cost of an all optical sonar array and we also patented two new fiber optic flexural disk accelerometers which are now being developed for hull mounted applications.

PUBLICATIONS:

Zhang, Q., Brown, D.A., Reinhart, L., and Morse, T.F., "Tuning Bragg wavelength by writing grating on pre-strained fibers," Photonics Letters, July 1994.

Zhang, Q., Brown, D.A., Reinhart, L., and Morse, T.F., "Fabrication of Linearly and Nonlinearly Chirped Bragg Grating Filters Written on Curved Fibers," Proceedings of the IEEE Lasers and Electro-Optics Society (LEOS), 7th Annual Meeting, November 1994.

Zhang, Q., Brown, D.A., Reinhart, L., Klilian, L.A., and Morse, T.F., "Photorefractivity in a Tantalum-Doped Optical Fiber," Proceedings of Lasers and Electro-Optics Society, 7th Annual Meeting, November 1994.

Zhang, Q., Chen, M., Reinhart, L., and Brown, D.A.,"Highly overcoupled fused taper couplers as optical switches," Proceeding of the International Society for Optical Engineering (SPIE), pp. 2216-2228, April 1994.

Zhang, Q., Brown, D.A., Reinhart, L., and Morse, T.F., "Linearly and Nonlinearly Chirped Bragg Grating Filters Fabricated on Curved Fibers," accepted for publication in Optics Letters, scheduled to appear in March 1995 issue.

Zhang, Q., Brown, D.A., Kung, H., Townshed, J., Reinhart, L., and Morse, T.F., "The use of Highly Overcoupled Couplers to Detect Bragg Wavelength Shift," accepted for publication in Electronics Letters, scheduled to appear in March 1995 issue.

OTHER:

Brown, D.A., Zhang, Q., Garrett, S.L., Reinhart, L., and Morse, T.F., "Technique for tuning Bragg wavelength in optical fibers," NPS patent application submitted June 1994.

Brown, D.A. Reinhart, L., and Morse, T.F., "Reflective over-coupled coupler switch/sensor," NPS patent application submitted June 1994.

Brown, D.A. and Zhang, Q., "Technique for fabricating Bragg gratings with a prism," NPS patent application submitted September 1994.

Brown, D.A. and Zhang, Q., "Technique for fabricating wavelength chirped Bragg gratings," NPS patent application submitted September 1994.

*Other significant output originating from the project include: the development of a set of working specifications for a new Navy submarine hull array program, "Specifications for Fiber Optic Acoustic Motion Sensor for CA VES (Conformal Acoustic Velocity Sensors)," by D.A. Brown, in NUWC-Technical Memorandum, Naval Undersea Warfare Center, (July 1994), the transfer of fiber optic sensor technology to the sponsors laboratory (NUWC), and the development of a pending CRADA between NUWC, NPS, and BROWN University to develop low cost fiber optic Bragg grating technology.

*A new laser. We were successful in designing, developing and fabricating a new optical fiber based laser including fabrication of Rare-earth doped Er-fibers, fabrication of distributed feedback mirrors in Rare-earth doped fibers using Bragg gratings fabricated using NPS's phase masks, and optical pumping at 980nm. Coherent laser output has been achieved in the all fiber optically pumped mechanism. Results have not been published.

DOD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Fiber Optic Sensors, Bragg Gratings, Demodulators, Multiplexing, Hull Arrays, Technology Transfer

REMOTE SENSING OF THE IONOSPHERIC E- AND F-LAYERS

D.D. Cleary, Associate Professor
Department of Physics
Sponsor: Naval Postgraduate School

OBJECTIVE: The goal of this project was to develop a passive technique for remote sensing the ionospheric electron density profile on a global basis. Specifically, we want to determine if the electron density can be inferred from the ultraviolet signature of the positive ions in the ionosphere.

SUMMARY: In March 1994, we conducted our third sounding rocket experiment. During this experiment two ultraviolet spectrographs measured the UV spectrum of the Earth's ionosphere between 100 and 320 km. This experiment was conducted over the Poker Flat Missile Range in Alaska during and intense geomagnetic storm. The purpose of this experiment to investigate the effects of auroral electron precipitation on the UV spectrum of the ionosphere. Analysis of the data obtained from this experiment is ongoing.

In addition, we made significant progress on the development of a new instrument for ionospheric remote sensing. This instrument is an All-Reflection Michelson interferometer. The design of this instrument was conceived in 1993 and a prototype was tested using a HeNe laser. During 1994 we demonstrated the prototype using incoherent visible sources. These sources included the Mercury emission at 5460-Å and the Sodium doublet at 5890-Å. For this prototype we used a CCD camera for the detector. We then modified the detector to operate in the ultraviolet. A UV image intensifier tube was added to the CCD camera. Using this modified detector we successfully demonstrated the operation of this instrument in the UV using the Mercury 2537-Å emission.

PUBLICATION:

Atkinson, J.D. and Cleary, D.D., "A technique for modeling interference patterns from two-beam interferometers," Computers in Physics, Vol. 8, p. 462, 1994.

THESES DIRECTED:

Gill, M.W., LT, USN, "Design, validation and prototype testing of a high resolution all-reflection Michelson interferometer for solar occultation measurements of the OI 1304-Å triplet emission," Master's Thesis, June 1994.

Hymas, H.M., LT, USN, "A calibration of the NPS Middle Ultraviolet Spectrograph and an analysis of the OII 2470-Å emission obtained by the Middle Ultraviolet Spectrograph," Master's Thesis, June 1994.

Deist, D.W., CAPT, USMC, "A simulation of plasma motion in the polar ionosphere," Master's Thesis, September 1994.

MacQuarrie, J.A., LT, USN, "A ground support electronic interface for the Ionospheric Spectroscopy and Atmospheric Chemistry (ISAAC) Ultraviolet Spectrograph," Master's Thesis, December 1994.

DOD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Ionospheric Electron Density, Ultraviolet Spectroscopy

POWER BEAMING TO SPACE SATELLITES WITH FREE ELECTRON LASERS

W.B. Colson, Chairman and Professor
Department of Physics
Sponsor: Naval Air Warfare Center, China Lake, CA

OBJECTIVE: Evaluate the free electron laser design proposed to beam optical power to satellites and rockets in space.

SUMMARY: The free electron laser (FEL) is proposed by NASA and NAWC, China Lake to beam optical power to satellites and rockets in space. The SELENE FEL is simulated to evaluate a design proposed by scientists in Novosibirsk, Russia.

PUBLICATIONS:

Blau, J., Wong, R.K., Quick, D., and Colson, W.B., "Three Dimensional Simulations of the Novosibirsk/SELENE FEL," Nuclear Instruments and Methods in Physics Research, A341, ABS94, 1994.

Quick, D., Blau, J., Wong, R.K., and Colson, W.B., "Phase Space Simulations of Electrons Bunching and Power Output in the Novosibirsk/SELENE FEL," Nuclear Instruments and Methods in Physics Research, A341, ABS92, 1994.

Quick, D., Blau, J., Wong, R.K., and Colson, W.B., "Phase Space Simulations of the Novosibirsk/SELENE FEL," SPIE O-E Lase '94 Symposium, "Gas Metal Vapor, Free Electron Lasers and Applications," 2118-23 Los Angeles, CA, pages 172-179 (1994).

Kelsey, E., Blau, J., Quick, D.D., Wong, R.K., and Colson, W.B., "The Effects of High Gain in an FEL Optical Klystron," Nuclear Instruments and Methods in Physics Research, forthcoming in 1995.

CONFERENCE PRESENTATIONS:

Quick, D., Blau, J., Wong, R.K., and Colson, W.B., "Phase Space Simulations of the Novosibirsk/SELENE FEL," SPIE O-E Lase, Los Angeles, CA, January 1994.

Kelsey, E., Blau, J., Quick, D.D., Wong, R.K., and Colson, W.B., "The Effects of High Gain in an FEL Optical Klystron," 1994 International Free Electron Laser Conference, Stanford, CA, August 1994.

THESIS DIRECTED:

Quick, D.D., LT, "Simulations of the High Average Power SELENE Free Electron Laser Prototype," Master's Thesis, June 1994.

OTHER:

Kelsey, E., Wong, R., and Colson, W.B., "SELENE High-Power Free Electron Laser," SPIE International Laser and Applications Conference on Laser Power Beaming, San Jose, CA, forthcoming in February 1995.

DOD KEY TECHNOLOGY AREA: Software, Propulsion and Energy Conversion

KEYWORDS: Free Electron Laser, High Energy Laser, Space Beam Beaming

CEBAF HIGH POWER UV FREE ELECTRON LASER RESEARCH

W.B. Colson, Chairman and Professor
Department of Physics
Sponsor: Southeastern University Research Association

OBJECTIVE: Simulate the CEBAF high-average power UV free electron laser to be used for industrial processing applications.

SUMMARY: CEBAF has proposed a design for a free electron laser (FEL) powered by a super-conducting RF accelerator. It would produce 100 kW of laser power at UV wavelengths and would cost about $30M. The applications of the FEL are to be industrial processing of materials and surface modification.

PUBLICATIONS:

Wong, R.K., Clark, D., and Colson, W.B., "Multi-pass Transverse Mode Effects in Free Electron Lasers," Nuclear Instruments and Methods in Physics Research, A341, ABS69, 1994.

Pinkley, Wilkenson, W., Blau, J., Wong, R.K., and Colson, W.B., "Resonant Wavelength Modulation in a Free Electron Laser," Nuclear Instruments and Methods in Physics Research, A341, ABS70, 1994.

Wong, R.K. and Colson, W.B., "Transverse Mode Effects in Free Electron Laser Oscillators," SPIE O-E Lase '94 Symposium, "Gas Metal Vapor, Free Electron Lasers and Applications,"
pp. 2118-23, Los Angeles, CA, 1994.

Blau, J., Wong, R.K., and Colson, W.B., "Ultra-Short Pulse Free Electron Laser Oscillators," Nuclear Instruments and Methods in Physics Research, A358, p. 441, forthcoming in 1995.

Wong, R.K. and Colson, W.B., "The Tunability of Free Electron Lasers," accepted by Physics Review, EXXX, to be published February 1995.

Wong, R.K. and Colson, W.B., "Frequency Response to an Electron Energy Shift," Nuclear Instruments and Methods in Physics Research, A358, ABS26, forthcoming in 1995.

CONFERENCE PRESENTATIONS:

Wong, R.K. and Colson, W.B., "Transverse Mode Effects in Free Electron Laser Oscillators," SPIE O-E Lase '94 Symposium, "Gas Metal Vapor, Free Electron Lasers and Applications," Los Angeles, CA, January 1994.

Wong, R.K. and Colson, W.B., "Frequency Response to an Electron Energy Shift," 1994 International Free Electron Laser Conference, Stanford, CA, August 1994.

Blau, J., Wong, R.K., and Colson, W.B., "Ultra-Short Pulse Free Electron Laser Oscillators," 1994 International Free Electron Laser Conference, Stanford, CA, August 1994.

DOD KEY TECHNOLOGY AREA: Software, Propulsion and Energy Conversion

KEYWORDS: Free Electron Laser, High Energy Laser, UV Lasers

FREE ELECTRON LASERS FOR SHIP DEFENSE

W.B. Colson, Chairman and Professor
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: Simulate free electron laser designs proposed for defending Navy ships against sea-skimming cruise missiles.

SUMMARY: The free electron laser (FEL) is proposed as a weapon to defend Navy ships against sea-skimming cruise missiles. Simulations describe the performance of an FEL capable of damaging cruise missiles at a range of about 10 km. The power requirements that must be provided by the ship are studied.

PUBLICATIONS:

Colson, W.B., "Status of Free Electron Lasers in 1994," Nuclear Instruments and Methods in Physics Research, A358, 532, forthcoming in 1995.

Lyon, R.A. and Colson, W.B., "Power Requirements for High-Average Power FELs," Nuclear Instruments and Methods in Physics Research, A358, ABS81, forthcoming in 1995.

Colson, W.B., "Status of High Power Free Electron Lasers," SPIE 2376, pp. 45-52, forthcoming in 1995.

CONFERENCE PRESENTATIONS:

Colson, W.B., "Navy Interest in High Power FELs," CEBAF Laser Processing Consortium Workshop, CEBAF Center, (Invited), Newport News, VA, September 1994,

Colson, W.B., "Status of Free Electron Lasers in 1994," 1994 International Free Electron Laser Conference, (Invited), Stanford, CA, August 1994.

Lyon, R.A. and Colson, W.B., "Power Requirements for High-Average Power FELs," 1994 International Free Electron Laser Conference, Stanford, CA, August 1994.

THESIS DIRECTED:

Lyon, R., LT, "Prime Power for Shipboard High-Average Power Free Electron Lasers," Master's Thesis, September 1994.

OTHER:

Colson, W.B., "Status of High Power Free Electron Lasers," SPIE International Laser and Applications Conference on Laser Power Beaming, (Invited), San Jose, CA, forthcoming in February 1995.

DOD KEY TECHNOLOGY AREA: Software, Propulsion and Energy Conversion

KEYWORDS: Free Electron Laser, High Energy Laser, Directed Energy

MEDICAL FREE ELECTRON LASER REVIEW

W.B. Colson, Chairman and Professor
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: The medical free electron laser (FEL) program was reviewed and research studied the Stanford Medical FEL project.

SUMMARY: The ONR Medical FEL program was evaluated with a team of international scientists. The team made several visited to Medical FEL sites around the country. Research was conducted on the Stanford Medical FEL facility in order to describe the proposed FIREFLY 1 kW FEL.

PUBLICATIONS:

Colson, W.B., "Amplification of the Optical Electric and Magnetic Fields Described by Ampere's and Faraday's Laws," Nuclear Instruments and Methods in Physics Research, A341, ABS64, 1994.

Small, D.W., Wong, R.K., Blau, J., and Colson, W.B., "Simulations of the Stanford FIREFLY 1 kW Free Electron Laser," Nuclear Instruments and Methods in Physics Research, A358, ABS44, forthcoming in 1995.

CONFERENCE PRESENTATION:

Small, D.W., Wong, R.K., Blau, J., and Colson, W.B., "Simulations of the Stanford FIREFLY 1 kW Free Electron Laser," 1994 International Free Electron Laser Conference, Stanford, CA, August 1994.

DOD KEY TECHNOLOGY AREA: Software, Propulsion and Energy Conversion

KEYWORDS: Free Electron Laser, High Energy Laser, Medical Lasers

HIGH POWER UV FREE ELECTRON LASER

W.B. Colson, Chairman and Professor
Department of Physics
Sponsor: Southeastern University Research Association

OBJECTIVE: Simulate free electron laser designs proposed for the development of a high-average power UV industrial laser.

SUMMARY: The CEBAF scientists have designed a free electron laser (FEL) that makes use of a super-conducting RF accelerator. The continuous electron beam provided by the accelerator results in high-average laser power and can be applied to industrial processing. The technology is also similar to that needed to develop a ship defense weapon.

PUBLICATIONS:

Hall, J., Blau, J., Wong, R.K., and Colson, W.B., "Simulations of an X-Ray FEL Utilizing the SLAC LINAC," Nuclear Instruments and Methods in Physics Research, A341, ABS76, 1994.

Hall, J., Wong, R.K., Blau, J., and Colson, W.B., "Simulation of the SLAC X ray Free Electron Laser," SPIE O-E Lase '94 Symposium, "Gas Metal Vapor, Free Electron Lasers and Applications," 2118-23, pp. 163-171, Los Angeles, CA, 1994.

Colson, W.B., "Short Wavelength Free Electron Lasers in 1994," Nuclear Instruments and Methods in Physics Research, A358, p. 555, forthcoming in 1995.

Winter, G.H., Hall, J., Wong, R.K., and Colson, W.B., "Simulations of a Klystron Undulator for the SLAC X-Ray FEL," Nuclear Instruments and Methods in Physics Research, A358, forthcoming in 1995.

CONFERENCE PRESENTATIONS:

Hall, J., Wong, R.K., Blau, J., and Colson, W.B., "Simulation of the SLAC X ray Free Electron Laser," SPIE O-E Lase '94 Symposium, "Gas Metal Vapor, Free Electron Lasers and Applications," Los Angeles, CA, January 1994.

Winter, G.H., Hall, J., Wong, R.K., and Colson, W.B., "Simulations of a Klystron Undulator for the SLAC X-Ray FEL," 1994 International Free Electron Laser Conference, Stanford, CA, August 1994.

THESIS DIRECTED:

Hall, J.B., CMDR, "Simulations of an FEL Producing Coherent X Rays Utilizing the SLAC Linac," Master's Thesis, June 1994.

DOD KEY TECHNOLOGY AREA: Software, Propulsion and Energy Conversion

KEYWORDS: Free Electron Laser, High Energy Laser, Industrial Lasers

INFRARED SURVEILLANCE AND TARGET DISCRIMINATION RESEARCH

A.W. Cooper, Professor
Department of Physics
Sponsor: Naval Sea Systems Command PEO-Theater Air Defense and Naval Postgraduate School

OBJECTIVE: To evaluate experimentally techniques of passive ranging and target discrimination against background through investigation of narrow-band two color radiance comparison and polarization filtering of target and background images, and to obtain horizontally and vertically (S and P) polarized images of small boats in the littoral environment. This is a continuing project in the program of infrared surveillance and target discrimination research under the Naval Academic Center for Infrared Technology, cost shared by the Naval Postgraduate School and Naval Sea Systems Command, PEO-Theater Air Defense.

SUMMARY: The AMBER FPA Mid Wave Infrared camera has been adapted for nearly simultaneous recording of narrow-band filtered images in the red spike and blue spike regions and also separately for S and P polarized images of targets and backgrounds. For this purpose a filter adapter for the AMBER camera was designed and factory installed which can be used for either spectral intensity ratio or for S and P polarization comparison measurements. This modification was accomplished during FY94, and the selected red and blue spike filters installed. During this period also techniques were developed for field recording comparison image frames digitally and data processing computational algorithms written and evaluated. A self contained thermal radiation source was built for a preliminary field measurement of intensity ratio versus range. Work will continue in FY95. During the spring of 1994 experimental LWIR measurements were made of comparative P and S polarized images of a Coast Guard boat against coastal background in Monterey Bay, using the dual band AGEMA Thermovision-780 scanning imaging system with externally mounted polarizing filters. Due to the time delays in the external polarizer mount and the scanning imager possible evidence of target polarization features is obscured by temporal changes in target and background, and results are inconclusive. Further experimentation with the AMBER system with better time resolution should remove many ambiguities. In future planned experimentation fast frame recording will be applied to allow time dependence of sun-glint and polarization data to be analyzed.

PUBLICATION:

Lentz, W.J., Cooper, A.W, and Regush, M.M., "Improved Klett Lidar Inversion Techniques," SPIE Proceedings, Vol. 2222, 1994.

CONFERENCE PRESENTATION:

Lentz, W.J., Cooper, A.W., and Regush, M.M., "Improved Klett Lidar Inversion Techniques," presented at SPIE Conference on Atmospheric Propagation and Remote Sensing III, Orlando, FL, April 1994.

THESES DIRECTED:

Dick, J.H., LT, USN, "Analysis of Two-Color Passive Infrared Ranging Utilizing the AMBER AE-4128 Infrared Camera System," Master's Thesis, December 1993.

Chang, T.-L., LCOL, Republic of China Air Force, "The IR (Spin Scan and Con Scan Seekers) Countermeasures," Master's Thesis, September 1994.

DOD KEY TECHNOLOGY AREA: Sensors, Environmental Effects, Electronic Devices

KEYWORDS: Atmospheric Optics, Infrared Sensors, IRST

INFRARED TECHNOLOGY SUPPORT TO THE AEGIS PROGRAM

A.W. Cooper, Professor
Department of Physics
Sponsor: Johns Hopkins University Applied Physics Laboratory

OBJECTIVE: To evaluate the performance improvement to be gained by incorporation of IRST in the AEGIS combat system and to provide support to the AEGIS program office in the area of Cost and Operational Effectiveness Analysis.

SUMMARY: This program was initiated in Quarter 4 of FY93 and continued through Quarter 1 of FY94. Evaluations have been made of possible locations for one or more IRST scanners on the AEGIS CG-47 and DDG-51 platforms. Elevation above sea level, maximum range to horizon, geometrically maximum detection range, and possible baselines for triangulation were estimated for these sensor locations on these two platforms. A preliminary analysis of single baseline and double baseline triangulation methods of passive range estimation has also been carried out and will be applied to the sensor locations identified. This work has been continued in FY94 under funding from NAVSEA, PMS-400. In support of this program measurements of polarization contrast improvement in infrared imaging were made in the MAPTIP NATO measurement exercise held off the coast of the Netherlands in October and November 1993. Over 3500 images in horizontal and vertical polarized pairs were obtained in the 3-5 and 8-12 μm wavebands using the dual band AGA-780 Thermal Imager with polarization analyzer. These continue to be analyzed under other projects. Initial examination showed clear target-background contrast improvement by polarization filtering, particularly in the LWIR band. This is attributed to significant emission polarization of thermal radiation from the sea surface at near grazing angles.

DOD KEY TECHNOLOGY AREA: Sensors, Environmental Effects, Electronic Devices

KEYWORDS: Atmospheric Optics, Infrared Sensors, IRST

AEGIS ENVIRONMENTAL ASSESSMENT SUPPORT

A.W. Cooper, Professor
Department of Physics
Sponsor: Naval Sea Systems Command, AEGIS Program Office, PMS400B

OBJECTIVE: To provide support to the AEGIS Combat System Environmental Assessment Program by analysis of the application of IRST technology to the AEGIS Combat System. Analyses are to be made of requirements and options for estimation of essential environmental parameters for prediction of combat system performance, and of performance improvement achievable by integration of infrared (IRST) systems in the Combat System.

This multiyear project is a continuation of the program previously supported by Johns Hopkins University APL.

SUMMARY: During the past two years intense discussion has focused on the direction of development of the Navy's next generation Infrared Search and Track System (IRST) and in this context the definition of requirements for infrared system integration with the AEGIS Combat System. This program was initiated to provide support to the AEGIS Program Manager in the area of (1) Cost and Operational Effectiveness Analysis of IRST technology as applied to the AEGIS Weapon System, by evaluation of feasibility of inclusion of IRST technology in the AEGIS system including identification of unique AEGIS requirements, and (2) support for the AEGIS Program Manager's Environmental Assessment program by generation of a atmospheric data requirements for system performance prediction, both radio frequency and infrared. Included is evaluation of potential shipboard atmospheric monitoring systems and alternative approaches. Definition of target threat signature and discrimination data for small craft crossing the horizon are included. A small low cost eye-safe lidar based on

a Nd:YAG frequency doubled laser at 532 nm wavelength with eighteen inch output beam expansion optics has previously been built for cloud and target ranging and atmospheric transmission analysis in conjunction with the IRST. This system has been operated on a roof-top site at NPS and its performance verified by ranging to ground fog at 3800m and to clouds at ranges up to 1400m at night. During FY94 this system was redesigned with improved detection capability and increased transmit/receive beam overlap to operate to lower levels in the marine boundary layer and to permit operation during daylight hours by improving signal to background discrimination. The improved LIDAR is now to be operated in parallel with the NPS Atmospheric Profiler to evaluate correlation between changes in LIDAR return and changes in atmospheric vertical structure. The issue in question is whether the lidar can be used to monitor the atmosphere for changes requiring a radiosonde launch to initialize prediction codes. This study will continue in FY95. Further calculations have been made of pointing precision in passive range estimates by single and double baseline triangulation and results will be presented in spring 1995.

THESES DIRECTED:

Pelegris, G.A, LCOL, Greek Army, "Triangulation Method for Passive Ranging," Master's Thesis, September 1994.

Mallo, G., LCDR, USN, "Modification of the Naval Postgraduate School Lidar System," Master's Thesis, September 1994.

DOD KEY TECHNOLOGY AREA: Sensors, Environmental Effects, Electronic Devices

KEYWORDS: Atmospheric Optics, Infrared Sensors, IRST

ELECTRO-OPTIC SENSING TECHNIQUES

A.W. Cooper, Professor
Department of Physics
Sponsor: Naval Command Control and Ocean Surveillance Center, RDT&E Division, (NRaD)

OBJECTIVE: To develop instrumentation and techniques for measurement of environmental factors needed for prediction, analysis and modeling of infrared sensor performance in the marine boundary layer, including target and background signatures, polarization and sun glint, and local atmospheric profiles. Emphasis in FY94 has been on development of instrumentation to obtain pixel-registered image pairs with vertical and horizontal polarization.

SUMMARY: Degree of polarization and polarization contrast enhancement have previously been measured in infrared sun glint and stationary ship images, and these effects should be included in analytical ship target/background models. Current dual-band external filter techniques are limited by delay time and narcissus effects. A two-channel split-field polarimeter unit for concurrent polarization component measurement with the LWIR scanning AGA imager has been designed with contractor assistance and is undergoing "breadboard" construction. As an interim measure two polarizers are being installed in the internal filter wheel of the AGA system. Concurrently the MWIR Indium Antimonide (InSb) focal plane array camera has been modified for two component polarimeter use, in cooperation with other projects. As a test of the external polarizer system a series of 25 sets of polarization pair images of small craft in each of the IR wavebands has been recorded in Monterey Bay using a Coast Guard 44-foot Motor Surf Boat as a cooperative target, using the AGA with external polarizers. These tests verified that concurrent S and P polarization measurement is necessary to measure polarization features on small targets at short range. Development of the split-field polarimeter should overcome this limitation. Polarized images recorded during the MAPTIP experiment have been analyzed for ship/background contrast enhancement. Sequences at varied time of day and under varied conditions showed little polarization of ship radiance, but degree of polarization of sea background in the 8 to 12 μm band ranged from 7 to 80%

predominantly in the vertical direction, verifying the importance of emission polarization of sea radiance at near-grazing angles. The influence of reflected ambient or solar radiation during daylight hours is dominant in the 3 to 5 μm band, as expected.

PUBLICATION:

Cooper, A.W., Lentz, W.J., Walker, P.L., and Chan, P.M., "Infrared Polarization Measurements of Ship Signatures and Background Contrast, In Characterization and Propagation of Sources and Backgrounds," Wendell W. Watkins and Dieter Clement, Eds., Proceedings SPIE, Vol. 2223, pp. 300-309, 1994.

CONFERENCE PRESENTATION:

Cooper, A.W., Lentz, W.J., Walker, P.L., and Chan, P.M., "Infrared Polarization Measurements of Ship Signatures and Background Contrast," presented at SPIE Conference on Characterization, Propagation and Simulation of Sources and Backgrounds, Orlando, FL, April 1994.

THESIS DIRECTED:

Chan, P.M., "Experimental Investigation of Infrared Polarization Effects in Target and Background Discrimination," Master's Thesis, December 1993.

DOD KEY TECHNOLOGY AREA: Sensors, Environmental Effects, Electronic Devices

KEYWORDS: Atmospheric Optics, Infrared Sensors

SHIP SIGNATURE AND TARGET DETECTION RESEARCH

A.W. Cooper, Professor
Department of Physics
Sponsor: Naval Command Control and Ocean Surveillance Center, RDT&E Division, (NRaD)

OBJECTIVE: To improve the prediction of detection range for infrared signatures through: evaluation of environmentally modified ship signatures; and experimental evaluation of criteria for detection and recognition.

SUMMARY: Polarized imagery was taken during the MAPTIP NATO exercise October 11 to November 5 1993, using the AGA-78- dual band imager with manually rotated polarizer mounted externally for each band. 3236 picture files of targets and backgrounds were recorded under varied conditions and different times of day and night. Polarization contrast has been evaluated from sequences of horizontally and vertically polarized images of the Oceanographic Ship Tydeman. Polarization contrast can be measured only for stationary targets with the equipment available. Very significant improvement in target/background contrast through polarization filtering is observed under a variety of conditions. A summary report of data description and availability from the MAPTIP experiment was distributed and a results summary presented at the MAPTIP Workshop in Oslo in June 1994. Comparisons of degree of polarization averaged over target and background and polarization target to background contrast were extracted showing 20 to 50% contrast improvement for horizontal polarizer relative to vertical, consistent with sea emission polarization. Further techniques for extraction of target-background contrast and Contrast Improvement Factor for polarized versus unpolarized imaging were developed and applied to the MAPTIP stationary ship images. These results were presented at the AGARD Sensor and Propagation Panel Symposium on Propagation Assessment in Coastal Environments in September 1994. The results indicate polarization contrast improvement factor for target against sea background consistently in the range 10 to 20% for the cases observed.

A visibility-based model has been developed for predicting the Minimum Resolvable Temperature for a FLIR sensor, which accounts for contrast reduction due to spatial frequency limiting factors of system components, and involves no assumptions regarding the recognition process. This model has been compared with the NVL Static Performance Model, showing improved realism at very low and at very high spatial frequency, and was presented at the SPIE Orlando conference in April 1994.

PUBLICATIONS:

Pieper, R.J. and Cooper, A.W., "A Visibility Model for MRTD Prediction," SPIE Proceedings, Vol. 2224, pp. 259-269, 1994.

Cooper, A.W., Lentz, W.J., Walker, P.L., and Chan, P.M., "Polarization Enhancement of Contrast in Infrared Ship/Background Imaging, to be published in AGARD Proceedings, CP 576, 1995.

CONFERENCE PRESENTATIONS:

Pieper, R.J. and Cooper, A.W., "A Visibility Model for MRTD Prediction," presented at the SPIE Conference on Infrared Imaging Systems Analysis Modeling and Testing V Orlando, FL, April 1994.

Cooper, A.W., Lentz, W.J., Walker, P.L., and Chan, P.M., "Polarization Enhancement of Contrast in Infrared Ship/Background Imaging," Paper 26, AGARD SPP Symposium on Propagation Assessment in Coastal Environments, Bremerhaven, September 1994.

Cooper, A.W., Lentz, W.J., Moretz, D.G., and Skowronek, P.J., "MAPTIP Polarized Imagery and Data Availability," presented at MAPTIP Workshop, Oslo, June 1994.

THESIS DIRECTED:

Skowronek, P.J, LT, US Coast Guard, "Infrared Polarization Imaging Characteristics," Master's Thesis, September 1994.

OTHER:

Cooper, A.W., Lentz, W.J., Moretz, D.G., and Skowronek, P.J., "MAPTIP Polarized Imagery, Data Availability Summary," Data Report distributed at MAPTIP Workshop, Oslo, June 1994.

DOD KEY TECHNOLOGY AREA: Sensors, Environmental Effects, Electronic Devices

KEYWORDS: Atmospheric Optics, Infrared Sensors, FLIR Performance

RESEARCH IN SPATIALLY MULTIPLEXED IMAGING

D.S. Davis, Associate Professor
Department of Physics
Sponsor: Naval Sea Systems Command, Code PEO (TAD)

OBJECTIVE: This is a continuing project which has as its primary goal the development of a prototype instrument capable of recording fully multiplexed images and multispectral images at long infrared wavelengths, where efficient focal plane array technology is not available.

SUMMARY: FY94 represented the second year of this project, which is now expected to require approximately

five years for its completion. The major activity to which the year was devoted was the detailed design of unique reflecting and transmitting spatial encoding mask systems based upon orthogonal Walsh function patterns mapped into Cartesian and non-Cartesian coordinate systems. A great deal of effort was then put into identifying potential manufacturers who could fabricate such unique, never-before-attempted optical components. After such a potential vendor was identified, several months effort went into fighting the bureaucratic battles necessary to initiate the mask fabrication via the NPS Supply Department and to doing the in-house CAD-CAM (computer-aided design and computer-aided manufacturing) steps necessary to start the manufacturing process. Additional activities centered around design and prototyping of the new instrument's servo control and data acquisition systems.

PUBLICATION:

Davis, D.S., "Multiplexed Imaging by Means of Optically-generated Kronecker Products: 1. the Basic Concept," Applied Optics, 1995, accepted, in press.

THESES DIRECTED:

Middleton, M., "Development of a Prototype Servo Control System for a Spatially Multiplexed Imaging System," Master's Thesis, December 1994.

Davis, J.H., "A Study of Embedded Correlations in Walsh-transformed Images," Master's Thesis, December 1994.

Wager, N., "Image Correlations and Recognition," Master's Thesis, December 1994.

OTHER:

Two claim addenda were prepared for inclusion in Navy Case 74667, PTO 07/973,099, An Efficient and Versatile Method and Apparatus for Multiplexed Imaging using Optically-generated Kronecker Products (original application submitted in FY93).

DOD KEY TECHNOLOGY AREA: Sensors, Electronic Devices

KEYWORDS: Sensors, Infrared, Passive

SHIPBOARD ELECTRONIC THERMOACOUSTIC COOLER (SETAC)

S.L. Garrett, Professor
Department of Physics
Sponsor: Naval Science Assistance Program and
Office of Naval Research

OBJECTIVE: The goal of this project is to fabricate and test a thermoacoustic cooling engine which is capable of providing cooling for a CV-2095 Radar Azimuth Converter on surface ship radar system.

SUMMARY: During this reporting period, a thermoacoustic cooling unit, capable of providing up to 200 Watts of heat pumping power, was assembled and tested. A computerized instrumentation system was developed which was capable of accurately measuring electrical, thermal, and acoustical power flows and acoustical parameters within the engine and the associated internal and external heat exchanger components. Adaptation of the thermoacoustic cooler and measurement system for use on a navy surface ship was begun with the goal of testing the chiller at sea in April, 1995, as a cooler for an essential radar system component.

PUBLICATIONS:

Garrett, S.L., Perkins, D.K., and Gopinath, A., "Thermoacoustic refrigerator heat exchangers: design, analysis and fabrication," Heat Transfer-1994, Proceedings, 10th International Heat Transfer Conference, Vol. IV, pp. 375-380, 1994.

Garrett, S. L., and Gaitan, D. F., "Determination of effective piston are by three methods," Journal of the Acoustical Society of America, Vol. 96, pg. 3290, 1994.

CONFERENCE PRESENTATION:

Garrett, S. L., "ThermoAcoustic Refrigeration: A CFC alternative," presented as the Topical Lecture on Frontiers in Engineering & Physical Science Technology, AAAS Program and Abstracts, pp. 67-68, San Francisco, CA, 20 February 1994.

THESIS DIRECTED:

Russel, R.A., LCDR, USN, "Exergy analysis of the ThermoAcoustics Life Sciences Refrigerator," Master's Thesis, March 1994.

DOD KEY TECHNOLOGY AREA: Electronic Devices

KEYWORDS: Thermoacoustic, Refrigerator, Radar

IMPROVED EFFICIENCY AND POWER DENSITY FOR THERMOACOUSTIC COOLERS

T.J. Hofler, Research Assistant Professor
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: To perform basic research on thermoacoustic cooling processes for applications requiring high cooling power and a small temperature span. Such applications could include cooling onboard Navy ships.

SUMMARY: The following research was performed in 1994. Previously, we had shown that short heat exchangers with very fine fin structure can perform efficiently in engines having very high acoustic amplitude. We anticipate improvements in overall system efficiency of roughly 25%, compared to more conventional heat exchangers, while operating at high cooling power densities. The new heat exchangers require metal fin spacings on the order of 100 microns. We have been developing new heat exchanger fabrication techniques that are capable of creating fin structures of this size. Also, the new technique should require fewer steps and save time compared to the previous process, which can require 6 to 8 months including procurement steps. Also, a new design for a heat driven cooling engine has been modeled and optimized. The model predicts an overall system COP (cooling power/heat input) of 50%. Because of model approximations, we anticipate experimental COP's in the range of 30% to 40%. This would represent a large improvement over the original thermoacoustic heat-driven-cooler developed by Wheatley and Hofler, which had an overall COP of under 10%. Advantages of heat driven coolers are, in general, that the acoustic amplitude can be very high without the complexity of a high power electrodynamic driver, which also limits the reliability. High amplitude operation should allow high cooling power in a relatively small engine. Also, some experimental work has been done on a small thermoacoustic "demonstration" refrigerator with a temperature span of 30° or 40° C. The measured COP (cooling power/ acoustic power input) was roughly 70%.

PUBLICATION:

Hofler, T.J., "Annual summary report for improved efficiency and power density for thermoacoustic coolers," Naval Postgraduate School Technical Report, NPS-PH-94-009, June 1994.

CONFERENCE PRESENTATION:

Hofler, T.J., "Numerical study of various thermoacoustic refrigerator configurations," Journal of the Acoustical Society of America, Vol. 96, No. 5, Pt. 2, p. 3220, San Antonio, Texas, 28 November 1994.

THESES DIRECTED:

Brooks, B.R., LT, USN, "Construction of a thermoacoustic refrigerator demonstration apparatus," Master's Thesis, March 1994.

Berhow, T.J., LT, USN, "Construction and performance measurement of a portable thermoacoustic refrigerator demonstration apparatus," Master's Thesis, December 1994.

DOD KEY TECHNOLOGY AREA: Propulsion and Energy Conversion

KEYWORDS: Thermoacoustic, Refrigeration, Cooler

THERMOACOUSTIC REFRIGERATOR DESIGNS FOR SPACE

T.J. Hofler, Research Assistant Professor
Department of Physics
Sponsor: Naval Research Laboratory

OBJECTIVE: The objective is to construct third generation prototypes of thermoacoustic refrigerators (TARIII) suitable for use in spacecraft, for the purpose of cooling electronics and sensors to cryogenic temperatures. The goal of this research is to improve the refrigerator performance and design on a fundamental level, so as to increase the temperature span with acceptable efficiency.

SUMMARY: In 1994, the following work was accomplished. Construction of the second experimental TARIII cooler was finished and it was tested. Although the design was modeled numerically, and should have produced cold temperatures of 130°, the measured temperatures fell far short of this goal. These designs are intended to explore the middle ground between normal thermoacoustic engine performance and Stirling engine performance. This requires a thermoacoustic stack that is similar to a regenerator is some respects, and a means of removing acoustic power from the cold end of the refrigerator. Much time was spent trying to remove the correct amount of acoustic power with the least amount of heat leak to the cold end. We now believe (by process of elimination) that the stack/regenerator performance is poor. We have nearly finished building a third variation of the TARIII cooler, that incorporates yet another means of removing acoustic power from the cold end. Also, another stack/regenerator is being fabricated. The history of the Stirling engine community would indicate that regenerator technology is as much art as science, and is not thoroughly understood. Two new electrodynamic acoustic driver designs have been developed. The first and simpler of the two designs provides modest amounts of power at a modest efficiency, and is be usable over a broad range of frequencies. This driver has enabled our experimental work to continue, in the near term. A second and more complicated driver design has also been partially developed, which should deliver high acoustic power and high efficiency in a compact unit, over a narrow frequency range. It has not been built, as yet.

CONFERENCE PRESENTATION:

Hofler, T.J. and Adeff, J.A., "Towards a thermoacoustic cryocooler," American Physical Society meeting, (Invited), Arlington, VA, April 1994.

THESES DIRECTED:

Monahan, D.A., LT, USN, "Design improvements for a high efficiency thermoacoustic driver," Master's Thesis, March 1994.

Mode, K.S., LT CDR, USN, "Development of a higher amplitude thermoacoustic driver having a relatively wide frequency bandwidth," Master's Thesis, March 1994.

DOD KEY TECHNOLOGY AREA: Propulsion and Energy Conversion, Electronic Devices, Sensors

KEYWORDS: Thermoacoustic, Refrigeration, Cryocooler

THERMOACOUSTIC PIN STACKS

R.M. Keolian, Assistant Professor
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: The primary objective of this (essentially) first year of continuing research is to construct and test "pin stacks." It is hoped that this new stack geometry will improve the efficiency of thermoacoustically based refrigerators, heat pumps, and acoustic sources. Secondary objectives include the exploration of the desirability and practicality of fractal heat exchanger designs and of parametric sound sources.

SUMMARY: The stack is the heart of a thermoacoustic device. A conventional stack can be thought of as a stack of separated flat plates, with sound passing through a fluid in the gaps between the plates. In a pin stack, an array of thousands of wires aligned along the acoustic axis in the fluid is used instead. By removing essentially unnecessary material from the stack, viscous losses can be reduced while keeping optimal thermal contact between the stack and the fluid.

This year, we ran computer simulations using the program DeltaE, comparing the performance of various pin stacks against a conventional stack that was used in previous experiments. Our simulations matched the old data well. We designed a pin stack to work in the same experimental rig, with 75 micron diameter wires spaced by 750 microns in a hexagonal lattice wound between hot and cold heat exchangers. The simulations predicted a potential 50% efficiency gain for the pin stack over the conventional stack. However, we also learned that pin stacks are much fussier than conventional stacks with regards to their operating conditions.

Experimental progress for this reporting period included the design and construction of parts for a pin stack test. The secondary objectives of fractal heat exchangers and parametric drives have not been pursued extensively.

CONFERENCE PRESENTATIONS:

Keolian, R.M., "Thermoacoustic Pin Stacks," presented at ONR Physical Acoustics PI meeting, Austin, TX, November 1994.

Nessler, F.S. and Keolian, R.M., "A Thermoacoustic Pin Stack," presented at the 128th meeting of the ASA, Austin, TX, November 1994. (Abstract: J. Acoust. Soc. Am. 96, Pt. 2, p. 3221 (1994)).

PATENT:

Keolian, R.M. and Swift, G.W., "Thermoacoustic Pin Stack," Navy Case No. NC75596.

DOD KEY TECHNOLOGY AREA: Propulsion and Energy Conversion

KEYWORDS: Thermoacoustics, Acoustic Transducer, Refrigeration, Heat Pump

WAVE TURBULENCE AND SOLITON DYNAMICS

R.M. Keolian, Assistant Professor
A. Larraza, Assistant Professor
Department of Physics
Sponsor: Office of Naval Research, Physics Division and Naval Postgraduate School

OBJECTIVE: This project dealt with experimental and theoretical studies of nonlinear random surface waves driven far off equilibrium. Investigations of the self focusing mechanisms of nonlinear waves were also considered.

SUMMARY: Theoretical investigations of nonlinearly interacting random waves driven far off equilibrium have led to the prediction of new propagating collective modes. Two experiments were conducted in a 20 m long wave tank with fans to create a wind driven background sea state. In one experimental arrangement, a computer controlled mechanical paddle modulated the background sea state, with the modulation length smaller than the interaction length of wind generated waves. Preliminary results seem to indicate the first observation of a longitudinal collective mode as a nondispersive decrease in the background spectral energy density. The propagation speed was determined to be a function of the spectral peak frequency, in qualitative agreement with the theory. In the second experiment, the phase between a fixed swell (the fundamental mode of the tank) and the wind generated waves was measured. Preliminary results indicated that under certain wind conditions, the excess energy of wind generated waves has a phase other than zero degrees relative to the crest of the swell.

We also conducted experimental and theoretical investigations of nonlinear dispersive waveguide modes in an acoustic duct. The experiment was performed in a 21 m long, 5 cm diameter acoustic duct. We made preliminary observations of a localized envelope that splits into two disturbances moving with two different velocities of propagation. As a consequence, we predicted that if a signal is amplitude modulated at the source, spatial beating between the two disturbances will occur, and at periodic positions in space the signal will become frequency modulated. These results can have applications in an all-optical AM-FM conversion and in high data rate fiber optic communications.

CONFERENCE PRESENTATIONS:

Larraza, A., "Collective modes in nonlinear random surface waves," Workshop on Waves in the Ocean, Mathematical Science Research Institute, Berkeley, CA, 8 February 1994.

Keolian, R. and Larraza, A., "Wave turbulence," ONR Workshop on Ocean Waves, Mathematics Department, University of Arizona, AZ, 17 March 1994.

Larraza, A., "Two experiments on nonlinear wave interactions," ONR Workshop on Ocean Waves, Mathematics Department, University of Arizona, AZ, 18 March 1994.

Larraza, A., "Pulse splitting and AM-FM conversion in nonlinear dispersive systems," Department of Physics, University of Mississippi, Oxford, 24 January 1994.

Larraza, A., "Absorption of sound by noise," Department of Physics, Naval Postgraduate School, Monterey, CA, 5 May 1994.

Denardo, B. and Larraza, A., "Nonlinear wave phenomena: Self -localized waves, absorption of sound by noise, and wave turbulence," Lecture presented by Bruce Denardo at the second Physical Acoustics Summer School, Asilomar, CA, 29 June 1994.

THESES DIRECTED:

Coleman, W.F., LT, USN, "Pulse-splitting and AM-FM conversion in a nonlinear dispersive medium," Master's Thesis, December 1993.

Davies, J.P., LCDR, CF, "Techniques for the investigation of wave turbulence in water wave data," Master's Thesis, September 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Nonlinear Waves, Random Waves, Ocean Waves

PROJECT GUSTY ORIOLE

M.E. Melich, Professor
Department of Physics
Sponsor: United States Air Force

OBJECTIVE: The goal of this research has been the understanding of the properties of complex sensor systems and their interactions with one another and the military units that make use of their measurements. This is a continuation of a multi-year, multi-person research effort.

SUMMARY: This years we have investigated the operational characteristics of existing systems. The goal has been to determine how the information that these systems generate is complementary to that available from other sensor systems. The information developed thus far has been incorporated into instructional materials. A doctoral student in Electrical and Computer Engineering is pursuing ideas developed this year.

DOD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Military, Sensor Systems

SEALAR, HTSSE, STAR SPACE TECHNOLOGY

M.E. Melich, Professor
Department of Physics
Sponsor: Naval Research Laboratory

OBJECTIVE: This year was the last year of a multi-year effort and was devoted to documenting a portion of the previously conducted research.

SUMMARY: The results of an investigation of calorimeter performance was presented at an international

meeting and the published in the conference proceedings. It was shown that the performance of the calorimeter used by the Harwell Laboratory of the British Atomic Energy Authority in its 1989 experiments on the PdD system was better than their analysis suggested.

PUBLICATIONS:

Hansen, W.N. and Melich, M.E., "Pd/D Calorimetry - The Key to the F/P Effect and a Challenge to Science," Transactions of Fusion Technology, Vol. 26, No. 4T, Part 2, pp. 355-364, December 1994.

Melich, M. and Hansen, W., "Back to the Future: The Fleischmann-Pons Effect in 1994," Proceedings: Fourth International Conference on Cold Fusion, Vol. 2, Electric Power Research Institute, EPRI TR-104188-V2, pp 10-1 to 10-10, July 1994.

DOD KEY TECHNOLOGY AREA: Electronic Devices, Propulsion and Energy Conversion

KEYWORDS: Rockets, Super Conductors, Thermoacoustics, Refrigerators

JOINT WARFARE ANALYSIS

M.E. Melich, Professor
Department of Physics
Sponsor: Naval Postgraduate School

OBJECTIVE: To develop a research project with a DOD organization concerned with interoperability issues.

SUMMARY: The Joint Test Force (JADO/JEZ) assigned to assess the effectiveness of Joint Air Defenses has conducted exercises for the past three years. The capabilities and interests of the Combat Systems, Join Command, Control and Communications, Operations Research and the Institute for Joint Warfare Analysis students and faculty coincide with those of the JADO/JEZ. NPS has established itself as a team member of the successor organization, the All Service Combat Identification Evaluation Team (ASCIET), and will participate in the design and evaluation of the forthcoming exercises.

DOD KEY TECHNOLOGY AREA: Electronic Devices

KEYWORDS: Interoperability, Combat, Joint Warfare

SPACE POWER EXPERIMENT ABOARD ROCKET (SPEAR)

R.C. Olsen, Associate Professor
Department of Physics
Sponsor: Defense Nuclear Agency

OBJECTIVE: This was an ongoing project, in support of the SPEAR III experiment. The objective was to work with the plasma measurements and wave measurements, to address the charging and dis-charging mechanisms for high-voltage systems in space.

SUMMARY: The rocket was successfully launched on 15 March 1993. Funding cutbacks eliminated analysis funds, however, so subsequent work has been unsupported. James Morris, an NPS student, attended the Plum Brook tests in 1992, and the launch. He completed his thesis in 1994.

THESIS DIRECTED:

Morris, J., "Space Experiments Aboard Rockets: SPEAR III," Master's Thesis, March 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Spacecraft Charging

LIQUID METAL ION GUN FLIGHT EXPERIMENT

R.C. Olsen, Associate Professor
Department of Physics
Sponsor: NASA/GSFC

OBJECTIVE: Prepare charge control experiment for launch on the European Space Agency (ESA) Cluster satellite mission. NPS responsibilities are to procure tile substrate, support charging analysis.

SUMMARY: This ongoing study continues. Delivery of the flight units by the principal investigator (Dr. Riedler, Graz, Austria) was completed. Attended team meeting in Graz, Austria.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Spacecraft-Environment Interaction

PLASMA MOTOR GENERATOR (PMG) - DELTA

R.C. Olsen, Associate Professor
Department of Physics
Sponsor: NASA/JSC

OBJECTIVE: Support design phase, launch, and data analysis for the PMG-Delta experiment. The experiment is an electrodynamic tether, designed to test plasma contactor technology.

SUMMARY: PMG-Delta was successfully launched in June 1993. Olsen supported the activity by working at the Hawaii ground radar site. Flight data were reduced at NPS. Student thesis work was conducted by several NPS students.

THESES DIRECTED:

Chang, C.-J., "Electrodynamic behavior of PMG-Delta," Master's Thesis, June 1994.

Olson, D.M., "Radar Observations of Field-aligned Plasma Propagations associated with NASA's PMG Experiment," September 1994.

Brewster, W.A., "Space Tether - Radar Data Processing," Master's Thesis, September 1994

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Spacecraft Charging

COMPARISON OF IN-SITU AND REMOTELY SENSED OCEANIC PARAMETERS

R.C. Olsen, Associate Professor
Department of Physics
Sponsor: National Research Laboratory

OBJECTIVE: Address the effectiveness of existing algorithms for the determination of wind speed from the DMSP microwave sensor, SSM/I. Compare data from the satellite with equatorial and mid-latitude measurements made in-situ.

SUMMARY: Coincident data sets were obtained for the USAF DMSP satellites (provided to NPS by NRL) and from the TOGA (equatorial) weather buoys (from NOAA). Approximately 25,000 coincident measurements were obtained for the initial 3 month survey. Comparison showed that the standard algorithm over-estimates wind speed for low wind speed values. Further work is being done.

THESES DIRECTED:

Sayward, E.G., "Validation of Special Sensor Microwave/Imager Ocean Surface Wind Retrievals in Equatorial Regions," Master's Thesis, December 1994.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Environmental Monitoring, Remote Sensing

APPLICATION OF MULTI-SPECTRAL IMAGING TO NAVAL APPLICATIONS

R.C. Olsen, Associate Professor
Department of Physics
Sponsor: National Research Laboratory

OBJECTIVE: Address the application of multispectral and hyperspectral imaging to Naval needs. Prepare for work with the HYDICE instrument.

SUMMARY: Hyperspectral image data have been acquired from experimental sensors, and are being analyzed using non-literal techniques. The objectives are to identify target signatures, and other features of interest in land and littoral scenes. The current stage of study is in preparation for deployment of the HYDICE instrument.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Environmental Monitoring, Remote Sensing

PHOTOELECTRONS AND EQUATORIALLY TRAPPED ELECTRONS

R.C. Olsen, Associate Professor
Department of Physics
Sponsor: Naval Postgraduate School

OBJECTIVE: Address the nature of low energy plasma (electrons) as observed in the magnetosphere.

SUMMARY: Data from the Los Alamos geosynchronous satellites, and NASA's AMPTE/CCE satellite were studied. The statistical occurrence pattern was established using the AMPTE data, and the anti-coincidence of

trapped electron and ion distributions was established. Studies of the Los Alamos data sets showed that the trapped electron distributions were being fed by photo-electrons emitted from the dayside ionosphere..Parallel studies showed that at times, these field-aligned distributions showed evidence of auroral acceleration processes.

THESES DIRECTED:

Lantto, E.S., "Detailed Analysis Case Studies of Trapped Plasmas at the Earth's Magnetic Equator," Master's Thesis, June, 1994.

Laszakovits, J.S., "Ionospheric Photoelectrons Measured at Geosynchronous Orbit," Master's Thesis, June 1994.

Gaw, R.C., "Electron Beams at geosynchronous orbit," Master's Thesis, September 1994.

OTHER:

The above noted theses, along with previous thesis work by Peter Braccio, lay the foundation for an article to be submitted to the Journal of Geophysical Research.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Magnetosphere

THE PHYSICS OF HIGH VOLTAGE BREAKDOWN

F. Schwirzke, Professor
Department of Physics
Sponsor: Naval Postgraduate School

OBJECTIVE: To understand the high voltage breakdown process and the process of plasma formation on the surfaces of electrodes of a vacuum diode.

SUMMARY: Electrical breakdown and formation of cathode spots are basic processes in many areas of high voltage engineering and pulsed power technology. Micron-sized cathode spots form within nanoseconds on the cathode of a vacuum diode, vacuum arc, and most other discharges. Despite the fundamental importance of cathode spots for the breakdown process, their structure and the source of the highly localized energy density were not well understood. A self-consistent physical model of the breakdown process has been developed. Field emission of electrons from spots on the cathode leads to desorption of neutral molecules. A positive space charge is formed by ionization of the desorbed neutrals which further enhances field emission.Surface heating of the electron emitting spot by ion bombardment is by orders of magnitude a more efficient energy deposition mechanism than the previously believed Joule heating. The localized buildup of plasma above the electron emitting spot leads to pressure and electric field distributions which ignite unipolar arcs.The high current density of the unipolar arc provides the "explosive" like formation of a cathode spot plasma.Plasma production on the surface of the anode is characterized by the occurrence of anode spots. The unipolar arc model also explains the formation of anode spots. Experimental results obtained with the NPS Flash X-Ray and Electron Accelerator System confirm the new breakdown model.

PUBLICATIONS:

Schwirzke, F. and Carter, J.P., "Magnetic Field Generation in Shock Waves," Conference Record, IEEE Catalog No.94CH3465-2, 1994 IEEE International Conference on Plasma Science, 6-8 June 1994, Santa Fe, NM; American Institute of Physics, Conference Proceedings 318, Laser Interaction and Related Plasma Phenomena,

11th International Workshop, George H. Miley, ed., p. 117-127, Monterey, CA.

Schwirzke, F., Callahan, M.O., Maruyama, X.K., and Wright, C.M., "Plasma Formation on Electrodes of a High Voltage Diode," Abstract published in Bulletin of American Physics Society, Vol. 39, November 1994.

CONFERENCE PRESENTATION:

Schwirzke, F. and Carter, J.P., "Magnetic Field Generation in Shock Waves," 1994 IEEE International Conference on Plasma Science, 6-8 June 1994, Santa Fe, NM.

THESES DIRECTED:

Carter, J.P., "Magnetic Field Generation in Shock Waves," Master's Thesis, June 1994.

Callahan, M.O., "X-Ray Pulse Considerations and Electron Flow in High Voltage Diodes," Master's Thesis, December 1993.

Wright, C.M., "Time Resolved Measurements of Light Produced by Onset of Plasma Formation on Electrodes of Fast Pulsed High Voltage Diodes," Master's Thesis, December 1993.

OTHER:

Fred Schwirzke was elected a Fellow of The Institute of Electrical and Electronics Engineers with the following citation: "For contributions to the understanding of high voltage breakdown across a vacuum gap, and the subsequent high current emission by cathode spots."

DOD KEY TECHNOLOGY AREA: Materials and Processes

KEYWORDS: High Voltage Breakdown, Cathode Spots, Vacuum Diode

BURSTING BUBBLES/AEROSOL SOURCE FUNCTION

D.E. Spiel, Research Associate Professor
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: Bubble generated aerosols play an important role in many processes including, for example, air-sea dynamics, global climate, gas exchange, and ocean background acoustic noise. The purpose of this continuing work is to understand the physics of individual bursting bubbles as it relates to the oceanic aerosol source function.

SUMMARY: Work was completed on the measurements of the number and size of jet drops produced by collapsing bubbles with radii from 350 to 1500 micrometers. This work was published in two articles as described below. In addition, the speeds of ejection, the times of ejection and the heights above the surface at which the droplets separate from the ascending jet, the so-called jet drop birth parameters, were also completed. This work has been accepted for publication as mentioned below. Measurements of bubble cap thickness and disintegration speed as a function of bubble size were begun.

PUBLICATIONS:

Spiel, D.E., "The sizes of the jet drops produced by air bubbles bursting on sea- and fresh-water surfaces," Tellus, Vol. 46B, pp. 325-338, 1994.

Spiel, D.E., "The number and size of jet drops produced by air bubbles bursting on a fresh water surface," Journal of Geophysical Research, Vol. 99, pp. 10289-10296, 1994.

Spiel, D.E., "On the births of jet drops from bubbles bursting on water surfaces," Journal of Geophysical Research, in press, scheduled to appear in March 1995.

DOD KEY TECHNOLOGY AREA: Environmental Effects

KEYWORDS: Bursting Bubbles, Jet Drops, Aerosols

APPLICATION OF A NEW METHODOLOGY FOR SUPPORTING C3I REQUIREMENTS

J. Sternberg, Professor
R. Thackeray, Adjunct Research Professor
Department of Physics
Sponsor: Office of Net Assessment, O.S.D.

OBJECTIVE: The goal of this project is to develop and experiment with a unique wargame designed to assess the value of TRAP information to the mission success of a carrier battle group.

SUMMARY: The development of the software support system for handling the basic functions of the TRAP information flow, the background message traffic, the preparations for offensive and defensive operations, and the evaluations of the outcomes of those operations has been completed and extensively tested. Since the prime objective of the wargame is to show how, or whether, the differences between the player's intelligence picture and "ground truth" affects mission success in a contingency scenario, the software has been designed to keep separate the player's perception of the status of enemy weapon systems and activity, used in decision making, and the corresponding "ground truth", which is used in evaluating engagement outcomes. This is a continuing project.

CONFERENCE PRESENTATION:

Sternberg, J., Thackeray, R., and Johnson, F., "A New Methodology for Assessing the Military Value of Tactical Surveillance and Intelligence Systems," presented at the 1994 Symposium on Command and Control Research and Decision Aids, Naval Postgraduate School, Monterey, CA, June 1994.

DOD KEY TECHNOLOGY AREA: Other (Information Warfare)

KEYWORDS: Information, Wargame, C3I Requirements

ATMOSPHERIC OPTICAL TURBULENCE MEASUREMENTS FOR ADAPTIVE OPTICAL PROGRAMS

D.L. Walters, Associate Professor
Department of Physics
Sponsor: USAF Phillips Laboratory, Kirtland AFB, NM

OBJECTIVE: To develop and collect balloon measurements of the stratospheric microthermal fluctuations critical to resolving optical propagation limits imposed on the USAF Airborne Laser Program.

SUMMARY: The magnitude and spatial distribution of atmospheric turbulence is a critical issue to the USAF Airborne Laser Program that must be resolved in order to successfully accomplish a Theater Missile defense mission. The Air Force has scheduled a series of aircraft to aircraft laser tests over 50-200 km stratospheric paths to resolve some of these questions. NPS has the responsibility for collecting, balloon borne, high spatial resolution, temperature measurements in the stratosphere during these tests. These measurements provided a measure of the optical index of refraction fluctuations that are severely detrimental l to the program. NPS will support this program by quantifying the microthermal induced index of refraction fluctuations within the stratospheric during the tests. To accomplish this, we have developed a balloon sensor, probes and a digital telemetry system that can collect microthermal temperature measurements with a .001K noise and with vertical resolution of 2-4 cm in the stratosphere. The extreme stratospheric temperatures around 200 K as well as the impossibility of recovering a sensor package after launch have complicated this research effort. To date, two successful launches have occurred, and two more development, test launches are scheduled before the actual ABEL- ACE mission tests.

PUBLICATIONS:

Davis, C.A. and Walters, D.L., "Atmospheric inner-scale effects on normalized Irradiance variance," Applied Optics, Vol. 33, pp. 8406-8411, 1994.

Walters, D.L., "Atmospheric optical turbulence measurements using higher order structure functions," accepted for publication in Applied Optics, March 1994.

CONFERENCE PRESENTATION:

Walters, D.L., "Stratospheric Atmospheric Turbulence Balloon Measurements," presented at the, NASA UCLA Workshop on Laser Propagation in Atmospheric Turbulence, March 1994.

THESIS DIRECTED:

Davis, C.A., LT USN, "Computer Simulation of Wave Propagation Through Turbulent Media," Doctoral Dissertation, June 1994.

DOD KEY TECHNOLOGY AREA: Sensors, Environmental Effects

KEYWORDS: Adaptive Optics, Theater Missile Defense, Turbulence

DEPARTMENT
OF
PHYSICS

1994
Faculty Publications
and Presentations

JOURNAL PAPERS

Atchley A.A. and Kuo, F.M., "Stability Curves for a Thermoacoustic Prime Mover," Journal of the Acoustical Society of America, Vol. 95, pp. 1401-1404, 1994.

Atchley, A.A., "Analysis of the Initial Buildup of Oscillations in a Thermoacoustic Prime Mover," Journal of the Acoustical Society of America, Vol. 95, pp. 1661-1664, 1994.

Atkinson, J.D. and Cleary, D.D., "A Technique for Modeling Interference Patterns From Two-Beam Interferometers," Computers in Physics, Vol. 8, p. 462, 1994.

Commander, K.W., Lim, R., Huskey, T.W.L., Baker, S.R., and Kargl, S.G., "Acoustic form Function for Porous Solid Spheres: Comparison Between Theory and Experiments," Journal of the Acoustical Society of America, Vol. 96, No. 5, Pt. 2, p. 3264, 1994.

Davis, C.A. and Walters, D.L., "Atmospheric Inner-Scale Effects on Normalized Irradiance Variance," Applied Optics, Vol. 33, pp. 8406-8411, 1994.

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Hansen, W.N. and Melich, M.E., "Pd/D Calorimetry - The Key to the F/P Effect and a Challenge to Science," Transactions of Fusion Technology, Vol. 26, No. 4T, Part 2, pp. 355-364, December 1994.

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Keolian, R.M., "A Simple Harmonic Oscillator Teaching Apparatus with Active Velocity Feedback," Journal of the Acoustical Society of America, Vol. 95, Pt. 2, p. 2934, 1994.

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Zhang, Q., Brown, D.A., Reinhart, L., and Morse, T.F., "Tuning Bragg Wavelength by Writing Gratings on Prestrained Fibers," Photonics Letters, July 1994.

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Cooper, A.W., Lentz, W.J., Walker, P.L., and Chan, P.M., "Infrared Polarization Measurements of Ship Signatures and Background Contrast, In Characterization and Propagation of Sources and Backgrounds," Proceedings SPIE, Vol. 2223, pp. 300-309, 1994.

Garrett, S.L., Perkins, D.K., and Gopinath, A., "Thermoacoustic Refrigerator Heat Exchangers: Design, Analysis and Fabrication," Proceedings of 10th International Heat Transfer Conference, Vol. IV, pp. 375-380, 1994.

Hall, J., Wong, R.K., Blau, J., and Colson, W.B., "Simulation of the SLAC X ray Free Electron Laser," SPIE O-E Lase '94 Symposium, "Gas Metal Vapor, Free Electron Lasers and Applications," Los Angeles, CA, pp. 163-171, 1994.

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Pieper, R.J. and Cooper, A.W., "A Visibility Model for MRTD Prediction," SPIE Proceedings, Vol. 2224, pp. 259-269, 1994.

Quick, D., Blau, J., Wong, R.K., and Colson, W.B., "Phase Space Simulations of the Novosibirsk/SELENE FEL," SPIE O-E Lase '94 Symposium, "Gas Metal Vapor, Free Electron Lasers and Applications," Los Angeles, CA, pp. 172-179, 1994.

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Atchley, A.A., Bass, H.E., Keolian, R., Larraza, A., and Sabatier, J., "Acoustics: Sound of Science and Science of Sound," Annual Meeting of the American Association for the Advancement of Science, San Francisco, CA, February 1994.

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Colson, W.B., "Navy Interest in High Power FELs," CEBAF Laser Processing Consortium Workshop, CEBAF Center, Newport News, VA, September 1994.

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Department of Systems Management

The Department of Systems Management is responsible for academic programs designed to educate officers and DoD civilians in a variety of functional management specialties. The diversity of the faculty's professional expertise and scholarship is reflected in the wide variety of research projects conducted in the department.

In addition to permanent faculty, the department's research efforts have been augmented by the participation of a number of adjunct professors. The research projects cover a broad range of defense-related management issues, ranging from basic scholarly research projects to applied research designed to assist policy makers and operational decision makers. For ease of exposition, the research projects are grouped into the following functional areas: acquisition and contracting; logistics and transportation; information and technology management; financial management; manpower, personnel, and training analysis; Organization, management and policy analysis.

Professor D. Lamm continued his research project to identify and examine various characteristics of the contracting profession through the development and use of the taxonomical approach. The research effort involves three studies: in the first a classification scheme was developed; in the second, specific homogeneous goods with specific sets of buyers were examined; and in the third, Professor Lamm examined the practical applications and benefits that can be gained through use of the taxonomy. In a second research project, Professor Lamm examined the use of the simulated negotiation method in preparation for contract negotiations.

Professor A. McMasters continued a multi-year project sponsored by the Navy Supply System Command to develop a wholesale level inventory model to be used by the Navy to replenish inventories of repairable items. In this year's effort, he concentrated on determining the distribution of net inventory and the relationship between the mean and variance of the net inventory distribution as a function of the various important parameters used by the Navy in its management of such items. In a second continuing project funded by Naval Air Systems Command, Professor McMasters is developing models to predict the savings in life-cycle costs of proposed engineering changes intended to improve reliability, maintainability, and sustainability of turbine aircraft engines for Naval aircraft. The first phase of this multi-year project examined current lifecycle cost models. The second phase is to validate the actual costs and logistics effectiveness of the aircraft engine Component Improvement Program (CIP) by looking at historical data. A third phase was added this past year to address the problem of justifying warranties on aircraft engines.

Professor David Brown started a new research effort to in investigate the welfare economics associated with incremental changes in freight service quality. This includes developing a shipper surplus model which treats service quality as a second price in addition to freight rate, using this welfare measure to determine a characterization of socially optimal service quality, and then examining issues such as carrier competition and freight rate regulation relative to this characterization. Professor Brown is also continuing work on two ongoing projects. The first examines and compares the unit stockout cost and probability-of-stockout procedures for specifying safety stock with respect to criteria primarily based on microeconomic problems such as carrier choice and the problem of minimizing the sum of shipper inventory and carrier costs with respect to transportation quality. The second project continues the development of detailed track inspection procedures designed to support maintenance management of U.S. Army railroad networks.

Professor Paul Fields research extends the classic newsboy problem to determine order quantities for perishable goods under conditions of demand uncertainty.

Professors Boger and Liao's are collaborating on the second phase of a multi-year project sponsored by the Army's Program Management Systems Development Agency to review and analyze the existing version of the Depot Maintenance Resource Prediction Model for possible refinement and enhancement.

Professor Norman Schneidewind continued his highly visible research work of software reliability models. He is currently involved in two projects sponsored by the Naval Surface Warfare Center. The objective of the first project is to validate and apply metrics discriminant and predictor functions on large projects (Space Shuttle Flight Software) to control, predict, and assess software quality. The second research effort involves the development of Schneidewind Software Reliability Model enhancements for predicting test time, total failures, remaining failures, program quality, as applied to the Space Shuttle.

Professor Kishore Sengupta and Anthony Ciavarelli (of the Aviation Safety Office) continued research on a project to develop a multimedia-based intelligent tutoring system. The system is for training aviators in the acquisition and use of perceptual skills required in flying with night vision devices. The project has been funded by the Naval Air Systems Command.

Professor Ramesh continued a multi-year project sponsored by the Naval Surface Warfare Center to develop models and mechanisms for requirements traceability in large scale systems development. He is also initiating an internally funded project to develop an environment to support various stakeholders involved in systems development by reasoning with design rationale knowledge.

Professors Dan Dolk and M. Ackroyd are investigating the problems and opportunities with respect to the application of object technology to enterprise modeling. Their work is sponsored by the Defense Information Systems Agency. In addition, the are continuing their work for the Army Program Management System Development Agency (PMSDA) to review and analyze the existing version of PMSDA'a Depot maintenance Resource Prediction Model (DMRPM). This research will use data related to combat vehicles to identify and validate the resource predictive algorithms, and to identify additional decision needs of current users and areas for refinement.

The U.S. Coast Guard continues to sponsor **Professor Hemant Bhargava's** project to improve and facilitate the development of computer-aided modeling environments to facilitate the construction, exercise, and management of mathematical models for decision making.

Professor Magdi Kamel is concurrently involved in two projects. The first project seeks to develop a prototype maintenance advisor expert system for MK92 Fire Control System to enhance the ability of MK92 technicians to better determine, diagnose, and resolve problems within the system. The second project is sponsored by the Marine Corps, and involves the development of a prototype Monitor Assignment Support System to support and assist the monitors of the Manpower Management Officer assignment (MMOA) branch of Headquarters United States Marine Corps in the placement of trained qualified officers into authorized billets both internal and external to the Marine Corps.

Professors William Haga and Kenneth Euske collaborated on a research project to improve the process improvement process. The project is funded by the Office Of Director of Defense Information. The specific goal of this project is to develop the redesign Experts and Practices (REAP) database to support DoD functional managers in undertaking business process re-engineering.

Professor L. Jones is involved in three concurrent research efforts. The first is a continuing research project to assess the roles, participants and relationships in the Navy system for Ship Maintenance and Repair and to analyze methods for improving the efficiency and cost effectiveness of the system. Selected issues in programming and budgeting for ship maintenance and repair are also examined. The objective of the second research project is to assess the budget and the impact of budget reductions in the AIRPAC, PACFLT command, to assess management control system and accounting changes to respond to budget austerity including those related to the DMR process and to analyze U.S.-Japan national defense resource burdensharing. The project is sponsored by COMNAVAIRPAC. The goal of the third research project, which is sponsored by the Comptroller, DoD, is to assess the impact of budget reductions in DoD including those related to the DMR process and to conduct a

survey of quality assessment in DoD Financial Management Education and Training Institutions.

Professors W. Gates is continuing a research project sponsored by the Bureau of Naval Personnel to help develop a cost-effective mix of drug demand reduction programs in DoD. The objective is to identify the characteristics of the at-risk population and design specific initiatives to efficiently address that population.

The Deputy Chief of Naval Operations (MPT) N1/BUPERS is the sponsor of a project that provided umbrella funding within which individual projects were proposed and carried out by individual researchers. **Professor Mehay** coordinated the overall project and facilitated interactions between individual faculty and N1/BUPERS. There are two specific sub-projects. The first models the career paths of enlisted personnel and officers, and use this as a framework for specifying and estimating models of promotion using standard multivariate statistical techniques. The focus of the second sub-project is to estimate the direct effects of various downsizing programs on separation behavior by enlisted and officer personnel. Professor Mehay is also the principal investigator on a research project for the Navy Personnel Research and Development Center to develop a economic framework to evaluate the effectiveness of Navy graduate education (GE) programs, the benefits of the programs to the Navy, and the rate of return on such programs.

Professor Mark Eitelberg was involved in a research project for the Office of the Assistant Secretary of Defense (Force Management and Personnel) to chronicle the manpower policies and programs that succeeded --- or failed --- in sustaining the All-Volunteer Force (AVF); and to provide a "lessons learned" evaluation that will assist in setting a course for the future.

Professor John Barrios-Choplin is exploring the source, topic, and valence of surprises that newcomers experienced during their first months on their first jobs.

Professors Keebom Kang and K.L. Terasawa are collaborating on a project sponsored by the U.S. Army recruiting Command. The project has two objectives: (1) to develop a transparent and documentable cost per output methodology for the US Army recruiting activities; and (2) to identify the areas for cost-savings with the future changes in recruiting environment.

Professor David Henderson is being sponsored by the Center for the Study of American Business to conduct to economic studies. In the first he seeks to bring together much of the literature on economic growth around the world since World War II, and to draw conclusions about what kinds of government policies enhance economic growth and what kinds hinder it. In the second study, his goal is to bring together much of what health economists know and show its implications foe health care reform.

In a related project, NPS is funding **Professor Richard Doyle** to examine the effect of the federal deficit upon the process of health care reform within the 103rd Congress (1993-94).

In another internally funded project, **Professor Douglas Moses** is documenting cross-sectional and time-series patterns exhibited by financial ratios within the U.S. Defense Industry.

The Naval Air Warfare Center, Aircraft Division is funding **Professor Susan Page Hocevar** to conduct a number of projects. One project constitutes the second in a series of annual surveys of employee Quality of Work Life, the results of which will be aggregated with prior data for longitudinal analysis. A second project involves gathering data and preparing a case history of the evolution of organizational restructuring at NAWC-ADI. The third effort is a collaboration with **Professor Gail Fann Thomas** to study the development of high-performance self-managed teams.

The Naval Aviation Systems Command is sponsoring **Professor Roger Evered** to find ways to assess the overall effectiveness and value added by the Naval Aviation Engineering Service Unit (NAESU) organization of NAVAIR.

Professor Nancy Roberts is investigating how to design strategic planning and management processes for DoD and DoN organizations given the constraints of size and public sector management.

PLEASANT SURPRISE: THE BRIGHTER SIDE OF NEWCOMER SOCIALIZATION

J.R. Barrios-Choplin, Visiting Assistant Professor
Department of Systems Management
Sponsor: Naval Postgraduate School

OBJECTIVE: The objective of this research was to explore the source, topic, and valence of surprises newcomers experienced during their first months on their first jobs. It was an extension of previous research and was intended to advance our knowledge of key socialization processes.

SUMMARY: Fifty-one BBA and MBA graduates were interviewed by phone five times during their first four months on their first jobs after graduation. The conversations were recorded and the transcripts were coded for later statistical analysis. Pleasant surprise was more common than unpleasant surprise, which in itself is a surprise to those interested in newcomer socialization.

CONFERENCE PRESENTATION:

Barrios-Choplin, J.R., "Pleasant Surprise: The Brighter Side of Newcomer Socialization," annual meeting of the Academy of Management, Dallas, TX, August 1994.

DOD KEY TECHNOLOGY AREA: Other (Organization Behavior)

KEYWORDS: Surprise, Newcomers, Socialization

LONG TERM EFFECTS OF AN ORGANIZATIONAL STRESS PREVENTION PROGRAM

J.R. Barrios-Choplin, Visiting Assistant Professor
Department of Systems Management
Unfunded

OBJECTIVE: The purpose is to determine the effects of an "off the shelf" stress prevention program on employees of one firm in a dynamic service industry.

SUMMARY: Employees in a Canadian human resource consulting firm completed a questionnaire three times (base-line before the stress seminar, three months later, and one year later). The project is continuing, with the third data collection scheduled for February, 1995.

DOD KEY TECHNOLOGY AREA: Other (Organization Behavior)

KEYWORDS: Stress, Human Resource Management, Emotion

BODY, MIND, AND HEART: THE EFFECTS OF SELF-MANAGEMENT TOOLS

J.R. Barrios-Choplin, Visiting Assistant Professor
Department of Systems Management
Unfunded

OBJECTIVE: This study determined if a particular self-management tool affected participants' emotions, stress, menstrual cycle, and body chemicals.

SUMMARY: Fifty adults were measured via questionnaire, daily menstrual cycle logs, and saliva samples prior to being trained in the self-management technique. They were trained for one day and instructed to practice the technique daily. After one month, the same participants were re-measured on the same dimensions. Significant improvements were noted in anxiety, emotions, and body chemistry.

DOD KEY TECHNOLOGY AREA: Other (Organization Behavior)

KEYWORDS: Self-management, Stress, Emotion, Body Chemistry

INTEGRATED COMPUTER-AIDED MODELING ENVIRONMENT

H.K. Bhargava, Assistant Professor
Department of Systems Management
Sponsor: U.S. Coast Guard

OBJECTIVE: Computer-aided modeling environments, or model management systems, are designed to facilitate the construction, exercise, and management of mathematical models for decision making. In the current year, the project was concerned with improving, and facilitating the development of, modeling environments in a variety of ways, by studying issues such as a) Philosophy and principles of modeling, b) Embedded languages as an architecture for modeling systems, c) Extensions to formal modeling languages, and d) Computer-aided model construction.

SUMMARY: Methods for computer-based collaboration and computer-aided decision analysis were studied. The integration of these technologies was examined using a three-phase model (problem definition; problem structuring; modeling/analysis) of decision making activities. Decision support systems should facilitate the use of all of these methods in a way that supports the decision makers in switching from one activity to another. The embedded languages technique was examined as a way to systematically integrate multiple modeling languages and subsystems within a single environment. The use of strong typing was examined, and formal semantics for the type system in one such language---Ascend---was developed and analyzed. The analysis identified general issues in the design and implementation of type systems in mathematical modeling languages.

PUBLICATIONS:

Bhargava, H.K., Krishnan, R., and Whinston, A.B., "On Integrating Modeling and Collaborative Technologies," Journal of Organizational Computing, pp. 297-316, 1994.

Bhargava, H.K. and Kimbrough, S.O., "On Embedded Languages, Meta-level Inference and Computer-aided Modeling," Computer Science and Operations Research: The Impact of Emerging Technology, S. Nash and Ariela Sofer (eds.), Kluwer, Proceedings of the ORSA CSTS conference, Williamsburg, VA, January 1994.

CONFERENCE PRESENTATIONS:

Bhargava, H.K. and Krishnan, R., "On Semantics of Typed Modeling Languages," ORSA/TIMS joint national meeting, Boston, MA, April 1994.

Bhargava, H.K., Kimbrough, S.O., and Oliver, J., "Genetic Search Techniques for Exploratory Modeling," ORSA/TIMS joint national meeting, Boston, MA, April 1994.

OTHER:

Bhargava, H.K., Krishnan, R., and Piela, P., "On Formalizing the Semantics of Typed Modeling Languages," submitted to ORSA Journal on Computing, May 1994.

Bhargava, H.K., "Using Quiddities for Detecting Semantic Conflicts in Collaborative Work," submitted to the Journal of Organizational Computing, November 1994.

Bhargava, H.K., "TefaDep: Model Management via Computational Dependencies," Quintus Prolog program.

DOD KEY TECHNOLOGY AREA: Computers, Software, Other (Computer-aided Modeling)

KEYWORDS: Computer-aided Modeling, Model Management, Formal Modeling Languages

PRINCIPLES OF MODELING: DIMENSIONAL ANALYSIS

H.K Bhargava, Assistant Professor
Department of Systems Management
Sponsor: Naval Postgraduate School

OBJECTIVE: To develop a software program that employs methods of dimensional analysis in model validation, model solution, and model formulation.

SUMMARY: A general dimensional analysis program was created based on the author's previous work in dimensional analysis for mathematical modeling environments. The program is written in C++, and runs on Unix workstations at the Naval Postgraduate School. An executable copy of the program is available from the author.

OTHER:

Bhargava, H.K., "Dimensional Analysis Methods for Model Management," Working Paper, Naval Postgraduate School, 1994.

Bhargava, H.K. and Amakawa, K., "Ldim: Program for Dimensional Analysis," C++ program.

DOD KEY TECHNOLOGY AREA: Computers, Software, Other (Computer-aided Modeling)

KEYWORDS: Dimensional Analysis, Model Validation, Computer-aided Modeling

DEPOT MAINTENANCE RESOURCE PREDICTION MODEL: VALIDATION, REFINEMENT, AND ENHANCEMENT

D.C. Boger, Professor
S.S. Liao, Professor
Department of Systems Management
Sponsor: Program Management Systems Development Agency, Headquarters, Department of the Army

OBJECTIVE: The goal of this project is to review and analyze the existing version of the Depot Maintenance Resource Prediction Model for possible refinement and enhancement. This is the second phase of a multiyear project.

SUMMARY: The principal focus of this research project is on the data, quantitative methods, and algorithms of the model. The research is using data from combat vehicles and aircraft to identify, validate, and refine the predictive algorithms of the model. The research will identify additional decision needs of current Army users (ODCSLOG, ASA(FM), HQ AMC) and decision needs of other potential DoD users. Research results from prior year showed that the model does not produce consistent outputs. Therefore, the focus of this research for the current phase was shifted to examine whether the algorithms used in the model are correct. A "black-box" testing approach was utilized by using a small set of sample data to manually calculate what the end result should be and compare the manual calculation result with model output. Results from this testing show that a significant portion of source data was rejected due to various cross-validation procedures built into the model. NSN (National Stock Number) is not a stable set of numbers; new items are added to the list and different activities may use different NSN for the same item. Its use as the main validation criterion results in the large data input rejection rates.

OTHER:

A draft copy of technical report has been sent to the sponsor for comment: "Depot Maintenance Resource Prediction Model Validation, Refinement, and Enhancement."

DOD KEY TECHNOLOGY AREA: Software, Other (Resource Prediction Model)

KEYWORDS: Model, Depot Maintenance, Resource Requirements, Decision Support, Validation.

WELFARE ECONOMICS OF FREIGHT SERVICE QUALITY

D.G. Brown, Adjunct Professor
Department of Systems Management
Unfunded

OBJECTIVE: The goal of this project is to investigate the welfare economics associated with incremental changes in freight service quality. This includes developing a shipper surplus model which treats service quality as a second price in addition to freight rate, using this welfare measure to determine a characterization of socially optimal service quality, and then examining issues such as carrier competition and freight rate regulation relative to this characterization. This is a new active project this year.

SUMMARY: Activity during 1994 was primarily concerned with developing and examining two shipper surplus models. Most of the examination consisted of working with numeric examples developed in Maple, a computer program for algebraic symbolic manipulation.

In the first model, it is assumed that each shipper desires at most one unit of freight service which will be

purchased from the carrier if the freight rate and service level combination is evaluated to be less than or equal to the shipper's individual threshold. Formulation variations within this model related to whether or not individual shippers shared the same dollar evaluation of different freight service levels.

The second model was concerned with a single shipper for which cost or profit was specified as a function of the freight rate and service level. Separate formulations were developed based on shipper cost (profit) and the shipper's derived demand for freight service; these two measures were not always consistent, especially if the demand surface demonstrated Giffen-like behavior with respect to freight service quality.

Another significant finding this year was that shipper demand, specified as a general function of freight rate and service quality, can be reformulated without loss of generality as a function of full price (the sum of freight rate and a service evaluation function). This result augments previous work on freight service quality economics based on full cost and full price.

DOD KEY TECHNOLOGY AREA: Other (Transportation Economics)

KEYWORDS: Freight Service Quality, Welfare Economics, Shipper Surplus, Full Price

THE INTERNAL DYNAMICS OF TWO INVENTORY-THEORETIC FREIGHT SERVICE CHOICE MODELS

D.G. Brown, Adjunct Professor
Department of Systems Management
Unfunded

OBJECTIVE: Within the inventory-theoretic transportation literature, unit stockout cost and probability-of-stockout are the most popular procedures for specifying safety stock. The goal of this project was to examine and compare these two procedures with respect to criteria primarily based on microeconomic problems such as carrier-choice and the problem of minimizing the sum of shipper inventory and carrier costs with respect transportation service quality. This is a continuing project from last year and before.

SUMMARY: Activity during 1994 was primarily directly towards filling in some gaps, and developing a research paper based on this work.

DOD KEY TECHNOLOGY AREA: Other (Transportation and Logistics Models)

KEYWORDS: Freight Service Quality, Inventory-theoretic, Model Validation

DETAILED TRACK INSPECTION PROCEDURES TO SUPPORT MAINTENANCE MANAGEMENT OF U.S. ARMY RAILROAD NETWORKS

D.G. Brown, Adjunct Professor
Department of Systems Management
Unfunded

OBJECTIVE: The goal of this project was to continue the development of detailed track inspection procedures designed to support maintenance management of U.S. Army railroad networks, and to effectively communicate these procedures to potential users. This is a continuing project from last year and before.

SUMMARY: Activity during 1994 was primarily directly towards issuing a technical report culminating a eight year process which included two widely circulated draft reports.

DOD KEY TECHNOLOGY AREA: Other (Transportation Facilities)

KEYWORDS: Railroad Track Inspection Procedures, Maintenance Management, Condition Evaluation, Decision Support.

ENTERPRISE MODELING AND OBJECT TECHNOLOGY

D.R. Dolk, Professor
M.H. Ackroyd, Visiting Associate Professor
Department of Systems Management
Sponsor: Defense Information Systems Agency, Corporate Information Management

OBJECTIVE: The goal of this research was an investigation of the problems and opportunities with respect to the application of object technology to enterprise modeling.

SUMMARY: Object technology (OT) has proliferated primarily in the areas of systems analysis and design, programming languages, and, to a lesser extent, database management systems. A natural extension of this technology would seem to be to the overall modeling of organizations. We conducted a survey of current OT techniques for systems analysis and design and for enterprise modeling (EM). Our investigation showed that EM is a more complex undertaking than any of the activities for which OT is currently effective. We concluded that EM is more about simulation than automation, and that existing object-based techniques limit their scope to automation objectives. We laid out a general set of requirements for EM, suggested a broad framework in which to consider EM, and then discussed the ability of OT to meet the requirements within the framework.

OTHER:

Dolk, D.R. and Ackroyd, M.H., "The roles of object technology in enterprise modeling," Naval Postgraduate School Technical Report, due in February 1995.

To be presented at, and appear in the proceedings of, the Third International Conference of the International Society of Decision Support Systems, Hong Kong, June 1995: Dolk, D.R. and Ackroyd, M.H., "Enterprise modeling and object technology: Integrating organizational decision support and information modeling."

To be presented at TIMS XXXIII Conference, Singapore, June 1995: Dolk, D.R. and Ackroyd, M.H., "Structured enterprise modeling."
Dolk, D.R., "Qualitative enterprise modeling."

An extended paper on embedding structured modeling within an existing object-based modeling paradigm is being prepared for submission to the 29th Hawaii International Conference on System Sciences and for submission to a journal.

DOD KEY TECHNOLOGY AREA: Software, Design Automation

KEYWORDS: Enterprise Modeling, Object Technology, Model Management

DEPOT MAINTENANCE RESOURCE PREDICTION MODEL SYSTEM VALIDATION, REFINEMENT, AND ENHANCEMENT

D.R. Dolk, Professor
M.H. Ackroyd, Visiting Associate Professor
Department of Systems Management
Sponsor: Army Program Management System Development Agency (PMSDA)

OBJECTIVE: The goal of this project was to conduct a review and analysis of the Depot Maintenance Resource Prediction Model (DMRPM) decision support system developed by PMSDA to support programming and budgeting activities for Army depot maintenance at the Headquarters level.

SUMMARY: The research reviewed the DMRPM system from two perspectives: correctness of the modeling algorithms and assessment of the system architecture. Data related to combat vehicles was used to validate the DMRPM resource predictive algorithms. Inconsistencies and inaccuracies in the current data gathering process were identified as a result. A thorough analysis of the existing object-oriented architecture was conducted and the object model was re-engineered to better reflected the activities of depot maintenance budgeting and programming. A migration strategy for implementing this model into the current version of the system was devised and presented to the subcontractor in charge of programming.

DOD KEY TECHNOLOGY AREA: Software, Human-System Interfaces

KEYWORDS: Object Modeling, Depot Maintenance, Programming and Budgeting

HEALTH CARE REFORM AND THE FEDERAL DEFICIT

R. Doyle, Associate Professor
Department of Systems Management
Sponsor: Naval Postgraduate School

OBJECTIVE: The goal of this research was to examine the effect of the federal deficit upon the process of health care reform within the 103rd Congress (1993-94).

SUMMARY: The political, economic, fiscal and organizational problems associated with health care reform are briefly described. The deficit implications of the eight health care reform bills that were evaluated by the Congressional Budget Office are identified and compared. Six of the eight would have decreased the deficit, while two, including the president's proposal, would have increased it. But only two of the eight bills made it out of committee and only one was actually debated on the floor of one of the two houses of Congress. Even that bill was withdrawn shortly after it was called up for debate. The fact that health care reform failed during this Congress was indirectly a consequence of the deficit. Most reform measures included significant tax increases or cuts in existing health programs, or both, in order to offer both reform and deficit reduction. The logic of such packages is dictated by the fact that spending for health care is the primary cause of the deficit. The tax increases and spending cuts which accompanied reforms diminished support for the bills while also ameliorating their effects on the deficit. The link between health care programs and the deficit, illustrated in the

reform experience of 1993-94, significantly limits expansion of existing government health care programs and discourages establishment of new ones.

CONFERENCE PRESENTATIONS:

Doyle, R., "Searching for the Health Care Fairy: Congress, Health Care Reform and the Deficit," annual meeting of the Pacific Northwest Political Science Association, Portland, OR, October 1994.

Doyle, R., "Congress and Health Care Reform: Implications for the Health Care Industry," presented at the annual Issues Impacting Income conference, sponsored by Synergistic Systems, Inc., Laguna Beach, CA, August 1994.

OTHER:

The investigator has submitted an article for publication using the results of this research. The manuscript, "Searching for the Health Care Fairy: The Deficit and Health Care Reform, 1993-94," is being considered by Public Administration Review.

DOD KEY TECHNOLOGY AREA: Other (Budgeting)

KEYWORDS: Health Care, Deficit, Congress

AMERICA'S ALL-VOLUNTEER FORCE

M.J. Eitelberg, Associate Professor
Department of Systems Management
Sponsor: Office of the Assistant Secretary of Defense
(Force Management and Personnel)

OBJECTIVE: The goal of this project is to chronicle the manpower policies and programs that succeeded--or failed--in sustaining the All-Volunteer Force (AVF); and to provide a "lessons learned" evaluation that will assist in setting a course for the future.

SUMMARY: Information has been gathered from three major sources: published research, Congressional reports, and Department of Defense documents; data maintained by the Defense Manpower Data Center; and interviews with current and former officials in the Department of Defense who were directly involved in designing or executing manpower policies during the AVF era (1973-present). Contractor support was obtained for two phases of the research: a study of the evolution of the AVF and an assessment of the "effectiveness" of the military since the end of the draft. This project is a multi-year effort and will include an evaluation of ten areas, including recruiting, compensation, population participation, changing missions, and other topics.

PUBLICATIONS:

Eitelberg, M. J. and Mehay, S.L., "The Shape of Things to Come," Marching Toward the 21st Century, M.J. Eitelberg and S.L. Mehay, eds., Greenwood Press, 1994.

Eitelberg, M.J. and Mehay, S.L., "Demographics and the American Military at the End of the 20th Century," US Domestic and National Security Agendas: Into the 21st Century, S.C. Sarkesian and J. Flanigan, eds., Greenwood Press, 1994.

Eitelberg, M.J., "A Military of Volunteers: Yesterday, Today, and Tomorrow," Report of a Conference Held at the US Naval Academy, distributed by Smithsonian Institution/Office of Naval Research, NPS, Monterey, CA,

January 1994.

CONFERENCE PRESENTATIONS:

Eitelberg, M.J. and Little, R.D., "Influential Elites and the American Military After the Cold War," presented at Conference on Civil-Military Relations, Center for Strategic and International Studies and the Strategic Studies Institute of the Army War College, Carlisle Barracks, PA, September 1994.

Eitelberg, M.J., "Population Participation in the American Military," series of papers presented at The Technical Cooperation Program (TTCP) annual meeting of UTP-3, Panel on Military Human Resource Issues, Shelley Bay Air Force Base, Wellington, New Zealand, July 1994.

THESES DIRECTED:

Dye, G.B., CDR, USN, "Alternative Approach for Measuring Black Representation in Navy Enlisted Occupations," Master's Thesis, June 1994.

Cleveland, F.E., LCDR, USN and Ohl, M.A., LT, USN, "Don't Ask, Don't Tell: A Policy Analysis and Interpretation," Master's Thesis, June 1994.

Harris, W.E., MAJ, USMC, "Military Compensation and the All-Volunteer Force: Lessons Learned," Master's Thesis, December 1994.

OTHER:

The investigator is preparing a book-length manuscript for publication in 1996. Several student theses on related topics are in progress, with expected completion in March and June 1995. Two book chapters, including "The All-Volunteer Force After Twenty Years," will be published in 1995 (March and August). In addition, two technical reports by a contractor are due for publication in 1995.

DOD KEY TECHNOLOGY AREA: Other (Military Manpower Policy)

KEYWORDS: Military Manpower, Personnel, Recruitment, Population Representation, Compensation, Force Performance, Roles/Missions, Attrition, Accession Policy

IMPROVING THE PROCESS IMPROVEMENT PROCESS

K.J. Euske, Associate Professor
W.J. Haga, Visiting Associate Professor
Department of Systems Management
Sponsor: Office of Director of Defense Information

OBJECTIVE: The goal of this project was to develop the Redesign Experts and Practices (REAP) database to support DOD functional managers in undertaking business process re-engineering.

SUMMARY: The project developed the REAP database in Oracle for IBM-compatible PCs and populated it with demonstration data on best practices, experts and metrics for business process re-engineering.

DOD KEY TECHNOLOGY AREA: Materials and Processes

KEYWORDS: Business Process Re-engineering, Best Practices, Bench Marking

AN EXTENSION OF THE NEWSBOY PROBLEM FOR PERISHABLE GOODS

P.J. Fields, Assistant Professor
Department of Systems Management
Sponsor: Naval Postgraduate School

OBJECTIVE: This research extends the classic newsboy problem to determine order quantities for perishable goods under conditions of demand uncertainty. The assumption that instances of demand are independent and identically distributed is relaxed and the solution is not constrained to place limit ordering to only one order per demand period. This results in a more realistic formulation of the problem and a more practical solution.

OTHER:

The author is preparing the results of this research for publication in Management Science.

DOD KEY TECHNOLOGY AREA: Other (Production and Inventory Control)

KEYWORDS: Newsboy Problem, Perishable Goods, Order Quantity

STUDY OF SELF-MANAGED TEAMS AT NAWC-ADI

S.P. Hocevar, Visiting Assistant Professor
G.F. Thomas, Associate Professor
Department of Systems Management
Sponsor: Naval Air Warfare Center, Aircraft Division, Indianapolis

OBJECTIVE: NAWC-ADI recently moved to a team-based organizational design. This study was designed to study the development of high-performing self-managed teams.

SUMMARY: This research was conducted in the summer of 1994 to respond to NAWC-ADI's desire to learn more about high performing self-managed customer support teams (CST). The initial stage of the research included a review of the relevant literature of empowerment as it relates to high-performing self-managed teams. The purpose of the review was to surface relevant models and to explore ways in which other companies are dealing with these issues. To complete the second phase of the study, the research team interviewed three to five members of two struggling CSTs; two successful CSTs; and one recent struggling, turned successful team. In addition, representatives of senior management, middle (competency) management teams and, coaches, and other relevant stakeholders of each team's work were interviewed. The data analyses yielded several themes that exemplify struggling and successful CSTs at NAWC-ADI. In addition, managerial roles for building empowerment and critical policy issues for advancing team effectiveness were identified. As of 9/30/94, a workshop was being prepared for middle and senior managers at NAWC-ADI. The purpose of this workshop was to present the research results and facilitate the managers in action planning based on the data.

PUBLICATIONS:

Hocevar, S.P., Thomas, G.F., Thomas, K.W., Moore, N.B., and Barrett, F., "Developing High Performing Self-Managed Teams at NAWC-ADI," Naval Postgraduate School Technical Report, NPS-SM-94-004PR, 1994.

Moore, N., Thomas, K.W., Thomas, G.F., and Hocevar, S.P., "Team Empowerment: A Selected Bibliography," Naval Postgraduate School Technical Report, 1994.

CONFERENCE PRESENTATION:

Thomas, G.F., "Communicating Across Team Boundaries," 59th Annual convention of the Association for Business Communication, November 1994.

OTHER:

Thomas, G.F. and Hocevar, S.P., "The Relationship Between Internal Team Processes, Performance, and External Team Communication," paper in progress.

DOD KEY TECHNOLOGY AREA: Other (Self-Managed Teams)

KEYWORDS: Self-managed teams, Empowerment, Organizational Change

LONGITUDINAL STUDY OF QUALITY OF WORK LIFE AT NAWC-ADI

S.P. Hocevar, Visiting Assistant Professor
Department of Systems Management
Sponsor: Naval Air Warfare Center, Aircraft Division, Indianapolis

OBJECTIVE: This effort represents the second in a series of annual surveys of employee Quality of Work Life analyzed by NPS the results of which were aggregated with prior data for longitudinal analysis.

SUMMARY: A Quality of Work Life survey has been administered on a regular basis over the past 4 years at the Naval Air Warfare Center, Aircraft Division, Indianapolis. There is a fixed portion of the survey that is consistent across prior administrations; there is also a unique set of questions designed for each administration to focus on particular timely issues within the organization. This research provided a measurement study of the most recent survey to determine the most reliable and valid scale constructions. The results of the measurement study were used to analyze both the current status of QWL attitudes and compare current attitudes with prior years' results. The longitudinal analysis was integral to the organization's monitoring the effects of a significant large scale restructuring that was initiated in 1992. The results of this project were presented in a briefing to the organization's senior management board and implications for future action were discussed.

CONFERENCE PRESENTATION:

Hocevar, S.P., "Assessing the Impact of Organizational Restructuring Through the Application of Structural Equation Modeling," Paper presented at the Conference on Causal Modeling, Purdue University, March 1994.

THESIS DIRECTED:

Bauknecht, J.A., LT, USN, "An Evaluation of the Effects of Organizational Change on the Quality of Work Life and Culture at the Naval Air Warfare Center, Aircraft Division, Indianapolis," Master's Thesis, June 1994.

OTHER:

Presentation of the 1993 QWL survey results to the NAWC-ADI board of senior managers, January 1994, with thesis student, LT Joseph Bauknecht.

Hocevar, S.P., "QWL Survey Highlights," Review of 1993 research results published in the "Beamrider" newsletter of NAWC-ADI distributed to all 3000 employees.

DOD KEY TECHNOLOGY AREA: Other (Quality of Work Life)

KEYWORDS: Quality of Work Life, Organizational Change, Organizational Effectiveness.

STUDY OF ORGANIZATIONAL CHANGE AT NAWC-ADI

S.P. Hocevar, Visiting Assistant Professor
Department of Systems Management
Sponsor: Naval Air Warfare Center, Aircraft Division, Indianapolis

OBJECTIVE: The goal of this project was twofold during this fiscal year: 1) to prepare and present a briefing of the results of the study of employee-based data regarding the effectiveness of a significant organizational restructuring that occurred in 1992; 2) to gather data and prepare a case history of the evolution of change at NAWC-ADI including a summary of research findings over the past 3 years as they relate to this change effort.

SUMMARY: The Naval Air Warfare Center, Aircraft Division, Indianapolis (NAWC-ADI) undertook a significant reorganization in April 1992. This study was initiated in July 1992 and this year's efforts represent the closing phases of this project. The objective of the study was to empirically evaluate the current status of the effectiveness of the restructuring and the communication processes within NAWC-ADI. Data were gathered to examine employee perceptions about the quality of: teamwork, problem solving, communication, information availability, information accuracy, organizational adaptability. Findings were generated for the organization as a whole as well as subgroup comparisons by competency area and level. The research results were presented in a meeting of the organization's senior management board in 10/93. This briefing presented both the positive effects of the NAWC-ADI reorganization and the overall challenges remaining and initiated discussions of further actions needed to support the effective implementation of this change effort. The second aspect of this research project resulted in a historical case study of the relevant background events and the approach to planned change used by NAWC-ADI. This case study was derived from in-depth interviews with both senior managers and representatives from the Concept of Operations planning team. The case study report also includes an analysis based on relevant organization theory as well as the results of three years or research that NPS has been involved in with NAWC-ADI.

PUBLICATION:

Barrett, F., Thomas, G.F., and Hocevar, S.P., "The Central Role of Discourse in Large-Scale Change: A Social Construction Perspective," Journal of Applied Behavioral Systems, in press.

THESES DIRECTED:

Houglan, G.D., LCDR, USN, "The Impact of Matrix Structure and Self-Managed Teams at the Naval Air Warfare Center, Aircraft Division, Indianapolis," Master's Thesis, December 1993.

Green, T., LCDR, USN, "Reorganization at the Naval Air Warfare Center, Aircraft Division, Indianapolis, Indiana: A Case Study," Master's Thesis, June 1994.

OTHER:

Hocevar, S.P., Thomas, G.F., and Green, T., "A Case Study of Organizational Change at NAWC-ADI," Naval Postgraduate School project report under review by the sponsor.

DOD KEY TECHNOLOGY AREA: Other (Organizational Change)

KEYWORDS: Organizational Change, Organizational Effectiveness

DESIGN AND IMPLEMENTATION OF A PROTOTYPE MONITOR ASSIGNMENT SUPPORT SYSTEM

M.N. Kamel, Associate Professor
Department of Systems Management
Sponsor: Headquarters United States Marine Corps

OBJECTIVE: The objective of this project was to develop a prototype Monitor Assignment Support System to support and assist the monitors of the Manpower Management Officer Assignment (MMOA) branch of Headquarters United States Marine Corps in the placement of trained qualified officers into authorized billets both internal and external to the Marine Corps.

SUMMARY: This project involved the design and implementation of a prototype database system utilizing HQMC Personnel, the existing DBMS prototype, off-the-shelf software, and in-house resources with full involvement of the intended users. As the prototype is tested by actual users, additional functionality was added to the system and/or the design changed to satisfy the needs of the users. The development of the prototype required the accomplishing the following tasks:

a. Determining the data required by the users of MMOA to perform their mission.
b. Understanding and documenting the current assignment processes to see how the data identified in task one flows through MMOA.
c. Identifying the source of the data requirements and whether they are external or internal to MMOA.
d. Organizing the data and processes around the two main entities (i.e., officers and billets) in officer assignment decision making.
e. Identifying the system hardware or software requirements.
f. Developing the "canned" programs for repetitive monitor queries of manpower data.

THESES DIRECTED:

Neilan, L.T., LT, USN, "Design and Implementation of a Data Model for the Prototype Monitor Assignment Support System," Master's Thesis, September 1994.

Walsh, R.J., MAJ, USMC and Cheatham, I.M., CAPT, USMC, "Design and Implementation of a Prototype Monitor Assignment Support System (MASS)," Master's Thesis, September 1994.

OTHER:

The investigator is preparing a technical report of the results of the project. Completion is expected mid 1995.

DOD KEY TECHNOLOGY AREA: Software, Human-System Interfaces

KEYWORDS: Database Management Systems, Database Integration, Decision Support Systems

DESIGN AND IMPLEMENTATION OF A PROTOTYPE MAINTENANCE ADVISOR EXPERT SYSTEM FOR THE MK92 FIRE CONTROL SYSTEM

M.N. Kamel, Associate Professor
M.J. McCaffrey, Visiting Assistant Professor
Department of Systems Management
Sponsor: Port Hueneme Division, Naval Surface Warfare Center

OBJECTIVE: The overall objective of this project is to develop a prototype maintenance advisor expert system for MK92 Fire Control System to enhance the ability of MK92 technicians to better determine, diagnose, and resolve problems within the system.

SUMMARY: The effort for the current reporting period involved completing the following tasks:

a. Refining and expanding the expert procedures for both performance and calibration portion of DSOT, developed in an earlier effort.

b. Developing a database system that interacts with the expert system to store and maintain information on equipment/unit part numbers, identical part replacement locations, and documentation references.

c. Designing and implementing a plan for testing, validation, and verification of the MK92 Prototype Maintenance Advisor Expert System.

d. Investigating key hardware and software implementation issues related to the deployment of the MK92 Expert System to the fleet.

e. Developing a structured methodology for the design and implementation of an expert system using a visual programming environment.

f. Investigating the feasibility of using multimedia (graphics, audio, and video) to enhance the useability of the system

g. Providing support during the demonstration and evaluation phases of the project.

THESES DIRECTED:

Dills, K.R., LT, USN and Tutt, T.F., LT, USN, "The Verification and Validation of the MK92 MOD 2 Fire Control System Maintenance Advisor Expert System," Master's Thesis, September 1994.

Geick, D.M., LT, USN, and Mikler, S.E., LT, USNR, "Design and Implementation of the Calibration Module of the MK92 Prototype Maintenance Advisor Expert System," Master's Thesis, March 1994.

McGaha, J.L., LT, USN, "Implementation of the Production Version of the Performance and Calibration Modules of the MK92 MOD 2 Fire Control System Maintenance Advisor Expert System, Master's Thesis, September 1994.

Meisch, P., LT, USN, Applying Multimedia to the MK92 Maintenance Advisor Expert System," Master's Thesis, September 1994.

Smith, L.M., LT, USN, "Development of a Structured Design and Programming Methodology for Expert System Shells Utilizing a Visual Programming; Application of Structured Methodology to the MK92 Maintenance Advisor Expert System, Performance Module Prototype," Master's Thesis, September 1994.

Tally, S.G., LT, USN, "Design and Implementation of a Prototype Database for Part Information to Support the MK92 Fire Control System Maintenance Advisor Expert System," Master's Thesis, March 1994.

OTHER:

The investigators are preparing a detailed manuscript for publication of the results of the project. Completion is expected mid 1995.

DOD KEY TECHNOLOGY AREA: Software, Human-System Interfaces

KEYWORDS: Expert Systems, Knowledge Acquisition, Knowledge Representation

COST PER OUTPUT ANALYSIS FOR US ARMY RESERVE

K. Kang, Associate Professor
K.L. Terasawa, Visiting Associate Professor
Department of Systems Management
Sponsor: U.S. Army Recruiting Command (USAREC)

OBJECTIVE: The objective of this research is to develop a transparent and documentable cost per output methodology for the USAR recruiting activities. The results of this research will provide the decision-maker at the USAR with a decision support tool for policy making.

SUMMARY: This project is concurrently conducted with the Regular Army cost study. Compare to Regular Army study, this study is more complicated because of Reserve's unique characteristics. High attrition rates in the reserve force is a significant problem. Seventy percent of reserve soldiers do not complete their six year enlistment contract. Separation from the reserve unit before completion of the contractual term of service lowers readiness while increases training and recruiting costs.

Army reserve recruits are classified as non-prior service (NPS) -- those without prior miliary training and experience -- and as prior service (PS) -- individuals who have served in the active or reserve forces. Our study shows that PS soldiers have lower attrition rates and are more cost-effective over a seven year life cycle than NPS soldiers. High quality NPS soldiers show similar results when compared to lower quality NPS soldiers.

THESIS DIRECTED:

Mitchell, D., "US Army Reserve Recruiting: A Critical Analysis of Unit Costing and the Introduction of a Life Cycle Cost-Effectiveness Model," Master's Thesis, December 1994.

OTHER:

Kang, K. and Terasawa, K.L., "Life Cycle Cost: NPS/PS Mix and Quality Recruiting," Naval Postgraduate School Technical Report, in preparation.

DOD KEY TECHNOLOGY AREA: Other (Cost-Benefit Analysis)

KEYWORDS: Recruiting, Cost per Output, Life-Cycle Cost, Decision-Support, Manpower, Cost-Benefit Analysis, Reserve

READINESS-BASED SPARING REPLENISHMENT MODEL FOR REPAIRABLE ITEMS

A.W. McMasters, Professor
Department of Systems Management
Sponsor: Naval Supply Systems Command

OBJECTIVE: A continuing project to develop a wholesale level inventory model for the Navy's Inventory Control Points to use to replenish their inventories of repairable items; the objective function of this model should be related to readiness.

SUMMARY: A new inventory model for managing repairables at the wholesale level is needed to determine when to replenish repairable items associated with a specific weapon system. This model should have the same objective function as the wholesale provisioning (or first buy quantity) model developed on this project between 1982 and 1986; namely, the minimization of the aggregate Mean Supply Response Time (MSRT). Investigation of a realistic simulation model of the Navy's repairable inventory management process continued this past year, with the help of an OR thesis student, which allowed determination of the empirical time-weighted distributions for the inventory position (IP) and the net inventory levels. This year's effort were concentrated on determining the distribution of net inventory and the relationship between the mean and variance of the net inventory distribution as a function of the various important parameters used by the Navy in its management of such items. The net inventory distribution was found to be best represented by the convolution of the IP distribution derived in 1988 and a Poisson distribution for demand during the average lead time for procurement and repair. An exact formula was then derived for the mean of the net inventory distribution. The variance is not needed because the distribution can be derived directly for any set of inventory management parameters.

CONFERENCE PRESENTATION:

McMasters, A. W., "A New Repairable Item Inventory for the U. S. Navy," presented at the XXXII International Conference of the Institute of Management Sciences, Anchorage, AK, June 12-15, 1994.

THESIS DIRECTED:

Baker, S., LCDR, Royal Australian Navy, "Approximate Models for the Probability Distributions for Inventory Position and Net Inventory for Navy Repairable Items," Master's Thesis, September 1994.

DOD KEY TECHNOLOGY AREA: Other (Inventory Models)

KEYWORDS: Inventory management, Navy Repairable Items, Inventory Model

COST/EFFECTIVENESS ANALYSIS OF THE NAVAL AIRCRAFT ENGINE COMPONENT IMPROVEMENT PROGRAM

A.W. McMasters, Professor
Department of Systems Management
Sponsor: Naval Air Systems Command

OBJECTIVE: A continuing project to develop models to predict the savings in life-cycle costs of proposed engineering changes intended to improve reliability, maintainability, and sustainability of turbine aircraft engines for Naval aircraft.

SUMMARY: An important element of aircraft logistical support is the aircraft engine Component Improvement Program (CIP). The CIP is essential for the continuing evolution of these engines. This project is looking for ways to justify that program. The first phase was to examine the current life-cycle cost models used by the Air Force and the Navy which are intended to show the expected savings from a specific proposed component improvement. NPS' evaluation of the Air Force's Cost Effectiveness Analysis Model (CEAMOD) resulted in its adoption by the Navy's in May 1993. The second phase is to validate the actual costs and logistics effectiveness of the CIP by looking at historical data. That may also suggest ideas for an improved model. A third phase addresses the problem of justifying warranties on aircraft engines. A User's Manual for the Cost Effectiveness Analysis Model (CEAMOD) was developed for Version 2.0, the EXCEL version of the CEA model accepted by the Navy in May 1993. Analysis of the effect of eliminating the integerization of certain calculations in the model was also conducted; no change in the decision to implement a CIP Engineering Change Proposal was found. Two different engines' components were studied to determine their cost-effectiveness; the E-2C's

TF-34 thermocouple connecting harness and the Harrier's F-402 high pressure second stage rotor blades. The T56 engine component's break even point for maintenance life cycle cost savings was estimated to be in 1998. The break even point for the F402 blades was estimated to be the end of 1996. The warranty studies identified the fact that the Navy cannot be given replacement parts (because that would be a 'gift' to the government) nor can the repairing organization recover its costs since the vendor can only send the money to the Federal Treasury. Therefore, as part of the acquisition strategy, the short term assurance and incentive type warranties appear cost-effective but the long term insurance type warranties are not. The latter is currently the usual type negotiated for. A guide was also developed to assist program managers in assessing the strength and weaknesses of their integration of warranties into their acquisition strategy.

THESES DIRECTED:

Andrews, M.S., LT, USN and Hickey, S.C., CPT, USA, "Analysis of Navy Aircraft Engine and Engine Component Warranties," Master's Thesis, December 1993.

Caldwell, K.G., LCDR, USN," Integration of Warranties into an Aircraft Engine Acquisition Strategy," Master's Thesis, June 1994.

Murphy, T J., LCDR, USN, "An Analysis of the Costs and Benefits in Improving the T56-A-427 Interconnector Harness End and Mating Thermocouple Connector under the Aircraft Component Improvement Program (CIP)," Master's Thesis, June 1994.

Rau, K.F., LCDR, SC, USN, "An Analysis of Non-Integerizing the Aircraft Engines Cost Effectiveness Analysis Spreadsheet Model (CEAMOD Version 2.0)," Master's Thesis, December 1993.

Reeves, R.R., LCDR, SC, USN, "A User's Manual for the Cost Effectiveness Analysis Spreadsheet Model for Aircraft Engines (CEAMOD Version 2.0)," Master's Thesis, December 1993.

Walter, D.A. MAJ, USMC, "An Analysis of the Costs and Benefits in Improving F402-RR-406A High Pressure Turbine, Second Stage Blades under the Aircraft Component Improvement Program (CIP)," Master's Thesis, September 1994.

DOD KEY TECHNOLOGY AREA: Other (Cost Effectiveness Analysis)

KEYWORDS: Naval Aircraft Engines, Component Improvement Program (CIP), Cost/benefit Analysis, Aircraft Engine Warranties

NAVAL POSTGRADUATE SCHOOL MPTA FACULTY RESEARCH IN SUPPORT OF N1/BUPERS

S.L. Mehay, Professor
M. Eitelberg, Associate Professor
Department of Systems Management
Sponsor and Funding: Deputy Chief of Naval Operations (MPT), N1/BUPERS, Washington, D.C.

OBJECTIVE: This project provided an umbrella funding within which individual projects were proposed and carried out by individual researchers. Mehay coordinated the overall project and facilitated interactions between individual MPT faculty and N1/BUPERS. The two specific sub-projects were:

(1) "Statistical analyses of the occupational and promotion patterns of minority and officer and enlisted personnel"

(2) "Analyses of Retention and Continuation Rates During the Downsizing"

SUMMARY: (1) Prior research by the Defense Equal Opportunity Management Institute concludes that certain promotion results for Navy enlisted personnel are "racially biased." However, the methodology used to reach this conclusion involved an unsophisticated bivariate statistical technique, and unsupportable assumptions concerning the nature and statistical distributions of important variables. The study also did not control for background or Navy experience factors that affect one's productivity, performance, and promotability at the higher pay grades. Finally, the study did not attempt to model the career path of Navy personnel nor the selectivity issues inherent in the assignment and utilization process. The purpose of this task is to model the career path of enlisted personnel and officers and to use this as a framework for specifying and estimating models of promotion using standard multivariate statistical techniques.

(2) Current Navy enlisted and officer retention and continuation rates overstate "normal" rates due to the effects of the downsizing and various personnel drawdown policies. Navy needs statistical adjustment factors that could be used to adjust retention and continuation rates for the effects of the downsizing and specific drawdown policies. Navy also needs rigorous statistical analyses that would provide estimates of the direct effects of specific downsizing policies on separation, as well as the indirect effects of the general downsizing environment. The objectives of this effort are:

a) to develop a quasi-experimental statistical design to estimate the direct effects of various downsizing programs on separation behavior by enlisted and officer personnel, and the indirect effects of the downsizing environment;

b) to use the design to predict "baseline" continuation and separation rates in the absence of the drawdown and specific downsizing programs;

c) to develop the officer and enlisted data files necessary to estimate the models;

d) to decompose the separation rate into its various components: the portion due to:

(i) to specific policies, (ii) to the general downsizing environment, and (iii) to voluntary separation behavior that is independent of the downsizing;

e) to develop retention adjustment factors.

THESIS DIRECTED:

Dye, G., CDR, USN, "An Alternative Approach for Measuring Black Representation in Navy Enlisted Occupations," Master's Thesis, June 1994.

OTHER:

Mehay, S. and Hogan, P., "Analysis of Baseline Continuation Rates of Naval Aviators During the Downsizing," Technical Report in process.

DOD KEY TECHNOLOGY AREA: Other (Military Manpower/Personnel Policy)

KEYWORDS: Manpower, Retention, Promotion, Downsizing

ANALYSES OF NAVY GRADUATE EDUCATION PROGRAMS

S.L. Mehay, Professor
Department of Systems Management
Sponsor/Funding: Navy Personnel Research and Development Center, Code 113, San Diego, CA

OBJECTIVE: Navy lacks a coherent theoretical framework for evaluating its graduate education programs as a whole, for evaluating specific elements of the programs, or for making tradeoffs among competing GE programs, or between GE and other non-GE Navy programs. Navy needs a theoretical framework for guiding decision makers in making such tradeoffs and decisions. Navy also needs reliable statistical measures of the costs and benefits of its GE programs, and statistical analyses of the impact of graduate education on officer productivity and performance. This effort will develop the economic theory of human capital investment as it relates specifically to an intra-organizational environment. It will also integrate economic theories of life cycle decision making and occupational choice within this context. This theoretical framework will be used to generate testable hypotheses, and to identify the specific data elements needed to test such hypotheses. In particular, measures of officer effectiveness will be identified. These measures will be used to evaluate the effectiveness of GE programs, the benefits of the programs to the Navy, and the rate of return on such programs. Cost analyses will be conducted so that the measurable benefits can be weighed against the costs in determining the internal rate of return on the programs.

SUMMARY: The specific tasks of the research will be the following:

a) to develop the human capital investment and life cycle models and to apply these models to Navy's GE programs;

b) to identify the data requirements for statistically estimating the relationships and hypotheses identified in (a);

c) to review the Navy's subspecialty process within the context of the human capital/life cycle investment models;

d) to quantify the costs and benefits of various GE options and processes by assessing individual officer productivity profiles and program costs.

THESES DIRECTED:

Brutzman, T., LCDR, USN, "An Analysis of the Utilization of Graduated Educated Officers," Master's Thesis, June 1994.

Talaga, M., LT, USN, "Econometric Analyses of the Effect of Graduate Education on Naval Officer Promotion," Master's Thesis, March 1994.

OTHER:

Mehay, S. and Bowman, W., "Analysis of the Economic Rate of Return on Navy Investments in Officer Graduate Education," Technical Report in process.

DOD KEY TECHNOLOGY AREA: Other (Graduate Education)

KEYWORDS: Human Capital, Return on Investment, Officer Performance

INVESTIGATIONS OF FINANCIAL RATIO PATTERNS IN THE DEFENSE INDUSTRY

O.D. Moses, Associate Professor
Department of Systems Management
Sponsor: Naval Postgraduate School

OBJECTIVE: The goal of this project was to document cross-sectional and time-series patterns exhibited by financial ratios within the U.S. Defense Industry.

SUMMARY: This project was designed to describe financial ratio patterns within the defense industry with the purpose of laying a foundation for conducting future financial analysis of defense industry firms. A substantial portion of the effort involved the creation of a database of financial information for relevant firms. Three specific questions were addressed: (1) What are the fundamental dimensions of financial condition within the defense industry? Findings indicated seven consistent aspects of financial condition and identified specific ratios which best measured these aspects. (2) What models are most accurate for forecasting future values for financial ratios? Findings indicated that it was difficult to identify models which are superior to a random walk. (3) What changes have occurred in defense industry financial condition during the past decade? Findings documented significant changes along some, but not all, aspects of financial condition.

THESES DIRECTED:

Jenkins, J.D., LT, USCG, "Financial Ratio Time Series Models in Defense Industries," Master's Thesis, December 1994.

Gursoy, G., 1st LT, Turkish Army, "Financial Ratio Patterns in the U.S. Defense Industry," Master's Thesis, December 1994.

White, R.M., LCDR, USN, "The Primary Dimensions of Financial Condition for Firms Within The Defense Industry," Master's Thesis, December 1994.

Bailey, W.E., LT, USN, "An Analysis of Economic Value Added as a Measure of Financial Performance and Risk Assessment," Master's Thesis, December 1994.

OTHER:

The investigator is replicating work to date and writing technical reports related to questions (1) and (2) described in the above summary.

DOD KEY TECHNOLOGY AREA: Other (Financial Analysis)

KEYWORDS: Financial Analysis, Financial Ratios, Defense Industry

DESIGN RATIONALE CAPTURE AND REUSE TO SUPPORT SYSTEMS DEVELOPMENT

B. Ramesh, Assistant Professor
Department of Systems Management
Sponsor: Naval Postgraduate School

OBJECTIVE: The objective of this research is to develop an environment to support various stakeholders involved in systems development by reasoning with design rationale knowledge.

SUMMARY: Large scale systems development and maintenance efforts are often hindered because much of the

richness of the design process, namely the *design rationale*, involving the deliberations on alternative design decisions is lost in the course of designing and changing such systems. We have developed a model that is geared towards capturing the rationales behind design decisions and using this knowledge to reason about changes in design decisions. The use of this model for representation and reasoning with rationale behind formal specifications will greatly aid the development of systems based on formal specifications. A major objective of this research is to elevate the process of systems maintenance to the level of specifications and the rationale behind their creation. A prototype environment to capture and reuse rationale to support various systems development activities was developed.

PUBLICATION:

Ramesh, B. and Dhar, V., "Representation and Maintenance of Process Knowledge for Large Scale Systems Development," IEEE Expert, Special Series on Knowledge Based Software Engineering, April 1994.

THESIS DIRECTED:

Fuller, C.E., LCDR, USN and Russell, D., LT, USN, "Design Rationale Capture using REMAP/MM," Master's Thesis, June 1994.

OTHER:

The REMAP model and mechanisms developed in this research are being incorporated in the knowledge based software assistant CASE tool prototype being developed by the U.S. Air Force.

Ramesh, B. and Sengupta, K., "REMAP/MM: Multimedia in Decision Support, Decision Support Systems, forthcoming, 1995.

DOD KEY TECHNOLOGY AREA: Computers, Software, Design Automation

KEYWORDS: Design Rationale, Process Knowledge, Systems Development

COMPLEX TRACEABILITY TECHNIQUES FOR LARGE SCALE SYSTEMS

B. Ramesh, Assistant Professor
Department of Systems Management
Sponsor: Naval Surface Warfare Center Dahlgren Division

OBJECTIVE: The objective of this research is to develop a model of requirements traceability to support various stakeholders in large scale systems development.

SUMMARY: Development of complex, mission critical systems involves modification, refinement and evolution of initial requirements that lead to design solutions. In order to provide intelligent and useful support to the process of design and maintenance, a formal representation of the linkages between the design solutions and the requirements is essential. A comprehensive traceability scheme should not only identity traceability linkages to be maintained, but also provide the mechanisms to supports use in systems development and maintenance activities. Based on an extensive empirical study of systems development personnel, this project has developed several models for requirements traceability.

PUBLICATION:

Ramesh, B. and Luqi, "An Intelligent Assistant for Requirements Validation," Journal of Systems Integration, Vol. 5, No. 2, 1995.

THESES DIRECTED:

DeVries, G., LT, USN and Dwiggins, D.W., LT, USN, "Models of Requirements Traceability in Systems Development," Master's Thesis, September 1994.

Laubengayer, R.C., LT, USN and Spearman, J.S., LT, USN, "A model of pre-requirements specification traceability in the DoD," Master's Thesis, June 1994.

DOD KEY TECHNOLOGY AREA: Computers, Software, Design Automation

KEYWORDS: Requirements Traceability, Systems Development

STRATEGIC PLANNING AND MANAGEMENT IN DOD AND DON ORGANIZATIONS

N. Roberts, Associate Professor
Department of Systems Management
Unfunded

OBJECTIVE: The goal of this project was to investigate how to design strategic planning and management processes for DoD and DoN organizations given the constraints of size and public sector management.

SUMMARY: Managing public bureaus is not like managing private sector enterprises. The constraints of public management are different from the constraints of private sector management, especially at the strategic apex of a bureau. Thus, when developing their strategic planning and strategic management processes, public sector managers need to be aware that the transfer of business principles to public bureaus requires special adaptation and modification, especially in large-scale public bureaus like the U.S. Navy and the Department of Defense. The shared power system of governance, the criticality of missions, and time sensitivity of strategic issues all call for adaptations in decision making, planning, and managing. The unique features of public bureaus are explored in this research and recommendations for dealing with them are made.

PUBLICATIONS:

Roberts, N.C. and Wargo, L., "The Dilemma of Planning in Large-Scale Public Organizations: The Case of the United States Navy," Journal of Public Administration Research and Theory, Vol. 4, No. 4, pp. 469-491, 1994.

Roberts, N.C. and Dotterway, K., "The Vincennes Incident: Another Player on the Stage?," Defense Analysis, Vol. 11, No. 1, in press.

Roberts, N.C. and King, P.J., Dynamics of Entrepreneurship and Innovation: Radical Change by Legislative Design, San Francisco: Jossey-Bass, Manuscript accepted for publication.

CONFERENCE PRESENTATION:

Roberts, N.C., "Radical Change By Design," Paper presented to the Academy of Management, Public Sector and Nonprofit Division, August 1994.

THESES DIRECTED:

Sharp, P., "Strategic Planning for Botswana," Master's Thesis, September 1994.

Weatherlow, B., "Mentor-Protégé Program: An Innovative Approach," Master's Thesis, September 1994.

McCarthy, G., "The Marine Corps Lesson Learned System: An Assessment," Master's Thesis, June 1994.

Roetzler, C.A., "Team Performance in the DoD Acquisition Program Office," Master's Thesis, March 1994.

Roll, R., "Advantages and Disadvantages of Consolidating HS and HSL Communities," Master's Thesis, March 1994.

Deghetto, T., "Precipitating the Decline of Terrorist Groups: A Systems Analysis," Master's Thesis, March 1994.

Lockett, C., "Decision Making in Terrorist Groups," Master's Thesis, March 1994.

Tavares, J.L., "A Case History of the Fourteen-year development of the Marine Corps Standard Counting, Budgeting and Reporting System (SABRS)," Master's Thesis, March 1994.

Walsh, D., "Contracting Support for Army Special Forces," Master's Thesis, December 1993.

Bergeron, W., "Reengineering acquisition," Master's Thesis, December 1993.

Robinson, R. and Swenson, B., "Innovation and Entrepreneurship in Logistical Support: A Case Study," Master's Thesis, December 1993.

Carter, D.K., "Department of the Army Field Contracting Activities' Contracting Efforts with the Federal Prison Industries, Inc.," Master's Thesis, December 1993.

Irick, R.P., "Evaluation of Public-Private Competition in NADeps," Master's Thesis, December 1993.

OTHER:

The investigator has submitted a paper, "Dialogue and Deliberation: A New Mode for Crafting Strategy," for review at Human Relations.

The paper "Limits to Cooperation" has been accepted for presentation to the Conference on "Organization Dimensions of Global Change" sponsored by the Academy of Management, held at Case Western Reserve University in Cleveland, OH, 3-6 May 1995.

DOD KEY TECHNOLOGY AREA: Other (Management, Organization Behavior & Theory, Change)

KEYWORDS: Management, Strategic Planning, Change

RE METRICS VALIDATION AND APPLICATION: SPACE SHUTTLE FLIGHT SOFTWARE

N.F. Schneidewind, Professor
Department of Systems Management
Sponsor: Naval Surface Warfare Center, Code B-10, Dahlgren, VA

OBJECTIVE: Validate and apply metrics discriminant and predictor functions on large projects (Space Shuttle flight software) to control, predict, and assess software quality.

SUMMARY: Software quality metrics have potential for helping to assure the quality of software on large projects such as the *Space Shuttle* flight software. It is feasible to validate metrics for the purpose of controlling and predicting software quality during design by validating metrics against a quality factor. Quality factors, like reliability, are of more interest to customers than metrics, like complexity. However quality factors cannot be collected until late in a project. Therefore the need arises to validate metrics, which developers can collect early in a project, against a quality factor. We investigate the feasibility of validating metrics for controlling and predicting quality on the *Space Shuttle*. The key to the approach is the use of validated metrics for early identification and resolution of quality problems.

PUBLICATIONS:

Schneidewind, N.F., "Methodology for Software Quality Metrics," Fifth International Conference on Applications of Software Measurement, Presentation Notes, La Jolla, CA, 10 November 1994.

Schneidewind, N.F., "Methodology for Software Quality Metrics," International Symposium on Software Reliability Engineering, Tutorial Notes, IEEE Computer Society Press, Monterey, CA, 6 November 1994.

Schneidewind, N.F., "Methodology for Software Quality Metrics for Maintenance," International Conference on Software Maintenance, Tutorial Notes, IEEE Computer Society Press, Victoria, Canada, 20 September 1994.

Schneidewind, N.F., "Validating Metrics for Controlling and Predicting the Quality of Space Shuttle Flight Software," IEEE Computer, Vol. 27, No. 8, pp. 50-57, August 1994.

Schneidewind, N.F., "Using Metrics to Control and Predict the Quality of Space Shuttle Flight Software," Proceedings of the 1994 Complex Systems Engineering Synthesis and Assessment Technology Workshop (CSESAW '94), pp. 171-187, Beltsville, MD, 19-20 July 1994.

Schneidewind, N.F., "Methodology for Software Quality Metrics," Tutorial Notes, Sixteenth International Conference on Software Engineering, Sorrento, Italy, 16 May 1994.

Schneidewind, N.F., "Controlling and Predicting the Quality of Space Shuttle Software Using Metrics," Proceedings of the 1994 Annual Oregon Workshop on Software Metrics, Silver Falls, OR, 11 April 1994.

Schneidewind, N.F., "Methodology for Validating Software Metrics," Encyclopedia for Software Engineering, J.J. Marciniak, Editor-in-Chief, John Wiley & Sons, pp. 666-676, February 1994.

Schneidewind, N.F., "Software Metrics Validation: Space Shuttle Flight Software Example," Annals of Software Engineering, J.C. Baltzer AG, Science Publishers, (scheduled for publication in 1995).

Schneidewind, N.F., "Controlling and Predicting the Quality of Space Shuttle Software Using Metrics," Software Quality Journal, (scheduled for publication in 1995).

Schneidewind, N.F., "Statistical Methods for Controlling and Predicting the Quality of Software," Proceedings of the American Society for Quality Control, QC95, Santa Clara, CA, forthcoming in April 1995.

CONFERENCE PRESENTATIONS:

Schneidewind, N.F., "Methodology for Software Quality Metrics," Fifth International Conference on Applications of Software Measurement, La Jolla, CA, 10 November 1994.

Schneidewind, N.F., "Methodology for Software Quality Metrics," International Symposium on Software Reliability Engineering, Tutorial, Monterey, CA, 6 November 1994.

Schneidewind, N.F., "Non-Parametric Statistical Methods for Controlling and Predicting the Quality of Space Shuttle Flight Software," British Telcom Labs, Ipswich, England, 29 September 1994.

Schneidewind, N.F., "Methodology for Software Quality Metrics for Maintenance," International Conference on Software Maintenance, Tutorial, Victoria, Canada, 20 September 1994.

Madhavji, N.H., Munson, J., Oman, P., and Schneidewind, N., "International Workshop on Software Evolution Processes and Measurements," held in Conjunction with the International Conference on Software Maintenance '94, Victoria, Canada, 24 September 1994.

Schneidewind, N.F., "Non-Parametric Statistical Methods for Controlling and Predicting the Quality of Space Shuttle Flight Software," Sixteenth Minnowbrook Workshop on Software Engineering, Minnowbrook, NY, 29 July 1994.

Schneidewind, N., Panel: "Early Evaluation of Systems," 1994 Complex Systems Engineering Synthesis and Assessment Technology Workshop, Naval Surface Warfare Center, Beltsville, MD, 20 July 1994.

Schneidewind, N.F., "Using Metrics to Control and Predict the Quality of Space Shuttle Flight Software," 1994 Complex Systems Engineering Synthesis and Assessment Technology Workshop (CSESAW '94), Beltsville, MD, 20 July 1994.

Schneidewind, N.F., "Quality Control and Prediction for the Space Shuttle," Loral Federal Systems Division, Houston, TX, 13 July 1994.

Schneidewind, N.F., "Controlling and Predicting the Quality of Space Shuttle Software Using Metrics," Program Executive Officer, Standard Army Management Information Systems Engineering Command Conference, (PEO STAMIS) Reston, VA, 10 June 1994.

Schneidewind, N.F., "Methodology for Software Quality Metrics," Tutorial, Sixteenth International Conference on Software Engineering, Sorrento, Italy, 16 May 1994.

Schneidewind, N.F., "Controlling and Predicting the Quality of Space Shuttle Software Using Metrics," 1994 Annual Oregon Workshop on Software Metrics, Silver Falls, OR, 11 April 1994.

Schneidewind, N.F., "Controlling and Predicting Space Shuttle Software Reliability," Lawrence Livermore National Laboratory, Fission Energy and Systems Safety Program, Livermore, CA, 28 March 1994.

Schneidewind, N.F., "Applying Metrics to Space Shuttle Flight Software," Santa Clara Valley Software Quality Association meeting at Tandem Computers in Cupertino, CA, 11 January 1994.

THESIS DIRECTED:

Warburton, K.M., "A Model for Developing Reliability Statistics for Software Reusable Components," Master's Thesis, March 1994.

DOD KEY TECHNOLOGY AREA: Software

KEYWORDS: Software Reliability, Software Quality Metrics

PREDICTIONS FOR INCREASING CONFIDENCE IN THE RELIABILITY OF THE SPACE SHUTTLE FLIGHT SOFTWARE

N.F. Schneidewind, Professor
Department of Systems Management
Sponsor: Naval Surface Warfare Center, Code B-10, Dahlgren, VA

OBJECTIVE: Development of *Schneidewind Software Reliability Model* enhancements for predicting *test time, total failures, remaining failures, program quality*, as applied the *Space Shuttle.*

SUMMARY: We showed how software reliability predictions can increase confidence in the reliability of the *NASA Space Shuttle Primary Avionics Software.* These predictions, along with other methods of reliability assurance, such as inspections and fault tracking, provide a quantitative basis for achieving reliability objectives. Without a quantitative reliability assessment, software managers have no objective basis for deciding whether the software has been tested sufficiently to be ready for a flight or whether a serious failure during flight is likely. Our prediction methodology provides bounds on *test time, remaining failures, program quality,* and *time to next failure* that are necessary to meet *Shuttle* software reliability requirements. We also show that there is a pronounced asymptotic characteristic to the *test time* and *program quality* curves that indicate the possibility of big gains in reliability as testing continues; eventually the gains become marginal as testing continues. We conclude that the prediction methodology is feasible for the *Shuttle* and other safety critical applications.

PUBLICATIONS:

Keller, T., Schneidewind, N.F., and Thornton, P.A., "Predictions for Increasing Confidence in the Reliability of the Space Shuttle Flight Software," Proceedings of the AIAA Computing in Aerospace 10, San Antonio, TX, (scheduled for publication in March 1995).

Schneidewind, N.F., "Software Reliability Model with Optimal Selection of Failure Data for the Space Shuttle," Proceedings of the DoD Software Technology Conference, CD/ROM, Salt Lake City, UT, 14 April 1994.

CONFERENCE PRESENTATIONS:

Schneidewind, N.F., "A Software Reliability Model with Optimal Selection of Failure Data," British Telcom Labs, Ipswich, England, 29 September 1994.

Schneidewind, N.F., "Software Reliability Model with Optimal Selection of Failure Data for the Space Shuttle," DoD Software Technology Conference, CD/ROM, Salt Lake City, UT, 14 April 1994.

Schneidewind, N.F., "Modelling and Predicting the Software Reliability of the Space Shuttle," joint meeting of the Santa Clara Valley IEEE Product Safety Technical Committee and the System Safety Society, Wyndham Garden Hotel, Sunnyvale, CA, 16 March 1994.

DOD KEY TECHNOLOGY AREA: Software

KEYWORDS: Software Reliability, Software Quality Metrics

INSTRUCTIONAL SYSTEMS FOR NIGHT VISION GOGGLES

K. Sengupta, Assistant Professor
Department of Systems Management
Sponsor: Naval Air Systems Command

OBJECTIVE: The goal of this multi-year project is to construct a prototype multimedia instructional system for training aviators in the use of night vision goggles.

SUMMARY: Night vision goggles are being used increasingly widely by aviators for flying in night time and low light conditions. Such goggles are used for a wide variety of tasks, ranging from combat missions to medical evacuation procedures. The representation of the external world offered by night vision goggles is dramatically different from normal (daylight) perception. Thus, without adequate training in the use of these goggles, even otherwise experienced aviators are prone to committing errors that would not normally occur in daylight conditions. In the absence of suitable training mechanisms, the increasing use of night vision goggles has been accompanied by a dramatic rise in accident rates. This multi-year project envisages building a hypermedia system that will enable aviators to learn critical perceptual skills required for the effective use of night vision goggles. The system will provide self-paced instruction, along with practice and rehearsal sessions. The system will also evaluate students on their progress. The first phase of the project (completed in FY 94) entailed identifying key instructional objectives, translating the instructional objectives into lesson plans, and conducting a review of the technology to identify feasible configurations of hardware and software.

PUBLICATION:

Ciavarelli, A., Sengupta, K., and Baer, W., "Night Vision Goggle Training Technology," Naval Postgraduate School Technical Report in process, (prepared for Naval Air Systems Command, Washington, D.C.).

DOD KEY TECHNOLOGY AREA: Software

KEYWORDS: Computer-Based Instruction, Multimedia, Intelligent Tutoring

APPLICATION OF 800 PANEL RECOMMENDATIONS

M.W. Stone, Assistant Professor
Department of Systems Management
Sponsor: Naval Postgraduate School

OBJECTIVE: The goal of this project is to investigate certain implementations of the various recommendations of the Section 800 Panel to try to predict the impact of the implementations on the contracting community.

SUMMARY: Since the report of the 800 Panel (established by Section 800 of the National Defense Authorization Act of 1991, Public Law 101-510) was published, streamlining and reinvention have become the watchwords for procurement. Several aspects of the Panel's recommendations have been investigated, such as the use of commercial procedures, streamlining of procurement procedures, reinvention of local procurement practices, and the use of electronic commerce in Government procurement. This research project has primarily led to various student theses. Of particular interest has been the impact of procurement reform on the acquisition

of Federal information processing (FIP) resources. Even with the Government's efforts to streamline procurements, certain members of Congress have blocked any attempt to modify the processes previously established for the procurement of FIP. Investigations have looked at whether these processes remain useful or relevant in light of modern procurement practices. In addition, investigations have been made into the feasibility of the recent Congressional mandate that the Federal Government adopt electronic commerce.

This project is a continuing effort and includes an investigation into the feasibility of using electronic means to file disputes with the various administrative law hearing boards. This investigation has looked into the issues relating to the authentication and protection of data transmitted over public, unsecured networks.

THESES DIRECTED:

Willis, C.I., "The Brooks Act, Is It Relevant Today?," Master's Thesis, June 1994.

Snyder, T.S., "Applying the National Performance Review Procurement Reform Initiatives at the Naval Postgraduate School," Master's Thesis, June 1994.

Lyon, M.E., "Improved Market Research in United States Marine Corps Field Contracting," Master's Thesis, June 1994.

OTHER: The following are Master's theses scheduled for 1995:

Mustelier, R.H., "Repeal the Brooks Act?."
Doucette, E., "Army Acquisition Category (ACAT) IV Streamlining Initiates."
Clarke, M., "Implementation of FACNET in the Department of Defense.

DOD KEY TECHNOLOGY AREA: Other (Acquisition)

KEYWORDS: Acquisition Reform, Acquisition Streamlining

COST PER OUTPUT ANALYSIS FOR USAREC

K.L. Terasawa, Visiting Associate Professor
K. Kang, Associate Professor
Department of Systems Management
Sponsor: U.S. Army Recruiting Command (USAREC)

OBJECTIVE: The objective of this research is to develop a transparent and documentable cost per output methodology for the US Army recruiting activities; and to identify the areas for cost-savings with the future changes in recruiting environment.

SUMMARY: We analyzed the US Army's manpower related data collected from the Defense Manpower Document Center (DMDC) in Monterey, CA. We studied quality of recruits and life-cycle cost including recruiting/training costs. Although the unit cost per accession has increased more than 75% (in constant dollars) since 1980, the quality-adjusted unit cost (total cost divided by the number of quality soldiers accessed) did not change much during the same period. Our study also indicates that the quality soldiers are more cost-effective in the long run.

Our study of USAREC's unit costing revealed several potential problems. The Military Personnel Army (MPA) account, the largest among big ten, constitutes 57% of the total budget, yet USAREC does not have spending discretion over this account. Without spending authority and responsibility, managers may have little incentive

to reduce costs and the ones they can reduce are over-shadowed by what they do not control. The recruiters may be as productive as they could be, although they work very hard, because of the current quota system. The bonus incentive system would help maximize market potential and help USAREC in the efficient allocation of resources. We have examined the possibility of implementing the bonus incentive system for recruiters. In March 94, we visited USAREC Headquarters, and briefed research progress and proposed the *Bonus Incentive Recruiting Model* (BIRM) to directors and staff from various directorates. In May 1994, we also briefed the BIRM ideas to the Commanding General. Currently, we have a pending proposal for to implement the BIRM.

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OTHER:

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DOD KEY TECHNOLOGY AREA: Other (Cost-Benefit Analysis)

KEYWORDS: Recruiting, Cost-Per-Output, Life-Cycle Cost, Decision-Support, Manpower, Cost-Benefit Analysis

DEPARTMENT
OF
SYSTEMS MANAGEMENT

1994
Faculty Publications
and Presentations

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COMMAND, CONTROL & COMMUNICATIONS (C3) ACADEMIC GROUP



Dan Boger
Chairman

Command, Control, and Communications (C3) Academic Group

The Command, Control, and Communications (C3) Academic Group is an interdisciplinary association of faculty which consists of 16 faculty members who hold appointments in 7 departments at the Naval Postgraduate School, plus the Curricular Officer. The C3 Academic Group has responsibility for the academic content of the Joint Command, Control, Communications, Computers, and Intelligence Systems curriculum. C3 Academic Group faculty members carry out research in C4I systems to support the curriculum.

During 1994, the C3AG consisted of the following members:

Lieutenant Colonel Ernest K. Beran, USAF (39), Curricular Officer
Professor Dan C. Boger (SM)
Captain Michael A. Cervi, USAF (C3)
Professor Kenneth L. Davidson (MR)
Lieutenant Colonel David Gaitros, USAF (CS)
Professor Donald P. Gaver (OR)
Professor Wayne P. Hughes (OR)
Professor Carl R. Jones (SM)
Professor William G. Kemple (OR)
Professor Herschel H. Loomis (EC)
Professor Paul H. Moose (EC), Chairman
Professor Orin E. Marvel (C3)
Professor Craig Rasmussen (MA)
Lieutenant Commander Michael Shields (EC)
Professor Timothy J. Shimeall (CS)
Professor Michael G. Sovereign (C3)
Professor Donald V.Z. Wadsworth (EC)+

An overview of the Command, Control, and Communications (C3) Academic Group research program follows.

Common Data Link (CDL) Interfaces to the Global Network Architecture

Professors **Paul Moose**, Shridhar Shukla (EC), and Gilbert Lundy (CS) continued their research into emerging high speed networking architectures and protocols for design of a seamless interface of the CDL to the global broadband network. The first goal is to use these architectures and protocols to develop a CDL-network interface for both ends of the data link. A ranking methodology based on a set of evaluation metrics is being developed and will be applied to the different alternatives identified. The second goal is to develop an implementation plan for integrating CDL into the DoD global network architecture. The plan being developed includes a verification of the integration concept along with assessments of protocol availability, interoperability, network management issues, and performance-related modeling and tradeoffs.

Alternative Concepts of Operation for Direct Downlink of Sensor Information

Professors **Dan Boger** and **Carl Jones** continued their research into the potential benefits to the Joint Task Force Commander for real-time command and control of warfighting forces through the direct downlinking of information from sensors. By examining specific JTF-level scenarios, several alternative concepts of operation for directly-linked sensor information are being compared to current, existing sensor information architectures. Measures of effectiveness focus on the tradeoff of latency for quality of information. Scenarios involving both generic command and control as well as targeting quality information for specific weapons systems are being evaluated.

Support for TADMUS Experiments and Data Analysis

Professor **Michael Sovereign** and Research Psychologist Susan Hutchins began research support to the Tactical Decision Making Under Stress (TADMUS) Program, sponsored by ONR. The objective of the TADMUS program is to apply recent developments in decision theory, individual and team training, and information display to the problem of enhancing tactical decision quality under conditions of stress. The specific research support in this project is being provided to NraD, where the experiments are being conducted, and this support includes a decision support system, training strategies, and alternative human-machine interface concepts. Experimentation using specific antiair scenarios is used to assess the effectiveness of the newly developed decision support system.

Support for the Joint C4I Chair Professorship

Professor **Orin Marvel**, the holder of the Joint C4I Chair Professorship sponsored by the Defense Information Systems Agency, continued his research in systems engineering for C4I systems and theater missile defense. He also continued his support of the Joint C4I Systems curriculum through further development of systems engineering projects and courses.

ELECTRONIC WARFARE ACADEMIC GROUP



Frederic H. Levien
Chairman

Electronic Warfare Academic Group

The Electronic Warfare Academic Group (EWAG) is an interdisciplinary group of faculty who hold appointments in the eleven Departments at the Naval Postgraduate School. These faculty members are responsible for guidance of the electronic warfare curricula for U.S. and International students. Their participation in the EWAG is voluntary and is a result of their interest in applying their expertise to problems related to electronic combat.

Most EWAG faculty do some research related to electronic warfare. The primary purpose of this summary is to provide an overview of their work. In addition, there are a few faculty who so EW research and who are not presently EWAG members. They are included here, as well, in order to provide a comprehensive overview of NPS faculty participation in support of electronic warfare.

The research summaries and publication lists of the EWAG faculty are not included in this section. Since all EWAG faculty hold appointments in a Department, their summaries and publications appear there.

During 1994, the membership of the Electronic Warfare Academic Group was as follows:

Prof. Richard Adler, EC
Kenneth Davidson, MR
Robert Hutchins, EC
David Jenn, EC
Jeffrey Knorr, EC
Chin-Hwa Lee, EC
Fred Levien, EC/EW
Phillip Pace, EC
Ron Pieper, EC
Donald Wadsworth, EC/EW

Sponsors for the program are:

Naval Research Laboratory
Hughes Missile Systems Company
Joint Chiefs, Washington, D.C.
COMMNAVSECGRU
Surface Combat Systems
Naval Sea System Command
Naval Postgraduate School
OPNAV N64E
U.S. Army INSCOM
NAVAIR, Crystal City
Space and Naval Warfare Systems Command (SPAWAR)
Naval Command Control and Ocean Surveillance Center, RDT&E Division
Naval Air Warfare Center Weapons Division
Air Force Information Warfare Center (AFIWC/SAA)
Naval Research Laboratory Monterey
Naval Weapons Center, China Lake (NWC)
Johns Hopkins University Applied Physics Laboratory

An overview of the Electronic Warfare Group research program follows below:

EW Research Areas

- Signal-to-Noise Enhancement Program (SNEP)
- Communication System Performance Evaluation and High Latitude Propagation
- Field Station Research and Support
- Survey and Analysis of Measurement and Simulation Issues for Real-Time Missile Closure Simulation to Support Testing Missile Approach Warning Systems
- Need to Calibrate Indicator for Shipboard HFDF Systems
- Computer Modeling of Aerodynamic Radar and EW Radomes
- Radar Cross Section Synthesis
- Radar Cross Section Reduction of Indirect-File Projectiles
- Electronic Surveillance System Studies
- Foreign APAR Survey and Analysis
- Dual Baseline Triangulation
- Small Combatant Atmospheric EM/EO Sensors
- Coastal Region Refractive Assessments (VOCAR)
- Verification of Marine Aerosol Models
- Validation of SHAREM 110 Data for ENEWS Demonstration
- C2W Analysis and Targeting Tools for Mission Planning and Threat Assessment
- Communications Vulnerability to Jamming
- Hardkill-Softkill Combinations for Optimum Probability of Kill for Surface Ships
- Verification of the Radar Range Equation in the AFIWC IMIM Computer Model
- Observed Effects of an Ultra-Wideband Impulse Generator on the SLQ-32 and Other Microwave Systems
- Performance Evaluation of Ground Based Radar Systems Using the AN/UPS-1 at the Naval Postgraduate School as a Model
- Algorithms for Assessing the Effectiveness of Shipboard Countermeasures Against Anti-Shipping Missile Platforms
- High Resolution Direct Digitization and Optical Telemetry of Antenna Signals
- Surface Mode Processing for Target Detection and Declaration
- Employing High Power Microwaves as Communication Jammers
- Assessment of an Exploited Integrated Air Defense System
- A Study of Infrared Flare Decoy Effectiveness for the P3-C ASUW(AIP) Aircraft Against the AA-7D:APEX IR Missile Using MOSAIC
- MOSAIC (Modeling System for the Advanced Investigation of Countermeasures); A Case Study: The F-14 Versus AA-11

Research efforts are continuing in the following areas:

Prof. Richard Adler continues research and development in techniques to improve the signal-to-noise ratio at Navy receiving sites worldwide. Another area of research is the communication system performance evaluation and high latitude propagation. The goal of this seventh year of a continuing project was to conduct numerical analysis and experimental research in support of the Navy's requirement to site VLF through UHG communication antenna systems and support equipment in non-ideal locations such a polar and equatorial regions containing rugged terrain. A program of support for investigating the radiowave propagation characteristics of the polar (high-latitude) and the equatorial ionosphere was initiated in 1990 and continued in 1994. Also in Prof. Adler's research program is the Army's SIGINT sites in Korea and Ft. Gordon, GA which are subjected to excessive amounts of interference from internal and external noise sources. The NPS Signal Enhancement Laboratory staff and students were tasked to identify and begin mitigation of the sources.

Prof. Kenneth Davidson is working on small combatant atmospheric EM/EO sensors, Coastal region refractive assessments (VOCAR), verification of marine aerosol models, and validation of sharem 110 data for ENEWS demonstration. The small combatant atmospheric EM/EO sensors study provides the capability to make meteorological measurements to appropriate type, accuracy, and time frequency to support assessment of EM and EO propagation conditions by small combatants in coastal and littoral regions. The VOCAR research performed analyses and interpretation of atmospheric surface and mixed-layer data collected in "at sea" experiments, and from remote sensors; operational and research satellites. Prof. Davidson's Aerosol models will be evaluated/formulated on the basis of analysis and interpretation of measurements of near-surface influencing factors. Interpretations will continue on data collected in previous experiments; including the VOCAR experiment in August 1993 and the Marine Aerosol Properties and Thermal Imaging Program (MAPTIP) experiment in October-November 1993. Continued investigation will be performed on assessment of aerosol properties with multi-wavelength satellite remote sensing. He also prepared a validated "in situ" meteorological data set, obtained from ships during SHAREM 110, for interpreting factors performance of RPO and for use with ENEWS demonstration.

Prof. R. Gary Hutchins continues his survey and analysis of measurement and simulation issues for real-time missile closure simulation to support testing missile approach warning systems. NAWCWD is undertaking a study of simulation methodologies to support testing of missile approach warning systems (MAWS) without live missile firings. The actual missile sensor is to remain mounted on the ground, where it can receive illumination from the aircraft. This configuration does not permit the direct observation of aircraft orientation and background clutter that would be seen by an actual missile sensor in flight. The object is to study various issues involved in building a real-time simulation.

Prof. David Jenn worked on the need to calibrate indicator for shipboard HFDF systems, computer modeling of aerodynamic radar and EW radomes, radar cross section synthesis, and radar cross section reduction of indirect-file projectiles. The calibration objective was to investigate possible methods of calibrating shipboard high frequency direction finding (HFDF) systems, or at least developing a means of determining whether a need to calibrate existed. The computer modeling looked at all airborne high-performance radar, EW, and communication systems which require a radome to protect the antenna from a severe operational environment. Predicting the effect of the radome on the antenna performance is crucial during the early stages of the design process. The object of the research was to add further capability to a computer code developed on a previous program and currently used by several Navy organizations. In another study Prof. Jenn developed a synthesis procedure to determine the material properties of an arbitrary target so that a specified radar cross section is obtained. In his last area of study, Prof. Jenn knows weapons locating radars have the ability to detect and track incoming shells and extrapolate back to determine the coordinates of the firing mechanism. As a counter to these radars, the cross section of artillery and mortar rounds was computer and reduced using the method of passive cancellation. Significant reduction was achieved by simply adding two shallow slots to the round.

Prof. Jeff Knorr continues his studies in electronic surveillance systems. His goal is to demonstrate the feasibility of predicting the performance of a shipboard HF direction finding system using computer simulation.

Prof. C.-H. Lee is working on foreign APAR survey and analysis. The first deployment of Active Phased Array Radar (APAR) were in the USAF Advanced Tactical Fighter (ATF). Westinghouse and texas Instruments (TI) formed a joint venture for the development of APAR systems. Flight tests were done in 1990-91. A full scale development model was scheduled for late 1993. Since the middle of the 1980s, foreign countries have initiated numerous programs to develop future APAR systems in the future. Prof. Lee continues to analysis the ongoing development efforts and reveal the system parameters and the anticipated system performance.

Prof. Fred Levien is studying employing high power microwaves as a communications jammer, assessing exploited integrated air defense systems, hardkill-softkill combinations for optimum probability of kill for surface ships, verification of the radar range equation in the AFIWC IMOM computer model, observed effects of an ultra-wideband impulse generator on the SLQ-32 and other microwave systems, and performance evaluation of ground

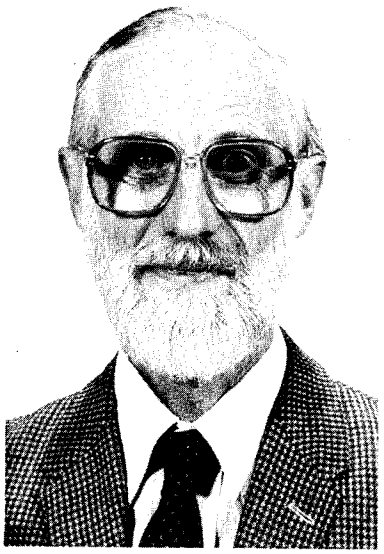
based radar systems using the AN/UPS-1 at the NPS as a model. He continues to evaluate the effectiveness of an ultrawide band (UWB) source at jamming a cellular telephone and to develop an operational assessment of an exploited Integrated Air Defense System (IADS) tracking algorithm. The hardkill-softkill study determines the optimum procedure for achieving the maximum probability of kill when using both hardkill and softkill weapons in defense of a typical Navy surface platform. The AFIWC IMIM (Improved Many [jammers] -On-Many [radars]) is presently in use by the U.S. Air Force to model the electronic EOB for pilots on operational missions. The SLQ-32 study was to determine if UWB devices could disrupt the operation of the SLQ-32, and if so, whether the technique could be developed into a useful weapon system. Another study was an approach for use in the evaluation of radar systems by establishing two measurable performance standards; the baseline and theoretical, and then using the NPS AN/UPS-1 radar as a model, demonstrating how to use this evaluation method.

Prof. Phillip Pace's research centered around algorithms for assessing the effectiveness of shipboard countermeasures against anti-shipping missile platforms, high resolution direct digitization and optical telemetry of antenna signals, and surface mode processing for target detection and declaration. The latter study was to experimentally evaluate the trade-offs between an inverse MTI filtering approach and a DFT filter bank approach to detect surface targets in actual recorded sea clutter. In the first study the object was to improve the process for evaluating hardware-in-the-loop and field test performance results. As part of this objective, new algorithms to measure the overall EW systems utility and effectiveness were developed. In his antenna signals study he investigated the feasibility of directly digitizing, wideband antenna signals using high-resolution symmetrical number system (SNS) techniques to achieve 14-bits resolution in a sampling rate of 5 MHz.

Prof. Ron Pieper is continuing research in dual baseline triangulation. The research address one approach to the provision of target range information by cooperative use of two or more passive sensors.

Prof. Donald Wadsworth has continued his research in communications vulnerability to jamming and C2W analysis and targeting tools for mission planning and threat assessment. Modeling for the first study includes jammers and propagation, while further development and analysis of the AFIWC C2W targeting models used for mission planning and threat assessment is proposed for the second study.

SPACE SYSTEMS ACADEMIC GROUP



Rudolf Panholzer
Chairman

Space Systems Academic Group

The Space Systems Academic Group (SSAG) is an interdisciplinary association providing direction and guidance for the Space Systems Engineering and Space Systems Operations curricula. SSAG relies on faculty and facilities support from the departments of Aeronautical and Astronautical Engineering, Computer Science, Electrical and Computer Engineering, Mathematics, Mechanical Engineering, Meteorology, Oceanography, Operations Research, Physics, and Systems Management. The mission of the Space Systems Academic Group (SSAG) is to provide space systems officer students practical learning opportunities via hardware-based theses and experience tours to supply our sponsors with adequate numbers of space-qualified military personnel; and to develop the Naval Postgraduate School's Space Systems Engineering and Space Systems Operations academic curricula programs. On-going projects within SSAG provide a space-hardware-oriented environment ideal for students to gain experience in design, development, installation, system integration, and maintenance of spacecraft and payloads. Officer students are exposed to space related research projects as well as formal classroom instruction, and are required to complete a space-oriented thesis for the Master of Science degree requirements. In the 1994 academic year, officer students in the Space Systems Curricula and participating faculty from several departments were engaged in four major areas of space research and development: (1) Spacecraft Technology; (2) Satellite Communications; (3) Space Environment; (4) Space Warfare and; (5) Computer Memory Technology in Space. In addition , SSAG assisted participating departments in the continuing development of several Spacecraft and Flight Hardware Laboratories and Support Facilities (6).

Spacecraft Technology:

Small Satellite Design Studies (PANSAT):

Directed by Professor Rudolf Panholzer, the Small Satellite Design Studies program is part of the Spacecraft Technology research effort incorporating proven and 'leading edge' technology in a hardware project. The Small Satellite Design Studies originated with the ORION Mini-Satellite Program, a prototype general purpose satellite. The continuing project is the Petite Amateur Navy Satellite (PANSAT) which will investigate spread spectrum communication with store-and-dump capability for relaying information digitally. The PANSAT research project will involve officer students in the design, fabrication and integration of a 150 lb. satellite dedicated to function as a small packet radio communications satellite using spread spectrum techniques. PANSAT will serve as a quick-reaction, low-cost, direct-sequence spread spectrum packet communication satellite. Since spread spectrum modulation provides low-probability-of-detection and low-susceptibility-to-jamming, PANSAT can quickly increase defense communication systems in times of crisis. The PANSAT satellite was originally presented at the 3rd Annual AIAA/Utah State University Conference on Small Satellites, September 26-28, 1989. An update was presented at the 5th Annual AIAA/Utah State University Conference on Small Satellites, Aug 30 - Sept 1, 1994, and at the AIAA Space Programs and Technologies Conference and Exhibit, Sept 27 - 29, 1994, Huntsville. Lt. Daniel Cuff, US Navy, presented his thesis titled Lifetime and Reentry Prediction for the Petite Amateur Navy Satellite (PANSAT) in Huntsville.

A Study of the Temperature History of PANSAT Over a Single Orbit:

Professor Allan D. Kraus modeled the Petite Amateur Navy Satellite (PANSAT) both for steady state and transient thermal analysis. The scientific objective of his research was to determine the temperature profile of the PANSAT vehicle using an existing computer code to determine the orbital temperature patterns for PANSAT.

Satellite Communications:

PANSAT Communications System Design:

Under Professor Randy Borchardt's guidance, the following six tasks were accomplished: 1) Building of a test bed for the RF front end with new design that lowered the power requirements, 2) Building and testing the TMUX and identifying areas for refinement, 3) Starting adaptation of the direct sequence spread spectrum modulator/demodulator Paramax PA100 chip for use with PANSAT with CPT Steve Hueneke, US Army, 4) Starting development of new ground station with LT Pete Eagle, USN, 5) Starting exploration of the PA100 chip for follow-on satellite designs and use with other satellites currently in orbit, and 6) Starting development of a channel simulator that will account for various signal losses and noises encountered in the channel.

Space Environment:

Photoelectrons and Equatorially Trapped Electrons:

Professor R. C. Olsen addressed the nature of low energy plasma (electrons) as observed in the magnetosphere. Data from the Los Alamos geosynchronous satellites, and NASA's AMPTE/CCE satellite were studied. The statistical occurrence pattern was established using the AMPTE data, and the anti-coincidence of trapped electron and ion distributions was established. Studies of the Los Alamos data sets showed that the trapped electron distributions were being fed by photo-electrons emitted from the dayside ionosphere. Parallel studies showed that at times, these field-aligned distributions showed evidence of auroral acceleration processes. (See Department of Physics).

Space Power Experiment Aboard Rocket (SPEAR):

Professor R. C. Olsen continued his project in support of the SPEAR III experiment. The objective was to work with the plasma measurements and wave measurements, to address the charging and dis-charging mechanisms for high-voltage systems in space. The rocket was successfully launched on 15 March 1993. Funding cutbacks eliminated analysis funds, however, so subsequent work has been unsupported. James Morris, an NPS student, attended the Plum Brook tests in 1992, and the launch. he completed his thesis in 1994.(See Department of Physics).

Remote Sensing of The Ionospheric E- and F-Layers:

The sounding rocket experiment for remote sensing of the ionosphere conducted by Prof. David Cleary is continuing. The goal of this project was to develop a passive technique for remote sensing the ionospheric electron density profile on a global basis. Specifically, we want to determine if the electron density can be inferred from the ultraviolet signature of the positive ions in the ionosphere. In March 1994, Professor Dave Cleary assisted in conducting our third sounding rocket experiment. During this experiment two ultraviolet spectrographs measured the UV spectrum of the Earth's ionosphere between 100 and 320 km. This experiment was conducted over the Poker Flat Missile Range in Alaska during and intense geomagnetic storm. The purpose of this experiment to investigate the effects of auroral electron precipitation on the UV spectrum of the ionosphere. Analysis of the data obtained from this experiment is ongoing.

In addition, we made significant progress on the development of a new instrument for ionospheric remote sensing. This instrument is an All-Reflection Michelson interferometer. The design of this instrument was conceived in 1993 and a prototype was tested using a HeNe laser. During 1994 we demonstrated a prototype using incoherent visible sources. These sources included the Mercury emission at 5460-Å and the Sodium doublet at 5890-Å. For the prototype we used a CCD camera for the detector. We then modified the detector to operate in the ultraviolet.

A UV image intensifier tube was added to the CCD camera. Using this modified detector we successfully demonstrated the operation of this instrument in the UV using the Mercury 2537-Å emission. (See Department of Physics).

Space Warfare:

ADSI AND MSTS SYSTEMS ANALYSIS:

Professor I. Michael Ross began conducting a three-year project which is aimed at analyzing the Air Defense System Integrator (ADSI) and the Multi-Source Tactical System (MSTS) in support of the warfighter. ADSI correlates national systems data, airborne and combined service data with ground based radars to support the warfighter. MSTS allows the warfighter to overlay current national and tactical intelligence data onto multiple types of maps and images thereby enhancing an aircrew's situational awareness. The Task Leader is Prof. W. Kemple and TENCAP Chair Prof. K. Alfriend is the CO-PI who supports this project. The project began in July 1994 and during the remaining months of FY94, much of the work performed was by Profs. Kemple and Alfriend in understanding these new systems, including travel to the Air Force Space Command.

Computer Memory Technology in Space:

Ferroelectric Technology:

Professor Panholzer's team continued research on Computer Memory Technology to evaluate ferroelectric technology for its suitability in military and space applications. Under Professor Panholzer's direction, a Thin-Film Ferroelectric Experiment (NPS FERRO-001) which was designed in 1993 to test the effects of space environment on aging and fatiguing characteristics of ferroelectric capacitors continued.

Spacecraft and Flight Hardware Laboratories/Facilities:

The Space Systems Academic Group (Code SP) and participating departments have continued to dedicate both labor and material resources to the development of several laboratories and support facilities:

(SP01) Spacecraft Integration & Test (SP);
(SP02) Open Site EMI/EMC (SP);
(SP03) Satellite ground Station (SP);
(SP04) AIS Computing (SP);
(SP05) Precision Fabrication Facility (SP);
(AA17) FLTSATCOM Satellite Operation, Sim. & Test (SP/AA);
(AA18) Spacecraft Attitude Dynamics & Control (SP/AA); and
(AA19) Spacecraft Environmental Simulation & Test (SP/AA).

SMALL SATELLITE DESIGN STUDIES (PANSAT)

R. Panholzer, Professor and Chairman
Space Systems Academic Group
Sponsor: Naval Research Laboratory,
Army Space Technology Research Office,
and Naval Postgraduate School

OBJECTIVE: The goals of the Continuing Small Satellite Design Studies program are (1) to enhance the education of officer students through a systems engineering approach; (2) to design, fabricate, test, and ultimately launch a small satellite for operation by NPS; and (3) to demonstrate the feasibility of small satellites in providing a valuable space asset to augment existing military communications.

SUMMARY: In the 1994 academic year, the PANSAT project made progress in the development of the communications payload, test and validation of flight solar panel identification, and procurement of many key components and technologies and further definition of operational requirements and procedures.

Specific subsystem tasks completed during the AY 94 period:

(1) Computer. Many devices were selected for non-volatile and error-detection and correction memory storage. As a power saving measure the processor and the demodulation chip were separated. Additionally, the temperature sensor multiplexor was prototyped and tested.

(2) Communication Payload. Control of the spread spectrum demodulator chip was exercised under the thesis research of Major Steve Hueneke, US Army. A link budget was recalculated and redundancy schemes were prototyped for the radio frequency (RF) portion.

(3) Electric Power. Flight solar panels were received from the vendor and a suite of acceptance tests were performed. All 20 flight solar panels successfully passed testing, although one was returned due to damage from handling. The battery contract for testing and selecting flight battery cells from terrestrial Ni-Cad battery cells was finalized. Power control electronics design is continuing.

(4) System Design. Work was completed dealing with the configuration of the spacecraft and its subsystems. This includes placement of subsystems, mass characteristics, and engineering drawings. The launch vehicle interface for attachment of PANSAT to the shuttle was designed, analyzed, and prototyped. System and subsystem block diagrams were updated and incorporated in a version of the Customer Payload Requirements (CPR) document. The CPR was submitted as a draft document to the Air Force Space Test Program for PANSAT integration with the shuttle. The Federal Communications Commission was contacted for frequency allocation in the 436.25 MHz band. The frequency allocation process is still in progress.

THESES DIRECTED:

Calvert, T., LT, USN, "Computer Interface Development for the Petite Amateur Navy Satellite (PANSAT) Simulator," Master's Thesis, June 1994.

Cuff, D., LT, USN, "Lifetime and Reentry Prediction for the Petite Amateur Navy Satellite (PANSAT)," Master's Thesis, June 1994.

Gannon, B., LT, USN, USN, "Design and Analysis of the Launch Vehicle Adapter Fitting for the Petite Amateur Navy Satellite (PANSAT)," Master's Thesis, September 1994.

Hand, G., LT, USN, "Intermediate Design and Analysis of the PANSAT Electrical Power Subsystem," Master's Thesis, March 1994.

Hueneke, S., CPT, USA, "Design of a Digital Direct Sequence Spread Spectrum Demodulator for the Petite Amateur Navy Satellite (PANSAT)," Master's Thesis, December 1994.

Lawrence, G., LT, USN, "Preliminary PANSAT Ground Station Software Design and Use of an Expert System to Analyze Telemetry," Master's Thesis, March 1994.

Rich, M., LCDR, USN, "A Systems Analysis and Project Management Plan for the Petite Amateur Navy Satellite (PANSAT)," Master's Thesis, September 1994.

Patterson, S., LCDR, USN, "Thermal Analysis of PANSAT Batteries and Electrical Power Subsystem," Master's Thesis, September 1994.

Victor, E., LT, USN, "Thermal Analysis of PANSAT Electric Power Subsystem," Master's Thesis, June 1994.

Weiding, D., LT., USN, "The Development of the Communications Systems for the Petite Amateur Navy Satellite (PANSAT)," Master's Thesis, September 1994.

DOD KEY TECHNOLOGY AREA: Software, Communications Networking, Electronic Devices, Environmental Effects, Energy Storage, Human-System Interfaces

KEYWORDS: PANSAT, Petite Amateur Navy Satellite, Small Satellites Design Program, Spread Spectrum

THIN-FILM FERROELECTRIC EXPERIMENT (FERRO NPS-001)

R. Panholzer, Professor and Chairman
Space Systems Academic Group
Sponsor and Funding: Naval Research Laboratory and Naval Postgraduate School

OBJECTIVE: The NPS research program on Computer Memory Technology for Space has as its objectives: (i.) to enhance the education of officer students in the Space Systems Curricula; (ii.) to provide a cost-efficient experiment to test the space-related characteristics of ferroelectric materials; and (iii.) to contribute to the military efforts to evaluate ferroelectric materials. The goal of the on-going thin-film ferroelectric memory research project (FERRO NPS-001) is to evaluate ferroelectric technology to determine its suitability in military and space memory applications.

SUMMARY: NPS-001 FERRO is a thin-film ferroelectric experiment manifested on the Advanced Photovoltaic and Electronics Experiment (APEX) satellite manufactured by Orbital Sciences Corporation (OSC) of Fairfax, VA. It will test the effects of space environment (most importantly radiation) on aging and fatiguing characteristics of ferroelectric capacitors. That is, thin-film capacitors will be tested for their ability to store and retain data in space. The FERRO NPS-001 experiment will test the effects of space environment (most importantly radiation) on aging and fatiguing characteristics of ferroelectric capacitors--they will be tested for their ability to store and retain data in space. One flight aboard the Pegasus launch vehicle (Pegastar Bus) occurred August 1994. Resulting data will help determine in what ways ferroelectrics can replace memory technology in military space applications.

Progress to Date:

Methodology. Testing methods to determine the radiation effects on ferroelectric material have been established. These tests will be conducted on ferroelectric test specimens in a high radiation orbit. No irradiated specimens will be tested in like manner on the ground.

On-ground Testing. A radiation-fatigue test board was designed to allow accurate and simultaneous testing of multiple ferroelectric devices; and experiment level environmental tests were continued in 1994 by SSAG staff engineers.
On-orbit Testing. Launch of NPS-001 occurred in August 1994. The time up to launch was used by the Orbital Science Corporation to perform space craft qualification tests. Due to space craft malfunctions, data has been recovered for only a portion of the time in orbit. Data will be analyzed in 1995.

DOD KEY TECHNOLOGY AREA: Electronic Devices, Materials and Processes

KEYWORDS: Ferroelectric Capacitors, nonvolatile memory, APEX mission

UNDERSEA WARFARE ACADEMIC GROUP



James Eagle
Chairman

Undersea Warfare Academic Group

The Undersea Warfare Academic Group (USWAG) consists of ten faculty members who hold appointments in five Departments at the Naval Postgraduate School, plus the Curricular Officer. The faculty members teach in the Undersea Warfare Curriculum and are responsible for its academic content. Members conduct Undersea Warfare-related research and serve as thesis advisors for Undersea Warfare students.

During 1994, the USWAG consisted of the following members:

Professor Steve Baker (PH)
Professor Robert Bourke (OC)
Professor Ching-Sang Chiu (OC)
Professor James Eagle (OR), Chairman
Professor Ralph Hippenstiel (EC)
Professor Robert Keolian (PH)
Professor James Sanders (PH)
Professor Clyde Scandrett (MA)
Professor Kevin Smith (PH)
Professor Alan Washburn (OR)
CDR Bob Young (37), Curriculum Officer

An overview of research supported by the Undersea Warfare Academic Group is below.

Conductivity, Temperature and Depth Studies

Professor Robert Bourke examined conductivity, temperature, depth (CTD) data collect by a submarine operating in the Arctic Ocean. This was the first study of CTD data collected by a submarine and revealed information on submesoscale vortices which drifted through the area. A follow-on research submarine cruise took place in August 1993, which collected additional CTD data. Professor Bourke's research has been influential in the planning for this submarine cruise.

Sonar Transducer Arrays

Professors David Canright (MA), Clyde Scandrett (MA), and Steve Baker (PH) continued their research program in low-frequency, active sonar transducer array performance modeling. The purpose of this research is to efficiently predict the performance of arbitrarily dense, volumetric active sonar arrays. They have developed a new, combined analytical/finite-element numerical analysis method for this purpose. The research goal is to couple a finite-element model of a low-frequency transducer of Navy interest to an acoustic field model which allows arbitrarily dense arrays. In 1992 a new methodology was developed for determining the acoustic source levels of a transducer array which is computational more efficient than previous methods. Also, the array modeling procedure was extended to shallow water. In this work, the problem of mutual interactions of transducers has been coupled to a water "sound channel" which incorporates the effects of a free surface, and either an acoustically hard bottom of uniform dept, or an acoustically "fast" bottom.

Acoustic and Electromagnetic Data Modeling

Professors Charles Therrien (EC) and Murali Tummala (EC) continued work on multigrid techniques for application to transient acoustic and electromagnetic data modeling and compression. New algorithms were developed for modeling and processing one- and two-dimensional signals. Preliminary investigative work was

conducted examining signal compression applications of wavelet transforms.

Acoustic Tomography

Professors James Miller (EC) and Ching-Sang Chiu (OC) proposed a new ocean acoustic tomography method for real-time coastal ocean monitoring. The proposed method used telemetered vertical line arrays to acquire a time series of both acoustic ray and mode arrivals in real time. Hybrid ray/mode inverse techniques are then used to map the ocean thermal structure at high spatial and temporal resolutions. Under the sponsorship of the Office of Naval Research, this new tomography method was successfully tested at sea in the Barents Sea Polar Front Experiment in 1992. Additionally, Professors Miller and Chiu continued to develop a procedure for localizing transient acoustic signals. The accuracy and robustness of their algorithms were tested in several simulated complex shallow-water scenarios.

Wavelet Transform

Professors Ralph Hippenstiel (EC) and Monique Fargues (EC) began a two-year program to investigate use of the Wavelet Transform in undersea surveillance. The Wavelet Transform can serve as an alternative to conventional time-frequency transforms and is well suited for transient detection. Also investigated was the potential use of the Wavelet Transform to the modeling of radar transient returns in the presence of sea clutter, multipath and radio frequency interference.

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