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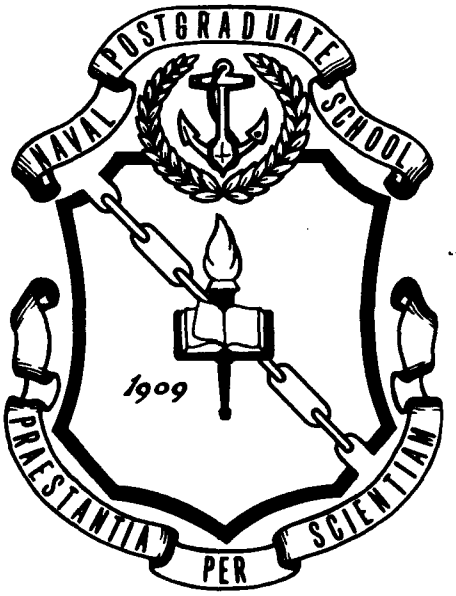
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A SUMMARY OF THE NAVAL POSTGRADUATE SCHOOL RESEARCH PROGRAM AND RECENT PUBLICATIONS

OCTOBER 1989 TO SEPTEMBER 1990



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NAVAL POSTGRADUATE SCHOOL
Monterey, California

Rear Admiral R.W. West, Jr.
Superintendent

H. Shull
Provost

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This report contains 357 summaries of research projects which were carried out under funding of the Naval Postgraduate School Research Program. A list of recent publications are also included which consist of conference presentations, contributions to books, published papers, magazine articles, and technical reports. The research was conducted under the areas of Computer Science, Mathematics, Administrative Sciences, Operations Research, National Security Affairs, Physics, Electrical and Computer Engineering, Meteorology, Aeronautics and Astronautics, Oceanography, Mechanical Engineering, C3 Joint Group, Electrical Warfare Group, ASW Group and the Space System Academic Group.

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INTRODUCTION

This volume summarizes faculty research activity during fiscal year 1990, and it lists recent publications and conference presentations. A separate volume, "Naval Postgraduate School Compilation of Abstracts of Theses Submitted by Candidates for Degrees," is a compilation of abstracts of theses written at NPS during fiscal year 1990.

Research is an integral part of the graduate education and there is a close connection between faculty research and student theses. Approximately 800 Masters Theses are written annually at the Naval Postgraduate School and many of the projects shown here make reference to those theses.

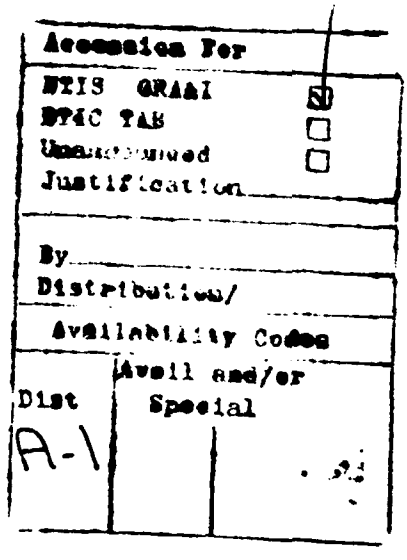
The projects summarized in this volume are organized by the academic department of the principal investigator. This provides a natural grouping by subject area, but does not give adequate recognition to the significant amount of research in the interdisciplinary areas, in particular the work of the school's Academic Groups in Antisubmarine Warfare, Space Systems, Electronic Warfare, and in Command, Control, and Communications.

The Naval Postgraduate School wishes to acknowledge Millie Fidel for her efforts in the preparation of this volume.

Additional information about research activities at NPS can be obtained from the Research Office, Code 08, Naval Postgraduate School, Monterey, California, 93943.

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DEPARTMENT OF AERONAUTICS AND ASTRONAUTICS

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 (including spacecraft). Within these technical disciplines, the research effort is focussed on topics of current Navy importance. The present areas of focus are as follows:

ENHANCED MANEUVERABILITY AND HIGH-ALPHA AERODYNAMICS

A collaborative effort is underway by Professors Platzer, Chandrasekhara, Hebbar and Ekaterinaris to investigate the flow behavior around fighter configurations during high angle of attack maneuvers. The effort involves water tunnel studies of the effect of pitch rate on the vortex breakup in the flow around F-18 aircraft models, wind tunnel studies of the effect of compressibility on the dynamic stall of airfoils, and the development of predictive computational methods based on both Navier-Stokes and viscous-inviscid interaction approaches. In related work, Professor Howard is studying canard-wing interaction for enhancing lift after recently completing a wind tunnel study of asymmetric vortices on ship-launched missiles at high angle of attack. Also, a troublesome flight instrumentation problem was examined by Professor Biblarz for the Pacific Missile Test Center.

HELICOPTER AEROMECHANICS

Three studies are ongoing. First, the unsteady aerodynamics of airfoils undergoing oscillatory motion is being studied experimentally by Professors Chandrasekhara and Platzer using a unique model actuator mechanism and applying point diffraction interferometry. Viscous computational simulation is being developed by Professor Ekaterinaris. Second, an interdisciplinary effort by Professors Wood and Kolar is the exploration of Higher Harmonic Control (HHC) for improving helicopter performance and modifying the helicopter's noise signature. The application of chaos method to HHC is also examined here. Third, the problem of landing helicopters on ships is being tackled by Professor Healey from several viewpoints. The aerodynamics of AOR ships are being studied experimentally in a wind tunnel in which the atmospheric boundary layer is properly simulated. Also, turbulence data have been obtained in model tests along specific flight paths to the deck of a DD-963. Finally, vortex ring models of hovering rotors have been used to develop predictions of rotor inflows.

STRUCTURAL MECHANICS AND COMPOSITE MATERIALS

Because of their growing importance in aerospace applications, structures research efforts are heavily focussed on composite materials. Professor Wu has undertaken the fundamental problem of describing the time and stress dependent strength loss in composite materials. The approach is an analysis which separates fiber, matrix and interface mechanisms, and careful experiments which establish the necessary statistical strength and life data. Professor Gorman is experimenting with acoustic emission (AE) in the detection of matrix cracking in graphite-epoxy materials and debonding in adhesives. He is also assessing the potential of AE for monitoring fatigue cracks in aging aluminum aircraft. An analysis of thick composite plates using higher-order three-dimensional finite elements is being attempted by Professor Kolar.

AIRCRAFT, MISSILE AND SPACE PROPULSION

Research is concentrated currently on problems related to gas turbine and solid fuel ramjet engines. Professors Shreeve, Hobson and associates have continued studies aimed ultimately at improving the stable off-design operating range of axial compressors and fans. LDV measurements and viscous code development to describe cascade blade stall are underway. Experimental studies to examine tip-clearance effects in a multi-stage arrangement have been completed. An experiment to examine the application of passive vortex generators in the alleviation of shock-induced separation in transonic fans has been designed. Professors Platzer and Ekaterinaris have continued the development of viscous computational methods for predicting turbine blade heat transfer. Related to the testing of complete gas turbine engines, Professor Netzer has continued experiments aimed at reducing NO_x emissions from jet engine test cells. Related to missile propulsion, Professor Netzer and his associates are conducting experiments on the combustion of boron-carbide fuels and experiments to examine the behavior of particulates in exhaust nozzles and plumes. Both light scattering techniques and particulate collection probes are applied in these studies.

FLIGHT MECHANICS AND CONTROLS

Three areas of concentration are noted. Professor Howard has initiated and is developing a flight research program for unmanned air vehicles (UAV's). Fixed wing and rotary wing models are tested for the purposes of addressing problems identified in full scale programs. Nineteen flight vehicles are currently involved in the program. Professor Collins is involved in studies of alternate controllers for Navy (F18) and research (X29) aircraft. H_2 and H_∞ methods are applied and the application of adaptive neural networks is being investigated. Professor Schmidt is attempting to understand the phenomenon of "wing rock", which is experienced by many aircraft, with particular reference to the F-14. Professor Schmidt has also successfully addressed ship control problems aimed at improved sea keeping.

SPACECRAFT DYNAMICS AND CONTROLS

A new research effort has been initiated by Professors Agrawal and Ross to study effects of flexibility due to structures and liquid propellant motion on the attitude control of spacecraft. A unique apparatus has been constructed for experiments which will attempt to verify new control techniques.

SURVIVABILITY/LETHALITY

Professor Ball continues to support the Joint Technical Coordinating Group on Aircraft Survivability by performing a number of analyses in aircraft combat survivability. Recent effort was concentrated on the analysis of evasive maneuvers of Navy tactical aircraft under missile attack, using the Air Force TRAP program with simulations of several current air-to-air missiles. Professor Ball's program, which was the first to treat the subject of "survivability", is in its seventeenth year.

ATTITUDE CONTROL OF FLEXIBLE SPACECRAFT

B.N. Agrawal, Professor of Aeronautics and Astronautics
M. Ross, Adjunct Research Professor of Aeronautics and Astronautics
Sponsor: Research Council/Navy Center for Space Technology
Funding: Naval Postgraduate School

OBJECTIVE: To study effects of flexibility due to structures and liquid propellant on the attitude control of three-axis stabilized and spin-stabilized spacecraft and development of improved control techniques. The improved control techniques will be validated by experimental tests.

SUMMARY: An experimental set-up to simulate pitch motion of a spacecraft configuration consisting of a central rigid body, two liquid propellant tanks and a flexible reflector has been designed. The primary actuator is a reaction wheel on the central body. In order to reduce gravitational effects and friction, the spacecraft simulator is supported on air pads/granite table. The effects of liquid propellant on attitude stability of spin-stabilized spacecraft are analyzed. The dynamic characteristics of liquid motion are analytically determined. Effects of inertia asymmetry on attitude stability in the presence of liquid fraction and limitations of Energy-Sink analysis are also determined.

CONFERENCE PRESENTATIONS: B. Agrawal, "Dynamic Characteristics of Liquid Motion in Partially Filled Tanks of Spinning Spacecraft," AIAA-90-0997-CP, Proceedings of 31st AIAA/ASME/ASCE/AHS/AHC Structures, Structural Dynamics and Material Conference, Long Beach, California, April 5-6, 1990.

B. Agrawal, "Attitude Stability of Asymmetric Dual-Spin Spacecraft with Large Liquid Fraction," AIAA-90-3491, Proceedings of AIAA Guidance, Navigation, and Control Conference, Portland, Oregon, August 20-22, 1990.

B. Agrawal, "Energy-Sink Analysis for Flexible Asymmetric Dual-Spin Spacecraft," IAF-90-320, presented at the 41st Congress of the International Astronautical Foundation, Dresden, Germany, October 6-12, 1990.

THESES DIRECTED: J.W. Myers, Jr., Major, USA, "The Effects of Liquid Propellant Motion on Attitude Stability of Spin-Stabilized Spacecraft," M.S. Astronautical Engineering, March 1990.

C.C. Ward, LT, USA, "Attitude Control of Flexible Structures," M.S. Astronautical Engineering, September 1990.

OTHER: One paper has been submitted for publication in a journal. Three papers are under preparation for presentations at conferences and publications in journals.

NPS SURVIVABILITY SUPPORT

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

OBJECTIVE: The objective of this project is to continue the technical support provided to the JTCG/AS for the past 17 years by conducting research and performing analyses in aircraft combat survivability.

SUMMARY: The survivability of a tactical aircraft threatened by an air-to-air missile is dependent upon the actions taken by the aircraft after the missile is launched. The aircraft, when warned of the launch, will take an evasive maneuver to avoid the missile and cause a large miss distance. The parameters that affect the effectiveness of the maneuver consist of the maneuver itself and the timing of the initiation of the maneuver with respect to the time-to-go of the missile. This project consisted of the selection of several evasive maneuvers and the computer simulation of these aircraft maneuvers and the flyout of the missile toward the maneuvering aircraft. The maneuver was initiated at a number of time-to-go values varying from very long to very short. The final measure of merit was the miss distance for each maneuver and maneuver initiation time. The computer program used for the simulation was an Air Force program called the Trajectory Analysis Program (TRAP). The program was executed using the flight characteristics of a current Navy tactical aircraft and several current air-to-air missiles. The results obtained can be used to determine the optimum maneuver to make and the time window to make the maneuver.

THESIS DIRECTED: One classified thesis.

IMPROVEMENT OF THE ALTITUDE MEASUREMENT CAPABILITY OF THE SAIP

Oscar Biblarz, Associate Professor of Aeronautics and Astronautics
Sponsor: PMTC, Point Mugu, California
Funding: NAVAIR

OBJECTIVE: The goal of this project is to identify the sources of error in the measurement of barometric-pressure altitude in the Navy's Service Aircraft Instrumentation Package (SAIP). These sources go beyond those well known for this standard technique to include pod alignment errors and internal electronic configuration errors. In the long term we hope to influence new designs.

SUMMARY: Altitude measurements with the SAIP do not conform with the specifications for the probe. Errors seem to worsen with aircraft speed and altitude and, therefore, appear to be of aerodynamic origin. Our work with a second-generation SAIP [model #NCA S/N 0040, P/N 2111940-001] indicates that the problem actually lies in the air data unit (ADU) where cross-talk and an overloaded power supply modify the input from the pressure transducers.

THESIS DIRECTED: S.R. Eastburg, LT, USN, "An Engineering Study of Altitude Determination Deficiencies of the Service Aircraft Instrumentation Package (SAIP)," Aeronautical Engineer Thesis, December 1990.

COMPRESSIBILITY EFFECTS ON DYNAMIC STALL OF OSCILLATING AIRFOILS

continued as

COMPRESSIBILITY EFFECTS ON AND CONTROL OF DYNAMIC STALL OF OSCILLATING AIRFOILS

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

OBJECTIVE: To study the effects of compressibility on the dynamic stall of oscillating airfoils and control the process of dynamic stall. The research has application in helicopter "retreating blade stall". The knowledge will be useful in extending the flight envelope of future helicopter systems. On-going program since March 1986, renewed in March 1990.

SUMMARY: The flow over a helicopter "retreating" blade is being simulated in the newly built Compressible Dynamic Stall Facility (CDSF) and studied with a view to understand the basic flow physics for possible improvements in the blade design. During the reporting period, extensive LDV measurements were carried out to document the velocity field over an oscillating airfoil. Also, another series of experiments was conducted that focused primarily on the flow near the airfoil leading edge. Further, a new diagnostic technique known as Point Diffraction Interferometry, which is a real-time interferometry technique was developed and used to measure the flowfield. From the measurements, a very detailed pressure distribution in the first 0.4% of the airfoil chord was obtained, which is considered a break-through.

PUBLICATIONS: M.S. Chandrasekhara and L.W. Carr, "Flow Visualization Studies of the Mach Number Effects on the Dynamic Stall of Oscillating Airfoils," AIAA Paper No. 89-0023, Journal of Aircraft, Vol. 27, No. 6, pp. 516-522, June 1990.

L.W. Carr and M.S. Chandrasekhara, "Design and Development of a Compressible Dynamic Stall Facility," AIAA Paper No. 89-0647, Forthcoming Journal of Aircraft.

L.W. Carr, M.F. Platzer, M.S. Chandrasekhara and J.A. Ekaterinaris, "Experimental and Computational Studies of Dynamic Stall," Numerical and Physical Aspects of Aerodynamic Flows IV, Chapter 14, pp. 239-256, Springer-Veriag, 1990.

CONFERENCE PRESENTATIONS: M.S. Chandrasekhara and B.E. Brydges, "Amplitude Effects on Dynamic Stall of an Oscillating Airfoil," AIAA Paper No. 90-0575, the AIAA 28th Aerospace Sciences Meeting, Reno, Nevada, January 8-11, 1990.

M.S. Chandrasekhara, L.W. Carr and S. Ahmed, "Comparison of the Pitch Rate History Effects on Dynamic Stall of Airfoils," NASA/AFOSR/ARO Workshop on Physics of Forced Unsteady Flow Separation, Moffett Field, CA, April 17-19, 1990.

L.W. Carr and M.S. Chandrasekhara, "A Study of Compressibility Effects on Dynamic Stall of Oscillating Airfoils," Invited Paper in the 1st International Conference of Computing Physics, Boulder, CO, June 11-15, 1990.

L.W. Carr and M.S. Chandrasekhara, "Experiments With Oscillating Airfoils in Compressible Flow Environment," Invited Paper, U.S. Army Workshop on Unsteady and Two-Phase Flows, London, UK, June 28-29, 1990.

OTHER: M.S. Chandrasekhara and M.F. Platzer, "Compressibility Effects on Dynamic Stall of Oscillating Airfoils," Final Report Submitted to ARO.

A Ph.D. student (Mr. R.D. Van-Dyken) was guided on his thesis work on this project during the course of the year.

COMPRESSIBILITY EFFECTS ON DYNAMIC STALL OF AIRFOILS UNDERGOING RAPID TRANSIENT PITCHING MOTION

M.S. Chandrasekhara, Adjunct Research Professor
M.S. Platzer, Professor of Aeronautics and Astronautics
Sponsor: U.S. Air Force Office of Scientific Research
Funding: AFOSR

OBJECTIVE: To study the effects of compressibility on the dynamic stall of an airfoil undergoing a rapid ramp type pitching motion with applications to supermaneuverability of fighter aircraft. On-going project since October 1986.

SUMMARY: A very detailed and complete series of stroboscopic schlieren flow visualization studies was performed during the reporting period for various flow conditions and pitch rates. Certain adjustments to the system and recalibration of the hydraulic pitching drive mechanism were carried out to produce low pitch rates. Also, the capability of a real-time interferometry system known as the Point Diffraction Interferometry system was established. This required testing out a lens based system, a schlieren type mirror based system and experimenting with two types of point diffractor source, namely a coated film and a line filter. Finally, a mirror based, line filter system was found to give the best quality interferograms and was adapted. Special electronic circuitry to record the delay in the triggering of the laser light source from an outside pulse (from an encoder on the hydraulic drive) was developed in order to correlate the PDI image with the instantaneous position of the airfoil during its rapid pitch-up motion.

A high speed movie camera with a controllable pulsed laser light source was identified for photographing the images in a single pitch-up cycle and is being procured for the research work by NASA ARC.

CONFERENCE PRESENTATIONS: M.S. Chandrasekhara, S. Ahmed, and L.W. Carr, "Schlieren Studies of Compressibility Effects on Dynamic Stall of Airfoils in Transient Pitching Motion," AIAA Paper No. 90-3038, 8th Applied Aerodynamics Conference, Portland, Oregon, August 20-22, 1990.

M.S. Chandrasekhara, L.W. Carr and S. Ahmet, "Comparison of the Pitch Rate History Effects on Dynamic Stall of Airfoils," NASA/AFOSR/ARO Workshop on Physics of Forced Unsteady Flow Separation, Moffett Field, CA, April 17-19, 1990.

L.W. Carr and M.S. Chandrasekhara, "A Study of Compressibility Effects on Dynamic Stall of Oscillating Airfoils," Invited Paper in the 1st International Conference of Computing Physics, Boulder, CO, June 11-15, 1990.

OTHER: M.S. Chandrasekhara and M.F. Platzer, "Compressibility Effects on Dynamic Stall of Airfoils Undergoing Rapid Ramp-Type Motion," Final Report Submitted to AFOSR, June 1990.

HIGH ALPHA HIGH SPEED AERODYNAMICS RESEARCH

M.S. Chandrasekhara, Adjunct Research Professor
M.F. Platzer, Professor of Aeronautics and Astronautics
Sponsor: Naval Air Systems Command
Funding: Naval Postgraduate School

OBJECTIVE: To study the unsteady aerodynamic effects on an airfoil undergoing rapid maneuver such as a rapid pitchup like that encountered in aircraft with supermaneuverability and agility capabilities.

SUMMARY: This project complements the research being carried out under funding from AFOSR. For the reporting period, the LDV data acquisition and processing software package was completed. Also, the necessary upgrading was done for it to be compatible with the latest version of the VMS operating system, (VMS 5.3-1) on the μVAX computer. Currently, additional graphics capabilities are being added to display the LDV results on IRIS Workstations. In view of the complementary nature of the AFOSR and this direct funded project, the results from the other study will enable achieving the goals of this project also.

CONFERENCE PRESENTATIONS: M.S. Chandrasekhara, S. Ahmed, and L.W. Carr, "Schlieren Studies of Compressibility Effects on Dynamic Stall of Airfoils in Transient Pitching Motion," AIAA Paper No. 90-3038, 8th Applied Aerodynamics Conference, Portland, Oregon, August 20-22, 1990.

M.S. Chandrasekhara, L.W. Carr and S. Ahmed, "Comparison of the Pitch Rate History Effects on Dynamic Stall of Airfoils," NASA/AFOSR/ARO Workshop on Physics of Forced Unsteady Flow Separation, Moffett Field, CA, April 17-19, 1990.

L.W. Carr and M.S. Chandrasekhara, "A Study of Compressibility Effects on Dynamic Stall of Oscillating Airfoils," Invited Paper in the 1st International Conference of Computing Physics, Boulder, CO, June 11-15, 1990.

ALTERNATE CONTROLLERS FOR THE F18 HIGH ANGLE OF ATTACK

Daniel J. Collins, Professor of Aeronautics and Astronautics
Sponsor: Naval Air Systems Command
Funding: Naval Air Systems Command

OBJECTIVE: The Naval Air Systems Command will be conducting high angle of attack investigations on the F18. Alternate controllers will be developed for the aircraft based on H infinity methods. In a recent research effort involving the X29 a decoupling controller resulted from an H infinity analysis. It is possible to have a direct implementation of modern control concepts such as direct pointing control. Some work will also be done on adaptive controllers based on neural networks. This effort has also been extended to all neural network investigations.

SUMMARY: High angle of attack data (to 35 degrees) has been requested on the F18. Work has not yet started on the H infinity controllers but some fundamental investigations have been completed on using neural networks as adaptive controllers. This work will need to be further extended before it can be applied to the F18. Considerable progress has been made in target identification.

THESES DIRECTED: Gerald A. Hartley, "F18 Robust Control Design Using H_2 and H_∞ Methods," Master of Science in Aeronautical Engineering, Naval Postgraduate School, Monterey, CA, September 1990.

William F. Lonchas, Jr., "Application of Neural Networks To The Identification of Intercepted Radar Signals (U)," Master of Science in Aeronautical Engineering, Naval Postgraduate School, Monterey, CA, June 1990.

John R. Loyer, "Automatic Classification of Isar Images Using Neural Networks," Aeronautical Engineering Degree, Naval Postgraduate School, Monterey, CA, September 1990.

J. Mark Tierney, "The Use of An Image Outlining Algorithm In The Classification of Inverse Synthetic Aperture Radar Images by Neural Networks, "Master of Science in Aeronautical Engineering, Naval Postgraduate School, Monterey, CA, December 1990.

PUBLICATIONS: T. McKannon, J. Loyer, L. Berman, D.J. Collins, "Automatic Classification of ISAR Images Using Neural Networks," Government Workshop on Neural Networks, NOSC, San Diego, CA, August 29-30, 1990.

W. Lonchas, D.J. Collins, "Identification of Elint Signals Using Neural Networks," Government Workshop on Neural Networks, NOSC, San Diego, CA, August 29-30, 1990.

See Control System Design of advanced Fighter Aircraft Project for a related publication.

A paper has been submitted to the 37th Annual Tri-Service Radar Symposium on ISAR Target Identification.

CONTROL SYSTEM DESIGN OF ADVANCED FIGHTER AIRCRAFT

Daniel J. Collins, Professor of Aeronautics and Astronautics
Sponsor: Naval Air Systems Command
Funding: Naval Postgraduate School

OBJECTIVE: The Naval Air Systems command is actively concerned with the development of advanced fighter concepts. Modern fighter aircraft involve multi-input multi-output (MIMO) control systems. Recent advances in stability robustness concepts and theory permit the development of MIMO controller that meet robustness and performance requirements for modern fighters. The X29 which has a large negative static stability margin is taken as a generic modern fighter and controllers using H_2 and H_∞ methods will be designed. In successive years nonlinear controllers and the application of adaptive neural networks to MIMO robust control systems will be investigated.

SUMMARY: Two and three input-output controllers have been designed for the longitudinal analog backup mode for a 14 state model of the X29 aircraft. These controllers were developed from the two Riccati solution for the H infinity problem. When the solution was not limited by actuator dynamics decoupled motion of the aircraft was strongly evident (i.e. direct pointing). Limiting the energy input to obtain realistic actuator performance resulted in degradation in the controller response.

THESIS DIRECTED: Donald L. Nedersky "The Use of Neural Networks in Adaptive Control," Master of Science in Aeronautical Engineering, September 1990.

PUBLICATIONS: W.L. Rogers, D.J. Collins, "X29 H_∞ Controller Synthesis," accepted for Publication by AIAA Journal of Guidance and Control and Dynamics.

R.W. Scott, D.J. Collins "Neural Network Adaptive Controllers," IJCNN, Vol. III, pp. 381-387, San Diego, CA, June 17-21, 1990.

MODELING THE IONOSPHERE FOR OVER THE HORIZON RADAR

Daniel J. Collins, Professor of Aeronautics and Astronautics
Sponsor: PEOSCS PMW-148, Captain Gordon L. Smith, USN

OBJECTIVE: The purpose of this investigation is to apply neural network technology to ionospheric modeling and to PMA operator training. A properly trained neural network could reduce the operator workload and increase the accuracy of ROTHR.

SUMMARY: Theoretical models of the ionosphere will be used to train neural networks based on the backpropagation algorithm. Testing of the neural networks will be done with actual data. Comparisons of the neural networks performance will be made with the present automatic selection system, with historical data and with expert selection of the ionospheric model.

PUBLICATIONS: This is a new investigation which will be funded in March 1991.

ACOUSTIC EMISSION MONITORING OF CRACK INITIATION IN 7075 ALUMINUM DURING FATIGUE SPECTRUM LOADING

Michael R. Gorman, Associate Professor of Aeronautics and Astronautics
Sponsor: Naval Air Systems Command, Patuxent River, Virginia

OBJECTIVE: This study will assess the potential for AE monitoring of fatigue crack initiation and propagation under E-2C Hawkeye spectrum loading conditions. Also, this will be the first measurement in aluminum of the recently discovered plate wave acoustic emission. Source characteristics measured by both the new and traditional monitoring techniques will be compared. Wave propagation characteristics of crack radiation (acoustic) allowed definite identification of crack growth despite noisy environment in 7075 T6. Specimens were stress analyzed and size of simulated fastener hole adjusted to match actual aircraft main beam section. Fatigue results showed that some aircraft could expect less than predicted fatigue life. Also acoustic emission could be monitored in critical areas to reduce costs.

THESIS DIRECTED: LT W.D. Smith, December 1990.

AN INVESTIGATION OF ACOUSTIC EMISSION PRODUCED BY CRACKING AND DEBONDING IN AEROSPACE ADHESIVES

Michael R. Gorman, Associate Professor of Aeronautics and Astronautics
Sponsor: NASA Langley Research Center, Hampton, Virginia

OBJECTIVE: Mode I fracture in aerospace adhesives will be induced in double cantilever beam specimens. The wave modes produced will be studied and classified according to plate theory. The results will provide insight into interpreting acoustic emission in composite material.

SUMMARY: New calibration plates were built and the effect of source orientation was studied. In-plane and out-of-plane source motion could be detected by monitoring the ratio of the amplitudes of the waves. A new theoretical attack on the acoustic emission problem yielded good agreement with experiment.

PUBLICATIONS: Gorman, M.R. and Prosser, W.H., "Application of Normal Mode Expansion to AE Waves in Finite Plates," submitted to Transactions of the ASME: Journal of Composite Mechanics (1990).

Prosser, W.H., Gorman, M.R. and Dorighi, J., "Extensional and Flexural Waves in a Thin-Walled Graphite/Epoxy Tube," submitted to the Journal of Composite Materials (1990).

Gorman, M.R. and Prosser, W.H., "AE Source Orientation by Plate Wave Analysis," forthcoming in the Journal of Acoustic Emission (1990).

DETECTION OF MATRIX CRACKING IN GRAPHITE/EPOXY BY AE AND UT

Michael R. Gorman, Associate Professor of Aeronautics and Astronautics
Sponsor: Astronautics Laboratory, Edwards, California

OBJECTIVE: It is the goal of this program to evaluate two nondestructive techniques, acoustic emission (AE) and ultrasonics (UT), on their ability to detect matrix cracking. This includes a comparison of current instrumentation, investigating physical fundamentals to improve understanding, and pointing out improvements for the future.

SUMMARY: Fundamental wave modes identified and transverse matrix cracking characterized. High pass filtering of flexural wave led to more accurate source (damage) location. Ultrasonic polar backscatter scan provided high resolution images of the cracks.

PUBLICATIONS: Gorman, M.R., "Plate Wave Acoustic Emission," Journal of the Acoustical Society of America, June 1991.

Gorman, M.R. and Ziola, S.M., "Plate Waves Produced by Transverse Matrix Cracking," Ultrasonics, March 1991.

Gorman, M.R., "Acoustic Emission in 2-D Carbon-Carbon Coupons Loaded in Tension," Journal of Composite Materials, March 1991.

Gorman, M.R., "Ultrasonic Polar Backscatter Imaging of Transverse Matrix Cracking," forthcoming in Journal of Composite Materials (1991).

Gorman, M.R. and Ziola, S.M. "Experimental Analysis of Dispersion Data for Plates," forthcoming in Journal of the Acoustical Society of America (1990).

Ziola, S.M. and Gorman, M.R., "Source Location in Thin Plates Using Crosscorrelation," forthcoming in the Journal of the Acoustical Society of America (1990).

Ziola, S.M. and Gorman, M.R., "Transverse Matrix Cracking and Longitudinal Splitting (in $[02, \pm 30]$s Graphite/Epoxy Tensile Coupons With Edge Notches as Determined by Acoustic Emission," Journal of Acoustic Emission, 8, No. 3 (1989).

INVESTIGATION INTO THE AERODYNAMICS OF AOR SHIPS

J.V. Healey, Associate Professor of Aeronautics and Astronautics
Sponsor: NAVAIR
Funding: Naval Postgraduate School

OBJECTIVE: Study the flow over the flight deck of an AOR ship with a view to the possible determination of the cause of blade strikes.

SUMMARY: In addition to the usual problems of restricted envelopes, the AOR class is particularly beset by blade strikes, mostly concerning the H-46 helicopter. This study was an attempt to determine the likely origin of the flows that cause the blade strikes. It examined the flow over the flight deck using smoke and helium bubbles and took 3-d hot-wire measurements at points in space around the periphery of the blade that is involved in most strikes.

Examination of individual videotape frames uncovered a new phenomenon; a recirculation that grew from a small size to one as large as the hangar, then collapsed to its original size and repeated the process over and over in an almost-periodic manner. The hot-wire measurements showed vertical updrafts near the edge of the deck that were as large as the relative wind/ship speed. Only a small portion of the blade tip locus was in reasonably uniform flow. The remainder was exposed to extreme levels of velocity and turbulence. To sum up, the AOR is a perfect example of how not to design a ship.

CONFERENCE PRESENTATION: Second Ship Aerodynamics Conference, D.C., September 1990.

THESIS DIRECTED: "A Study of the Airwake Aerodynamics Over the Flight-deck of an AOR Ship," M. Sc. Thesis by M.M. Rhodes, USN, September 1990.

OTHER: Paper in progress (likely completion date January 1991).

INVESTIGATION INTO THE TAILORING OF AIRWAKES

J.V. Healey, Associate Professor of Aeronautics and Astronautics

Sponsor: NAVAIR
Funding: Naval Postgraduate School

OBJECTIVE: Make a start at the tailoring of airwakes by studying the control of the flow over a backward facing step.

SUMMARY: Because of total disregard for aerodynamics in the design process, ships have severely limited safe operating envelopes. In addition many are beset by further problems involving blade strikes. The precise cause of the latter is unknown, but definitely related to extremely poor quality of the airflow near the flight deck. Controlling the sizes of the separation zones, so as to reduce or eliminate them, would be a significant contribution to the improvement of the flow. This suggests that the large numbers of ships in the fleet that will be around for twenty or more years could benefit from flow control or tailoring.

The simplest example of a separated flow is the classic 2-d problem of flow over a back-wards-facing step. The solution to this problem is well known, since it is used as a bench mark test for computation programs.

This problem was then an obvious choice for a first attempt at controlling the separation. It was approached on two fronts, one numerical and the other experimental. Because of a software problem and a computer that was very slow, only a small number of runs could be made so far. These analyzed the flow over the step when deflectors of varying size and porosity were placed near the top edge.

The predictions indicated that the deflectors could have a profound effect on the flow and that it was not always positive. A further experimental study was then conducted and some good correlation between the results was found. However, the numerical study needs extension to curved deflectors, and some previous predictions need to be re-examined, by doing further runs, to resolve a few anomalies.

CONFERENCE PRESENTATION: Second Ship Aerodynamics Conference, D.C., September 1990.

THESES DIRECTED: "Control of Flow Over a Backward Facing Step," M. Sc. Thesis by S. Wollman, USN, June 1990.

"Flow Modification Over a Backward Facing Step," M.S. Thesis, M. Narveson, USN, September 1990.

OTHER: Paper in progress (likely completion date February 1991).

SHIP AIRWAKE ANALYSIS: MAPPING THE WAKE OF A DD-963 ALONG SPECIFIC FLIGHTPATHS

J.V. Healey, Associate Professor of Aeronautics and Astronautics
Sponsor: NAVAIR
Funding: NAVAIR

OBJECTIVE: To map the airwake of the DD-963 along three specific helicopter flightpaths.

SUMMARY: These readings had been taken previously in the fall of 1989. In Spring 1990, I discovered that the software had a problem - the drivers sometimes switched channels while reading. In addition, the previous system did not have the capacity to resolve the low-frequency energy of the wake, necessitating further modifications. In July/August 1990, I personally balanced the hotwire bridges, calibrated the anemometer, re-took the data and processed it. The reduced data include the mean velocities, turbulence intensities, auto-correlations and spectra of the velocity distributions at seventeen points along three flightpaths. I then rearranged and packaged the data in ASCII form for the NATC, where it is now being set up as a database for their new simulation facility.

CONFERENCE PRESENTATIONS: Abstract was accepted for AIAA conference in Oregon in August 1990. The raw data was available but the processing software developed a bug that prevented presentation.

Second Ship Aerodynamic Conference, Washington, D.C., September 1990.

THESES DIRECTED: "Mapping the Airwake of a Model DD-963 Along Some Specific Helicopter Flight paths," M. S. Thesis, by G. Anderson, USN, December 1989.

OTHER: Paper submitted.

VORTEX RING MODELS OF HOVERING ROTORS

J.V. Healey Associate Professor of Aeronautics and Astronautics
Sponsor: NAVAIR
Funding: NAVAIR

OBJECTIVE: Find a relatively simple, but accurate method that predicts rotor inflows.

SUMMARY: Analysis of the performance of helicopters hovering in ground effect is an important part of the dynamic interface. After a review of models of inflow prediction, I proposed one based on the periodic generation of vortex rings. These rings are allowed to move about freely under their own self-induction and the induction of all other rings present. After a sufficiently low period from startup, I was able to compute the inflow into the rotor plane in various levels of ground effect. At one rotor radius or greater above the ground, the results agree well with experimental observations. I then went on to study the prediction of the model for a slowly descending rotor, when the well known vortex ring state occurs. In a certain descent speed range, it was found that the generated rings accumulate in a torus shaped region that grows with time.

CONFERENCE PRESENTATIONS: Eleventh National Congress of Applied Mechanics, University of Arizona, May 1990.

OTHER: Two papers submitted.

HIGH-ALPHA LOW-SPEED AIRCRAFT AERODYNAMICS RESEARCH

S.K. Hebbar, Adjunct Professor of Aeronautics and Astronautics
M.F. Platzer, Professor of Aeronautics and Astronautics
Sponsor: Naval Air Systems Command
Funding: Naval Postgraduate School

OBJECTIVE: This is a multi-year program aimed at establishing a state-of-the-art research center for high angle-of-attack, low-speed, steady/unsteady, aerodynamic studies at the Naval Postgraduate School.

SUMMARY: A low-speed experimental program on high-alpha, steady/unsteady aerodynamics was pursued in the low speed wind tunnel and the water tunnel of the Naval Postgraduate School, to carry out the investigations related to enhanced fighter maneuverability. During the period under review, the following major tasks were accomplished: (a) Investigation of the effects of pitch rate and sideslip on LEX vortices shed off a 2% F/A-18 aircraft model at high angles of attack in the NPS water tunnel, using dye injection to visualize vortex formation and bursting; (b) Fabrication of a 2.3% water tunnel model of a canard configured fighter aircraft similar to the Navy X-31A aircraft; (c) Initiation of flow visualization studies on the X-31A-Like model in the NPS water tunnel, using dye injection to determine the optimum canard location.

PUBLICATIONS: S.K. Hebbar and D.H. Leedy, "A Laser Sheet Flow Visualization and Aerodynamic Force Data Evaluation of a 3% YF-17 Fighter Aircraft Model at High Angles of Attack," Proc. AIAA 8th Applied Aerodynamics Conference, Vol. 1, pp. 452-462, Portland, Oregon, August 1990.

S.K. Hebbar and J.D. Sommers, "Wind Tunnel Studies of Support Strut Interference on a 3% YF-17 Fighter Aircraft Model at High Angles of Attack," Proc. AIAA 8th Applied Aerodynamics Conference, Vol. 2, pp. 598-607, Portland, Oregon, August 1990.

S.K. Hebbar, M.F. Platzer, S.N. Park, and O.V. Cavazos, "A Dynamic Flow Visualization Study of a Two Percent F/A-18 Fighter Aircraft Model at High Angles of Attack," Proc. NASA High Angle-of-Attack Technology Conference, Hampton, Virginia. Forthcoming.

CONFERENCE PRESENTATIONS: S.K. Hebbar and D.H. Leedy, "A Laser Sheet Flow Visualization and Aerodynamic Force Data Evaluation of a 3% YF-17 Fighter Aircraft Model at High Angles of Attack," AIAA 8th Applied Aerodynamics Conference, Portland, Oregon, August 20-22, 1990.

S.K. Hebbar and J.D. Sommers, "Wind Tunnel Studies of Support Strut Interference on a 3% YF-17 Fighter Aircraft Model at High Angles of Attack," AIAA 8th Applied Aerodynamics Conference, Portland, Oregon, August 20-22, 1990.

S.K. Hebbar, M.F. Platzer, S.N. Park, and O.V. Cavazos, "A Dynamic Flow Visualization Study of a Two-Percent F/A-18 Fighter Aircraft Model at High Angles of Attack," NASA High Angle-of-Attack Technology Conference, Hampton, Virginia, Oct. 30-Nov. 1, 1990.

THESES DIRECTED: O.V. Cavazos, LT, USN, "A Dynamic Flow Visualization Study of LEX Generated Vortices on a Scale Model of a F/A-18 Fighter Aircraft at High Angles of Attack," Master thesis, June 1990.

H.M. Kwon, Major, Korean Air Force, "Water Tunnel Flow Visualization Studies of a Canard-Configured X-31A-Like Fighter Aircraft Model," Master Thesis, September 1990.

OTHER: The water tunnel flow visualization results on LEX vortices of F/A-18 model will be presented in the AIAA 29th Aerospace Science Meeting, Reno, Nevada, January 7-10, 1991. The results of flow visualization studies on the X-31A-Like model will be presented in the AIAA 22nd Fluid Dynamics, Plasma Dynamics, and Lasers Conference, Honolulu, Hawaii, June 24-26, 1991. A NASA Technical Memorandum on support strut interference study of YF-17 model is in progress.

SMALL SCALE WIND TUNNEL INVESTIGATION OF F/A-18 AIRCRAFT AT HIGH ANGLES OF ATTACK

S.K. Hebbar, Adjunct Professor of Aeronautics and Astronautics
M.F. Platzer, Professor of Aeronautics and Astronautics
Sponsor: NASA Ames Research Center
Funding: NASA Ames Research Center (non-monetary support)

OBJECTIVE: This is the second project of a series of cooperative studies of F/A-18 between the Aero/Astro Department of the NPS and the Fixed Wing Aerodynamics Branch of NASA Ames Research Center and is aimed at studying the interaction between the F/A-18's LEX vortex and the vertical tail surfaces.

SUMMARY: A low speed investigation was conducted in the NPS wind tunnel to examine the vortex wake downstream of a three percent scale model of the YF-17 lightweight fighter prototype at high angles of attack. The study was in support of NASA Ames Research Center's upcoming investigation of a full scale F/A-18 in the NASA-Ames 80-ft x 120-ft wind tunnel as part of NASA's High Alpha Technology Program. During the period under review, the following major tasks were accomplished: (a) Smoke flow visualization to locate the downstream vortex wake; (b) Vortical flowfield surveys and power spectra measurements in the vortex wake using a cross hot-wire probe, with and without the LEX fence. The investigation has provided crucial input to the planned full scale F-18 tests at NASA Ames.

THESIS DIRECTED: W.D. Frink, Jr., Major, USA, "Hot-Wire Surveys in the Vortex Wake Downstream of a Three Percent Fighter Aircraft Model at High Angles of Attack," Master Thesis, December 1990.

OTHER: A summary report on the test results of this investigation has been submitted to NASA Project Director, NFAC F-18 High Alpha Test. A NASA Technical Memorandum on the earlier cooperative study on support strut interference of YF-17 model is in progress.

A FLIGHT TEST RESEARCH PROGRAM FOR JOINT-SERVICE UNMANNED AIR VEHICLES

R.M. Howard, Assistant Professor of Aeronautics and Astronautics
Sponsor: Naval Air Systems Command
Funding: Naval Postgraduate School

OBJECTIVE: To study advanced technologies for Unmanned Air Vehicles (UAVs), and to conduct flight research in the areas of performance and flying qualities for advanced UAVs.

SUMMARY: A program is ongoing for research flight testing of Unmanned Air Vehicles for joint-service applications, and for the development of stability augmentation systems for ducted-fan UAVs. Data have been gathered from flights of a half-scale UAV currently used in the fleet for addressing problems identified in the full-scale program. Flight instrumentation, such as a low-cost telemetry system for down-linking data, is still under development. A half-scale technology-demonstrator tilting-ducted-fan vertical-takeoff air vehicle, the Archytas TDF, has been designed and built this year for stability studies in vertical flight. Test flights are planned for FY91.

PUBLICATIONS: R.M. Howard, J.C. Tanner, and D.F. Lyons, "Flight Test Investigation of the Aerodynamic Performance of a Half-scale Unmanned Air Vehicle," Journal of Aircraft, forthcoming.

CONFERENCE PRESENTATIONS: R.M. Howard, D.F. Lyons, and J.C. Tanner, "Research Flight Test of a Scaled Unmanned Air Vehicle," Society of Flight Test Engineers 21st Annual Symposium, Garden Grove, CA, 6-10 August 1990.

R.M. Howard, "UAV Scaled Vehicle Flight Research in the Academic Environment," Association for Unmanned Vehicle Systems 17th Annual Technical Symposium, Dayton, OH, July 30 - August 1, 1990.

R.M. Howard, J.C. Tanner, D.F. Lyons, and D.E. Meeks, "Flight Test and Numerical Analysis of a Half-Scale Unmanned Air Vehicle," AIAA Paper 90-1260, AIAA 5th Biannual Flight Test Conference, Ontario, CA, May 22-24, 1990.

THESES DIRECTED: G.D. Black, LCDR, USN, "Aircraft Configuration Study for Experimental Two Place Aircraft and RPVs," Masters Thesis, March 1990.

B.M. Blanchette, LT, USN, "The Design and Construction of a Ship Launched VTOL Unmanned Air Vehicle," Masters Thesis, June 1990.

J.L. Ellwood, LCDR, USN, "Design and Construction of a Composite Airframe for UAV Research," Masters Thesis, June 1990.

J.D. Salmons, LT, USN, "Developmental Flight Testing of a Half Scale Unmanned Air Vehicle," Masters Thesis, September 1990.

ASYMMETRIC VORTEX STUDY OF A SHIP-LAUNCHED MISSILE AT HIGH ANGLES OF ATTACK

R.M. Howard, Assistant Professor of Aeronautics and Astronautics
Sponsor: Naval Postgraduate School
Funding: Naval Postgraduate School

OBJECTIVE: To experimentally study the mechanisms that affect the formation of asymmetric vortices for slender-nosed bodies such as fighter aircraft and missiles. This project is part of a continuing study of the Navy vertical launch missile at high angles of attack.

SUMMARY: A vertical launch capability for Navy surface-to-air missiles was recently introduced. Launching a missile vertically can expose it to significant crosswinds; also, angles of attack during push over maneuvers can reach up to 50 degrees (70 degrees for surface-to-surface missiles). Under these conditions, asymmetric vortices may form on the forebody causing unpredictable side forces and yawing moments. Wind tunnel studies of a 1/7-scale Navy surface-to-air missile have been conducted at high angles of attack to determine the effects of the low-aspect-ratio wings and of added nose strakes to the asymmetric vortices. The lee flow-field was found to be extremely dependent on the roll angle, as indicated by plots of crossflow velocities, pressure losses, and vorticity. The addition of nose strakes was found to have mixed results. The four-strake configuration almost completely eliminated the asymmetry, but the eight-strake configuration was ineffective at extremely high angles of attack.

PUBLICATIONS: R.M. Howard and A.S. Dunn, "Missile Loads at High Angles of Attack," Journal of Spacecraft and Rockets, forthcoming.

R.M. Howard, M.P. Rabang, M.-H. Lung, and J.A. Pinaire, "Effects of Freestream Turbulence on Asymmetric Vortex Formation over a Tangent-Ogive Forebody," AIAA Paper 91-0290, forthcoming.

CONFERENCE PRESENTATION: R.M. Howard, M.-H. Lung, J.J. Viniotis, D.A. Johnson, and J.A. Pinaire, "Wing Effects on Asymmetric Vortex Formation for a Ship-Launched Missile," AIAA Paper 90-2851, AIAA Atmospheric Flight Mechanics Conference, Portland, OR, 20-22 August 1990.

THESIS DIRECTED: C.-C. Yuan, LT, Taiwan ROC Navy, "The Effects of Forebody Strakes on Asymmetric Vortices on a Vertically Launched Missile," Masters Thesis, September 1990.

OTHER: Three manuscript submissions were made to the Journal of Spacecraft and Rockets, and one to a conference.

CANARD/WING INTERACTION FOR ENHANCED LIFT IN AIRCRAFT SUPERMANEUVERABILITY

R.M. Howard, Assistant Professor of Aeronautics and Astronautics
Sponsor: NAVAIR, Aircraft Division, Research and Technology
Funding: Naval Postgraduate School

OBJECTIVE: To study mechanisms for enhancing the lift of fighter aircraft for high-angle-of-attack maneuvering and control. This experimental study is part of a continuing project considering unsteady aerodynamics and vortical flows, and their application to supermaneuverability.

SUMMARY: The use of a canard, close coupled with a highly swept delta wing, has been known to provide lift enhancement at high angles of attack. The interaction of the canard leading-edge vortices with those of the wing tends to delay the wing vortex break-down, and to promote attached flow to much higher angles of attack. Though previous work has optimized the location of the canard with respect to the wing, no studies have fully characterized the optimum canard deflection angles required for maximum lift in this flight regime. Wind tunnel studies with a half model were performed to compare wing-body and canard-wing-body results for lift and lift-to-drag ratios up to angles of attack of 50 degrees and with canard deflections ranging from -25 to +25 degrees. Lift was enhanced up to 34% in the post-stall regime, after taking in account the increased lifting area. Though lift was significantly increased, lift-to-drag ratios were only slightly improved, indicating the high thrust levels required for post stall maneuvering.

PUBLICATIONS: D.K. Johnson, R.M. Howard, and P.N. Ilacqua, "Data Analysis for Unsteady Turbulence Measurements over Airfoils," Journal of Aircraft, forthcoming.

R.W. Renoud and R.M. Howard, "Airfoil Boundary Layer Response to an Unsteady Turbulent Flowfield," AIAA Journal, Vol. 28, No. 11, November 1990, pp. 1894-1900.

R.M. Howard and D.W. Kindelspire, "Freestream Turbulence Effects on Airfoil Boundary Layer Behavior at Low Reynolds Numbers," Journal of Aircraft, Vol. 27, No. 5, May 1990, pp. 468-470.

D.J. Gwilliam, Jr. and R.M. Howard, "Time-Dependent Post-Stall Airfoil Behavior in a Periodic Wake Flow," AIAA Paper 91-0431, forthcoming.

THESES DIRECTED: J.M. Kersh, Jr., LT, USN, "Lift Enhancement Using Close-Coupled Canard/Wing Vortex Inter-action," Masters Thesis, December 1990.

D.M. Lee, LT, USN, "Development of a 1/7th-Scale Fighter UAV for Flight Research," Masters Thesis, September 1990.

C.M. Cleaver, LCDR, USN, "Development of an Unmanned Air Research Vehicle for Super-maneuverability Studies," Masters Thesis, March 1990.

OTHER: One manuscript submission was made to the Journal of Aircraft.

ANALYSIS OF THICK COMPOSITE PLATES USING HIGHER-ORDER THREE-DIMENSIONAL FINITE ELEMENTS

R. Kolar, Assistant Professor of Aeronautics and Astronautics
Sponsor: Naval Postgraduate School
Funding: Naval Postgraduate School

OBJECTIVE: Investigate the effects of transverse shear in laminated composite plates and develop a finite element based on a higher order interpolation functions and three-dimensional nonlinear elasticity.

SUMMARY: Analysis of laminated composite plates assumes importance in the design of structural components where strength to weight and stiffness criterion are critical. For example, transverse strains are important in thick plates and accurate extension-twist coupling assumes major role in rotor blades. A finite element based on total Lagrangian formulation is presented and relevant element matrices are developed for a tri-quadratic finite element based on three-dimensional strain-displacement relations. Results are presented to validate the element, and show the response for different lay-ups and thickness ratios. Comparisons with classical plate theory and higher order shear deformation theory are given both isotropic and composite plates. An important result is that a single row of element in the direction of thickness seems to be adequate for any number of plies in modeling thick plates. The effects of mesh refinement and different integration schemes are provided.

CONFERENCE PRESENTATION: In preparation.

THESIS DIRECTED: Alon Yair, "Analysis of Thick Composite Plates Using Higher-order Three-Dimensional finite elements," Aeronautical Engineers Degree and M.S. in Aeronautics and Astronautics, December 1990.

OTHER: Paper in preparation.

COMBUSTION BEHAVIOR OF SOLID FUEL RAMJETS

D.W. Netzer, Professor of Aeronautics and Astronautics
T. Lee, Exchange Scientist
B. Natan, NRC Research Associate
Sponsor: Naval Weapons Center
Funding: Naval Postgraduate School

OBJECTIVE: To evaluate the effects of flowfield environment on the combustion of boron-carbide fuels. To determine the effects of temperature cycling on fuel properties and performance.

SUMMARY: The results of an earlier investigation on ignition and flammability characteristics have been accepted for publication in JPP. The results of another earlier investigation on regression rate/thrust modulation were submitted for publication.

A series of tests were conducted to determine the effects of temperature cycling on fuel properties and combustion. Differential scanning calorimetry and thermal gravimetric analysis together with measured performance showed that temperature cycling to 75°C had negligible effect on both metallized and non-metallized fuel.

An experimental investigation was conducted to explore the effects of equivalence ratio and air mass flux on the combustion efficiency and particle size distributions in a solid fuel ramjet using a fuel grain highly loaded with boron carbide. Particle distributions were measured at the grain exit and at the nozzle entrance using a Malvern 2600 HSD and at the nozzle throat using a collection probe. Combustion efficiency increased with increasing equivalence ratio (grain length) and decreasing air mass flux. In general, the particle distribution was trimodal or quadrimodal with mode peaks at approximately 4, 15, and 25 μm and possibly one at less than 2 μm. Probe measurements at the nozzle throat showed that considerable mass was contained in spherical particles smaller than 0.5 μm- outside the measurement range of the Malvern. The larger particles were the result of surface agglomeration, primarily within the recirculation region. Short grains that consisted primarily of the recirculation region produced larger particles and lower combustion efficiencies. Higher inlet air temperatures produced higher combustion efficiencies, apparently the result of enhanced combustion of the larger boron carbide particles that burn in a diffusion controlled regime.

PUBLICATIONS: A. Karadimitris, C. Scott III, D.W. Netzer and A. Gany, "Regression and Combustion Characteristics of Boron Containing Fuels for Solid Fuel Ramjets", Journal of Propulsion and Power, to appear in Vol. 6, No. 7, January-February 1991.

R.C. Wooldridge and D.W. Netzer, "Ignition and Flammability Characteristics of Solid Fuel Ramjets", accepted for publication, Journal of Propulsion and Power.

W.H. Campbell, Jr., B.N. Ko, S.R. Lowe and D.W. Netzer, "Solid Fuel Ramjet Fuel Regression Rate/Thrust Modula-tion", submitted to Journal of Propulsion and Power 1989, being revised.

C. Vaught, M. Witt, D. Netzer and A. Gany, "Investigation of Solid Fuel, Dual Mode Combustion Ramjets", submitted to Journal of Propulsion and Power in 1989, still in review process.

T. Lee and D.W. Netzer, "Temperature Effects on Solid Fuel Ramjet Fuel Properties and Combustion", submitted to Journal of Propulsion and Power, 1990.

CONFERENCE PRESENTATIONS: J. Nabity, T. Lee, B. Natan and D.W. Netzer, "Boron Fuel Combustion Behavior in Solid Fuel Ramjets", 27th JANNAF Combustion Subcommittee Meeting, Cheyenne, Wyoming, November 5-9, 1990.

D.W. Netzer, "NPS Missile Propulsion Research," Missile Propulsion Technology Exchange Meeting, Naval Weapons Center, China Lake, CA, February 28 - March 2, 1990.

NO_x EMISSION CONTROL FOR JET ENGINE TEST CELLS

D.W. Netzer, Professor of Aeronautics and Astronautics
Sponsor: Naval Air Propulsion Center
Funding: Naval Postgraduate School

OBJECTIVE: To evaluate alternative techniques for NO_x reduction in jet engine test cells.

SUMMARY: An experimental investigation was conducted to determine the feasibility of using catalytic reduction of NO_x emissions from a typical jet engine test cell environment. A modified T-63 combustor in combination with an instrumented 21 foot augmenter tube containing a vermiculite catalyst was used. Several methods for containing the vermiculite were attempted. Both vermiculite and vermiculite which had been coated with thiourea were used. Up to 19% reduction in NO_x concentrations was obtained using the vermiculite coated with thiourea, however the pressure loss across the catalyst bed was excessive. The techniques used proved unacceptable for gas turbine engine test cell applications. Tests were conducted using both Wynn's 15/590 and Catane TM (ferrocene) fuel supplements in order to determine their effectiveness for soot reduction and whether or not the exhaust plume temperature could be changed. For the test conditions utilized, the Wynn's additive was not effective in reducing the opacity of the exhaust plume nor for reducing the exhaust plume temperature. The Catane TM reduced the opacity by 6.2%, but had no significant effect on the plume temperature.

THESES DIRECTED: "An Experimental Investigation into NO_x Control of a Gas Turbine Combustor and Augmenter Tube Incorporating a Catalytic Reduction System", C.K. Behrens, M.S.A.E., March 1990.

"An Investigation into the Effects of Vermiculite on NO_x Reduction and Additives on Sooting and Exhaust Infrared Signature for a Gas Turbine Combustor", K. Engel, M.S.A.E., September 1990.

PARTICULATE BEHAVIOR IN EXHAUST NOZZLES AND PLUMES OF SOLID PROPELLANT ROCKET MOTORS

D.W. Netzer, Professor of Aeronautics and Astronautics
D. Laredo, NRC Research Associate
Sponsor: Air Force Astronautics Laboratory
Funding: Air Force Astronautics Laboratory

OBJECTIVE: Validate a combined light scattering/ particle collection probe for particle characterization in exhaust plumes. Use the probe to measure plume particle size distributions. Initiate investigation of relationship between particle characteristics and plume IR signature.

SUMMARY: A combined optical/collection probe was designed and utilized in initial plume particle size experiments using a Malvern Mastersizer. Changes in the specified absorption index over expected values for aluminum oxide (10^{-3}-10^{-7}) were found to have only very small effects upon the calculated particle size distribution. The specified real refractive index had increasing influence on the distribution for values less than the expected minimum value of 1.7.

Cold flow schlieren studies were made with varying motor pressures and nozzle pressure ratios, varying probe positions in the plume and varying ejector stagnation pressures. It was found that the probe internal flow remained supersonic for plume Mach numbers >1.3, with an approximately 20% loss in stagnation pressure from the probe tip to the measurement volume.

Several hot flow experiments were conducted with the probe located on the plume axis, at approximately ten exit diameters from the nozzle. A plume deflector was used to limit probe exposure to less than one second. Laser transmittance measurements showed that steady-state flow was attained in the measurement volume within approximately 25 msec from activation of the plume deflector. The initial data showed that most particles had diameters centered about one micron. However, a smaller number of particles were present which had diameters in the 4-10 micron range. Measurements made at the nozzle entrance showed that most particles were <2 microns, but with a mode peak between 8-10 microns. A new apparatus was completed which permits the Malvern instrument to be operated safely in the exhaust plume environment. Initial use of an IR imaging system was made to relate particle behavior to plume signature.

Propellants with aluminum loadings to 16% were also burned in a quench bomb to 750 psi. The collected residues were analyzed to obtain particle size distributions for comparison with the motor plume data.

PUBLICATIONS: E.D. Youngborg, T.E. Pruitt, M.J. Smith and D.W. Netzer, "Light-Diffraction Particle Size Measurements in Small Solid Propellant Rockets", Journal of Propulsion and Power, Vol. 26, No. 3, pp. 243-249, May-June 1990.

W.D. Brennan, D.L. Hovland and D.W. Netzer, "Measured Aluminum/Aluminum Oxide Particulate Behavior in a Subscale Solid Propellant Rocket Motor", submitted to Journal of Propulsion and Power in 1989, still in review process.

CONFERENCE PRESENTATIONS: D.W. Netzer, "Particle Sizing for Solid Propellant Motors: Motor, Nozzle, Plume", 1990 Meeting of the Mutual Weapons Development Data Exchange Agreement, WGIII, Plumes, Paris, France, November 26-27, 1990.

AIRCRAFT AND JET ENGINE UNSTEADY FLOW COMPUTATIONS

M.F. Platzer, Professor of Aeronautics and Astronautics
J.A. Ekaterinaris, Adjunct Professor of
Aeronautics and Astronautics
Sponsor: NAVAIR
Funding: NAVAIR

OBJECTIVE: Develop computational methods and obtain computational solutions for steady and unsteady flows over fighter aircraft configurations and helicopter blades at high angles of attack and through jet engine compressors and turbines.

SUMMARY: A numerical method for calculating unsteady two-dimensional incompressible viscous flow over airfoils was developed using the viscous-inviscid interaction approach. Furthermore, two- and three-dimensional compressible Navier-Stokes computations were completed to study the dynamic stall characteristics of oscillating and rapidly pitching airfoils as well as to study the vortical flow and the vortex breakdown characteristics on delta and double delta wings at high angles of attack.

PUBLICATIONS: L.W. Carr, M.F. Platzer, M.S. Chandrasekhara, J.A. Ekaterinaris, "Experimental and Computational Studies of Dynamic Stall," Proceedings of the Fourth Symposium on Numerical and Physical Aspects of Aerodynamic Flows, Springer Verlag, pp. 239-255, 1990.

J.A. Ekaterinaris and M.F. Platzer, "Investigation of Unsteady Flows over Airfoils," Proceedings of the IMACS First International Conference on Computational Physics, pp. 291-294, Boulder, Colorado, June 11-15, 1990.

CONFERENCE PRESENTATIONS: J.A.Ekaterinaris and L.B. Schiff, "Vortical Flows over Delta Wings and Numerical Prediction of Vortex Breakdown," AIAA Paper, No. 90-0012, 28th Aero-space Sciences Meeting, Reno, Nevada, January 8-11, 1990.

H.M. Jang, J.A. Ekaterinaris, M.F. Platzer, T. Cebeci, "Essential Ingredients for the Computation of Steady and Unsteady Blade Boundary Layers," ASME International Gas Turbine and Aero-Engine Congress, Brussels, Belgium, Paper No. 90-GT-160, June 1990 (to be published in ASME Journal of Turbomachinery).

J.A. Ekaterinaris and M.F. Platzer, "Computation of Unsteady Flows over Airfoils," NASA/AFOSR/ARO Workshop on Physics of Forced Unsteady Separation, NASA Ames Research Center, Moffett Field, California, April 17-19, 1990.

J.A. Ekaterinaris and L.B. Schiff, "Numerical Simulation of the Effects of Variation of Angle of Attack on Vortex Breakdown on Delta Wings," AIAA Paper No. 90-3000, AIAA 8th Applied Aerodynamics Conference, Portland, Oregon, August 20-22, 1990.

THESES DIRECTED: R.L. Coutley, "Numerical Studies of Compressible Flow Over a Double-Delta Wing at High Angles of Attack, Ae.E. Thesis, March 1990.

S.P. Grohsmeyer, "Numerical Investigation of Leading Edge Geometry on Dynamic Stall of Airfoils," Ae.E. Thesis, September 1990.

UNSTEADY HEAT TRANSFER ON TURBINE BLADES

M.F. Platzer, Professor of Aeronautics and Astronautics
J.A. Ekaterinaris, Adjunct Professor of
Aeronautics and Astronautics
Sponsor: NASA Lewis Research Center
Funding: NASA Lewis Research Center

OBJECTIVE: Develop a general method for the prediction of heat transfer on turbine blades subjected to flow unsteadiness.

SUMMARY: A general method was developed for calculating the unsteady heat transfer on turbine blades. It is based on the numerical solution of the unsteady boundary layer equations for laminar, transitional, and turbulent flows in combination with an inviscid panel code for airfoils in general unsteady motion. Heat transfer rates were calculated for airfoils subjected to a ramp change in angle of attack. Furthermore, a compressible unsteady Navier-Stokes solver was applied to this problem and heat transfer rates were computed for representative cases.

PUBLICATIONS: T. Cebeci, R.J. Simoneau, M.F. Platzer, "Unsteady Heat Transfer on Turbine Blades," Journal of Thermophysics and Heat Transfer, Vol. 4, No. 1, pp. 47-52, January 1990.

RUDDER ROLL STABILIZATION TO IMPROVE SHIP SEAKEEPING

L.V. Schmidt, Professor of Aeronautics and Astronautics
Sponsor: Office of Naval Technology
Funding: Naval Postgraduate School

OBJECTIVE: Improve ship sea-keeping by active control means for the purpose of increasing ship operational effectiveness as might be required for encounters in high sea states of Northern Latitudes.

SUMMARY: The principles of active control using rudder roll stabilization (RRS) were successfully demonstrated at sea in September 1987 by over 200 hours of active digital control of a Spruance class destroyer's rudder system using elementary state variable feedback concepts. This U.S. Navy first, digital control of a ship's rudder system, resulted in 40 percent reductions of roll motion in operating conditions up to sea state 5. Alternatively, roll motion reductions of this magnitude may be translated as an increase in operational effectiveness by approximately one sea state, a cost effective option for Navy consideration. NPS sponsored research work (starting in FY 1990) has resulted in: (a) Identification of an adaptive (digital) filter concept that effectively line arises the current, irregular, nonlinear behavior of the steering machinery as found on the Spruance and Ticonderoga ship classes; (b) Transfer to the NPS of a digital data base representing over 200 hours of sea trials on the USS Cushing (DD-985) for subsequent detailed analyses.

PUBLICATIONS: Paper in progress on the application of an adaptive digital filter to ship steering machinery.

CONFERENCE PRESENTATIONS: Not applicable in CY 1990.

THESIS DIRECTED: Not applicable. However, two (2) M.E. Department students are currently conducting M.S. level thesis research on the recently acquired ship dynamic data base.

WING ROCK DUE TO INERTIAL COUPLING

L.V. Schmidt, Professor of Aeronautics and Astronautics
Sponsor: Naval Postgraduate School
Funding: Naval Postgraduate School

OBJECTIVE: Identify features of aircraft nonlinear flight mechanics which may contribute to limit-cycle motions called "wing rock".

SUMMARY: The term "wing rock" is used to describe the rocking motion of an aircraft about its longitudinal axis. Numerous high performance aircraft (e.g., A-4, T-38, F-4, F-5, F-14, F-18, AV-8B, etc.) have shown this trait, usually when in flight near to stall onset. A candidate mechanism for the wing-rock limit cycle is the inertial coupling between an unstable literal-directional (Dutch Roll) mode with a stable longitudinal (Short Period) mode. Coupling is provided by the nonlinear interactions of inertially related terms in the complete set of motion equations. Dependence of the wing-rock amplitude upon the ratio of longitudinal to lateral-directional characteristic frequencies has been demonstrated. Further studies are in progress using F-14 aircraft reference data for reasons of Navy relevance. F-14 simulator data has been obtained from Grumman Aircraft Company (December 1990).

The F-14 aircraft is known to exhibit wing rock at angles of attack above 20 degrees, which effect impacts adversely upon the operational effectiveness of the aircraft during a critical phase in one-on-one combat.

PUBLICATIONS: L.V. Schmidt, "Wing Rock Due to Inertial Coupling," Proceedings of Symposium on Fluid Dynamics held at Calif. Inst. of Tech. (August 1989), World Scientific Publishing Co., August 1990.

CONFERENCE PRESENTATIONS: L.V. Schmidt and LT S.R. Wright (USN), "Aircraft Wing Rock by Inertial Coupling," submitted (December 1990) to the AIAA Atmospheric Flight Mechanics Symposium, which is to be held at New Orleans, August 1991.

THESIS DIRECTED: Not applicable. One student, LT S.R. Wright (USN) is currently completing Ae.E. thesis studies.

FAN-SHOCK BOUNDARY LAYER INTERACTION

R.P. Shreeve, Professor of Aeronautics and Astronautics
Sponsor: Naval Air Systems Command
Funding: Naval Air Systems Command
AIR-931E

OBJECTIVE: To explore the effectiveness of passive vortex generators in reducing losses due to passage shock boundary layer interaction in a simulated fan blade passage.

SUMMARY: Losses in advanced bypass fan designs are measured to be higher than can be explained by the summation of planar shock and viscous flow components, and are likely to be due to local shock induced boundary layer separation. The use of low profile vortex generators and an adaptation of vortex generator jets to suppress or reduce the amount of separation is being examined experimentally in a two dimensional cascade model of two adjacent blade passages. The simulated relative flow Mach number is 1.4. The tunnel installation was completed, the air supply and blowdown controls were verified and the manufacture of the model initiated. Measurements will include Schlieren and shadowgraph visualization, surface static pressure distributions and passage outlet flow surveys.

AGING CHARACTERIZATION OF COMPOSITE MATERIALS

Edward M. Wu, Professor of Aeronautics and Astronautics
Sponsor: Naval Surface Warfare Center
Funding: Naval Postgraduate School

OBJECTIVE: To formulate a characterization methodology for time and stress dependent strength loss of composite materials and to establish the necessary facilities for data generation for the composite used in the Trident D-5 motor case.

SUMMARY: Analytical partitioning of the strength degradation into fiber, matrix and interfaced controlled mechanisms, experimental correlation of the statistical strength and life data for the fiber to those for the composite.

Experimental facilities for fiber life testing using infrared LED switch and computer controlled data acquisition operational. Constant stress life tests for 512 samples being initiated. Probability model formulated to predict composite strength degradation due to interface weakening.

DEPARTMENT OF ADMINISTRATIVE SCIENCES

DEPARTMENT OF ADMINISTRATIVE SCIENCES

The Department of Administrative Sciences 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 public sector 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; logistics and transportation; computer and information systems; financial management; manpower, personnel, and training analysis; and policy analysis, management, and communications.

Acquisition

Professors D. Boger and S. Liao continued a multi-year, direct funded project under the sponsorship of the Naval Air Systems Command, Cost Analysis Division. The objective of the project is to develop parametric cost estimation models for aircraft modification (MOD) programs. In this phase, data on twelve MOD programs were analyzed. Also supported by NAVSEA's Cost Analysis Division, **Professor Doug Moses** began a direct funded project that attempts to identify and measure the factors expected to influence year-to-year changes in the unit cost of weapons systems.

Logistics and Transportation

Research in logistics focuses on providing support to the Navy Supply Corp in inventory modeling. **Professor A. McMasters** continued his long-term research effort to develop improved wholesale inventory models under the sponsorship of Navy Fleet Material support Office. He also continued a second direct funded project to develop expert systems to facilitate decision making by inventory managers at Navy Stock Points, concentrating on hazardous materials. **Professor D. Trietsch** continued his work for the Naval Sea Systems Command prioritizing set-up reduction times in shipyard repair operations. He also started a project that will implement TQM methods in Naval Repair Facilities. **Professor T. Moore** started a project for the Army Combat Developments Experimentation Center that attempts to implement a screening procedure to perform low-cost evaluations of the resiliency in specific Table of Organization and Equipment (TOE) designs.

Computers, Information and Communication Systems

The NPS Research Council supported the research efforts of several faculty members in the IS area. **Professor M. Zviran** completed a project that utilized Multiple Criteria Analysis to evaluate the selection of computer hardware, and continued a second project on the characteristics of user passwords and evaluation of alternative authentication techniques. He and **Professor W. Haga** started a new project, sponsored by the Space and Naval Warfare Systems Command, on evaluating the characteristics of alternative data integrity models. **Professor K. Sengupta** completed a direct funded project aimed at developing design principles for incorporating feedback in group decision support systems. He started a second project aimed at investigating the feasibility of constructing interactive knowledge acquisition mechanisms for building expert systems. **Professor T. Abdel-Hamid** continued a project on software cost and schedule estimation. **Professor M. Suh** started a project on the optimal configuration of a distributed database system. **Professor N. Schneidewind** received funding from Navy Surface Warfare Center to continue his research on enhancing his software reliability model. **Professor D. Dolk** continued a project developing a decision support system for emergency telecommunications. **Professor Haga and D. Henderson** are reviewing economic techniques used to evaluate ADP investments by the Navy.

Finally, **Professor M. Kamel** started a project to establish a multi-level framework for investigating the interoperability and integration of distributed databases in heterogeneous environments.

Financial Management

Professors D. Dolk and K. Euske collaborated on a direct funded project sponsored by Naval Supply Systems Command to analyze the management control and information systems that supports the RAMP project, which is concerned with developing highly automated manufacturing facilities using advance robotics. **Professors Euske and L. Jones** collaborated on a study to analyze the impact of budget issues on squadron operations of the Pacific Fleet Naval Air Forces. **Professors Euske, Jones, and J. McCaffery** continued an on-going project analyzing the effect of the resource allocation process on CINCPACFLT. **Professor L. Jones** also began a project sponsored by NAVCOMPT on the Navy budget justification process and the impact of Navy budget reductions. **Professor J. San Miguel** started a project with direct funding on unit costing of defense activities.

Manpower, Personnel, and Training Analysis

An umbrella reimbursable research project sponsored by the Deputy Chief of Naval Operations (Manpower) supported several MPT faculty members: **Professor A. Crawford** analyzed attrition policy at Navy A-Schools; **Professor L. Solnick** developed a prototype methodology for validating OPNAV manpower forecasting models; **Professor S. Mehay** analyzed naval officer accession programs and CRNC's officer goaling models; and **Professor D. Henderson** completed work on the impact of national service on the Navy. A second umbrella project funded by the Naval Avionics Center (NAC) supported several manpower-related efforts. **Professor K. Thomas and B. Roberts** completed an analysis of the career orientation and job satisfaction of scientists and engineers employed at NAC. **Professor L. Solnick** continued the development of a longitudinal personnel data base of NAC employees. This data base is to be used in several future sub-projects. **Professor M. Eitelberg** continued evaluating the effects of several different personnel procurement systems on the quality of defense manpower for the Office of the Assistant Secretary of Defense (FM&P). He is also examining the military selection and classification process for OSD.

The Army Recruiting Command also sponsored several MPT faculty. **Professors M. Eitelberg and S. Mehay** continued the project on recruiting in the 21st century. **Professors G. Thomas and L. Gorman** collaborated with K. Kocher and Professor S. Sohn from the OR Department on separate projects covering a wide range of recruiting-related issues, including a model of the commute behavior of Army Reservists, USAR Nurse retention and attrition, and the development of projections of the qualified military available and interested population in local areas in future years.

Policy Analysis, Management and Communication

Professor N. Roberts continued to work with Professor J. Tritten of the NSA Department on strategic management for the Department of Defense. This project has several sponsors within the Office of the Secretary of Defense. **Professor G. Fann-Thomas** started a direct funded project to examine communication strategies used for implementing organizational change. **Professor W. Gates, K. Terasawa and L. Jones** collaborated with Professors M Sovereign in the OR Department and E. Laurance in NSA on reimbursable research for the Chief of Staff of the Army. The project investigated various issues associated with burden sharing with U.S. allies.

Professor J. Suchan continued a project for the Personnel Security Research Center that assesses the impact of field agent's report writing on the adjudication process.

RELIABILITY GOAL DETERMINATION FOR MAJOR CALIBER AMMUNITION

Michael Bailey, Professor of Administrative Sciences
Keebom Kang, Professor of Administrative Sciences
Sponsor: Naval Weapon Support Center
Funding: Naval Weapon Support Center

OBJECTIVE: The objective of this research is to establish reliability performance measures for major caliber ammunition used in Naval Gunfire Support (NGFS) system, and to specify minimum reliability goals. A systematic method for evaluating the effectiveness of ammunition has been studied and a simulation model has been developed to estimate the relationship between the reliability measure and the effectiveness of NGFS. The results of this research will be used for procurement and surveillance of ammunition.

COMPUTER-AIDED MODEL CONSTRUCTION

Hemant K. Bhargava, Professor of Administrative Sciences
Funding: Naval Postgraduate School

OBJECTIVE: The objectives of this project are to investigate and develop methods for the representation and documentation of assumptions and rationales that justify the presence and mathematical form of the elements of a model version, and to facilitate the derivation, and efficient storage of new versions that correctly reflects changes, and the propagated effects of these changes, to elements of an existing version.

SUMMARY: This proposal covers research involving the analysis, design and development of computer systems to assist human modelers in the formulation of mathematical models. A variety of systems exist today to speedily solve sophisticated management science models. Yet few potential consumers of such models actually know how to formulate them. Our research aims to extend this work by studying the cognitive process underlying model formulation and by using the theory of defeasible reasoning to address the shortcomings of some of the existing approaches. Modeling is an iterative process, and conclusions arrived at some iteration are often defeated in later iterations, in the face of new information. Thus several model versions are developed for the same problem. My research is specifically concerned with issues arising from this iterative refinement. I am investigating methods for providing existing model management systems the capabilities to represent and retrieve rationales and justifications behind modeling decisions, examine, using modeling principles and knowledge about the application domain, whether proposed revisions to certain components of a model are consistent with the rest of the model, propagate the effects of changes to model components throughout the model, and manage the creation, and integration, of multiple and alternative versions of a model.

PUBLICATIONS: Hemant K. Bhargava and Ramayya Krishnan, "Computer-aided Model Construction," to appear as a chapter in a book on Model Management (R.W. Blanning, and A. Whinston, eds.).

FLEET MIX PLANNING IN THE U.S. COAST GUARD

Hemant K. Bhargava, Professor of Administrative Sciences
Sponsor: U.S. Coast Guard Patrol Boats Acquisition Group
Funding: U.S. Coast Guard Patrol Boats Acquisition Group

OBJECTIVE: The objectives of this project are: (a) to explore and examine systematic ways to address the problem of fleet mix planning in the U.S. Coast Guard; and (b) to design and implement an analytic method for fleet mix planning in a system to support decision making by the Patrol Boats Acquisition Office on the acquisition of about 100 patrol boats.

SUMMARY: Fleet mix planning involves determining the "optimal" configuration of a fleet, in terms of the type of assets within the fleet and the numbers of each type, that an organization must hold in order to optimize its defined objective satisfying the various environmental and organizational constraints. As a special case of this problem, the Patrol Boats Acquisition Office in the Coast Guard is tasked with selecting an ideal mix of about 100 boats to acquire. Patrol boats are primarily concerned with Search and Rescue, and Law Enforcement missions, but the demand for these missions over the boats' life span (about 30 years) is both uncertain and ambiguous. Further, it is hard to determine expected performance of such ships in terms of their mission requirements (i.e.,number of lives saved, number of smuggling ships interdicted, etc.). A number of constraints such as cost constraints, and constraints of physical realities (e.g., availability of ports for certain kinds of ships) must be satisfied by the selected fleet mix. I am examining ways to address these problems, structure them to a reasonable extent, and develop models for analyzing and solving this problem. These methods and models will be implemented in a decision support system to be used by the group. Experiments and experience in using this system will give us ideas on addressing the general fleet mix planning problem.

OTHER: H.K. Bhargava, Steven O. Kimbrough, and Clark Pritchett, "A Balance Sheet Approach for Fleet Mix Planning," working paper, 1990.

REPRESENTATION AND MANIPULATION OF SETS IN MATHEMATICAL MODELING

Hemant K. Bhargava, Professor of Administrative Sciences
Funding: Naval Postgraduate School

OBJECTIVE: The objective of this project was to examine methods for the representation and manipulation of sets in computer-based mathematical modeling systems, and more generally, to examine the representation and manipulation of mathematical models in such systems.

SUMMARY: This project involves the representation and manipulation of sets in mathematical modeling and model management languages and systems. While sets occur in all kinds of mathematical formulations of models, the state of the art in computer representation and manipulation of sets is far behind that employed by humans for a long time. In my research, I have proposed new methods for non-enumerative representations for sets in mathematical modeling languages. The research was conducted primarily in the context of such a system, TEFA, which is currently in use at the U.S. Coast Guard. The representations developed are now employed in TEFA. The larger objective of this project was in the area of modeling systems, and a new technique for building modeling systems, called embedded languages was developed. This technique provides a systematic and rigorous way to integrate multiple languages for mathematical modeling, including one concerned with the representation of sets, in to a single embedding language.

PUBLICATIONS: H.K. Bhargava, and S.O. Kimbrough, "Model Management via Embedded Languages," under review, Decision Support Systems, special issue on Model Management.

OTHER: A model management system, TEFA, discussed above in SUMMARY.

IMPACT OF COMPETITION ON WEAPON SYSTEM ACQUISITION

D.C. Boger, Associate Professor of Economics
Sponsor: Naval Center for Cost Analysis
Funding: Naval Center for Cost Analysis

OBJECTIVE: The goal of this project was to publish a monograph, edited by the PI, containing relevant work on competition in weapon system acquisition.

SUMMARY: This project revolved around the research, assembly, editing, and production of a monograph from all papers concerning the impact of competition on weapon system acquisition which were presented at several sessions of the 23rd Annual DoD Cost Analysis Symposium held in September 1989. The monograph has been completed.

PUBLICATION: D.C. Boger and D.A. Nussbaum, "Competition in Weapon Systems Acquisition: Cost Analyses of Some Issues," NPS Technical Report, NPS-54-90-021, September 1990.

DATA AND METHODS FOR ESTIMATING COSTS OF AIRCRAFT MODIFICATIONS AND DERIVATIVES

D.C. Boger, Associate Professor of Economics
S.S. Liao, Professor of Accounting
Sponsor: Naval Air Systems Command, Cost Analysis Division
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project is to develop databases and parametric cost estimating models for aircraft modifications and derivatives.

SUMMARY: In the prior reporting period of this multi-year project, a survey of data availability and the formulation of a cost element structure were completed, with major data acquisition begun. During this reporting period, data on the following six aircraft modification or derivative programs were obtained via student and PI visits to contractor sites: F-15 Multi Stage Improvement Program, B-52 Offensive Avionics System/Cruise Missile Integration, B-1B Offensive Avionics System, B-52 Strategic Radar, KC-135R Re-engine Program, and EF-111A Tactical Jamming System. Methods development and final database development will occur in later periods.

PUBLICATIONS: D.C. Boger and S.S. Liao, "Aircraft Modifications Cost Analysis, Volume 1: Overview of the Study," NPS Technical Report, NPS-54-90-005, February 1990.

D.C. Boger and S.S. Liao, "Aircraft Modifications Cost Analysis, Volume 2: C-141B Stretch Program," NPS Technical Report, NPS-54-90-009PR, April 1990.

D.C. Boger and S.S. Liao, "Aircraft Modifications Cost Analysis, Volume 3: C-5A Wing Modification Program," NPS Technical Report, NPS-54-90-018PR, July 1990.

THESES DIRECTED: S.A. Foglio, Capt., USMC, M.W. Malcolm, LT, USN, J.F. Williams, Jr., Capt. USMC, "Database Assimilation and Analysis for Cost Estimation of Aircraft Modification Programs," Master's Thesis, June 1990.

P. Coffey, Capt., USMC, "Parametric Data Collection and Analysis for the KCR-135 and the B-52 Modification Programs," Master's Thesis, December 1990.

R.E. Johnson, LT, USN, "Data Analysis for Cost Estimation Model of Aircraft Modification Programs," Master's Thesis, December 1990.

ANALYSIS OF THE MANAGEMENT CONTROL AND INFORMATION SYSTEM IMPLICATIONS OF RAMP

D.R. Dolk, Associate Professor of Information of Systems
K.J. Euske, Associate Professor of Accounting
Sponsor: Commander, Naval Supply Systems Command
Mr. Roberts Houts (NAVSUP PML 5505)

OBJECTIVE: The specific goals of this research project are to: (1) Analyze the current management control and information systems currently in place to support the RAMP project; (2) Recommend adjustments to those systems such that the output of those systems will provide information that accurately appraises the RAMP project; (3) Ensure that the systems provide valid and reliable information regarding the cost, effectiveness, and efficiency of the RAMP project. The project is still in process. We anticipate to continue this project through September 1991.

SUMMARY: The RAMP Project within the Navy is concerned with developing highly automated manufacturing facilities using advanced robotics. A prototype facility currently exists. A full scale operating facility is being constructed. Information and accounting systems in the U.S., both in the private and public sectors, are not designed to support this technology. This project is designed to systematically analyze the information needs for efficient and effective resource allocation and control of such facilities. The accounting and reporting requirements for the system have been developed. Compatibility of these requirements with existing Navy systems have been analyzed. Currently, operational specifications are being developed for the system. Issues of system replication and technology transfer to the other services and the defense industrial base are developing issues in the project. Integration of the CIM activity based accounting system with the conventional accounting system at Naval Avionics Center has begun.

A DECISION SUPPORT SYSTEM FOR EMERGENCY TELECOMMUNICATIONS

D.R. Dolk, Associate Professor of Information Systems
Sponsor: National Communications System
Mr. Norman Douglas

OBJECTIVE: This project is involved with the development of the TEDSS (Telecommunications Emergency Decision Support System) for tracking and allocating telecommunications resources during a national emergency. It is an ongoing effort in which NPS has participated the past five years. NPS' involvement this past year was threefold: (1) Serve as an internal validation and verification agent to NCS for the design of the overall system; (2) Develop a suite of tutorials to educate potential users in how to operate the TEDSS. The first stage in this task is the development of the EPISODE system to support participants in simulated exercises of national emergencies; (3) Investigate the feasibility of incorporating voice recognition technology into the TEDSS architecture.

SUMMARY: We continue to provide technology assessment reports upon sponsor demand. For example, delivered a report on the feasibility of using CD-ROM/WORM optical technology to store vendor software and alleviate acute disk storage problems with TEDSS. The suite of tutorials and EPISODE simulation have been contracted to Rolands and Associates. A functional design for the EPISODE simulation tutorial has been developed and an early prototype demonstrated to the sponsor. Work is underway to incorporate sponsor feedback on potential improvements to EPISODE. The analysis of voice recognition is also currently in progress. State-of-the-art voice recognition hardware was purchased in the form of the Dragon Dictate System and investigation is being conducted to see whether it can be fitted into the TEDSS architecture.

THE EFFECTS OF DIFFERENT PERSONNEL PROCUREMENT SYSTEMS ON DEFENSE MANPOWER QUALITY

Mark J. Eitelberg, Associate Professor,
Sponsor: Office of the Assistant Secretary of Defense,
(Force Management and Personnel),
Directorate of Accession Policy

OBJECTIVE: To develop several models of conscription and national service, for use in a policy analysis that would weigh the costs and benefits of alternatives to all volunteer recruiting--with primary emphasis placed on the strengths and weaknesses of selected options in achieving manpower quality objectives under a variety of circumstances.

SUMMARY: Research on the project was extended through fiscal 1991, and the focus shifted to the effects of defense manpower policies (not limited to procurement alone) on the quality of the force. This change was made because recent international events have greatly diminished the likelihood of large-scale experimentation with new forms of personnel procurement. Three research papers were prepared during the reporting period. The first paper examined the military's historical use of "marginal man," or persons on the fringe of qualifying for service, and the prospects for accepting low-aptitude men and women in the years ahead. A second study looked at the issue of assigning women to combat occupations. Finally, a study was conducted of selection and classification policies affecting women and minorities.

CONFERENCE PRESENTATIONS: M. J. Eitelberg, "Your Mother Wears Combat Boots...But Should She Pack a Gun?", 98th Annual Meeting of the American Psychological Association, August 1990.

M. J. Eitelberg, "Marginal Man and the Military: Past, Present, and Prospects," 98th Annual Meeting of the American Psychological Association, August 1990.

M. J. Eitelberg, "Women and Minorities in Military Aviation Maintenance," Fourth Federal Aviation Administration Meeting on Human Factors Issues in Aircraft Maintenance and Inspection, December 1990.

M. J. Eitelberg, "Manpower Policy Research in the U.S. Military," a collection of six papers presented at the Annual Meeting of The Technical Cooperation Program (TTCP), Christchurch, New Zealand, October 1990.

THESES DIRECTED: M. Foster, Lt., USN, "An Analysis of the Relative Productivity of Officers from Different Accession Sources," Master's Thesis, June 1990.

R. J. Boisvert, Capt., and J. C. Sumner, Capt., USMC, "Retention in the Marine Corps: The Importance of Quality in the Enlisted Force," Master's Thesis, December 1990.

R. Yardley, Lt., USN, "An Analysis of the Effect of ASVAB Waivers on A School Attrition," Master's Thesis, December 1990.

HUMAN RESOURCE DEVELOPMENT IN THE DEPARTMENT OF DEFENSE: THE ROLE OF MILITARY SELECTION AND CLASSIFICATION

Mark J. Eitelberg, Associate Professor of Administrative Sciences
Sponsor: Accession Policy Directorate,
Office of the Assistant Secretary of Defense,
(Force Management and Personnel)
Funding: U.S. Military Entrance Processing Command

OBJECTIVE: To review the historical role and accomplishments of the military in human resource development and to explore several additional contributions that can be made through the military's selection and classification system.

SUMMARY: The first phase of work on this project involved the preparation of a report to Congress. The report looked at the historical contributions of the Department of Defense with respect to human resource development. It also examined the "transferability" of education, training, and occupational skills from the military to the civilian sector. In addition, the report reviewed the initial results of two related projects: an experiment in pre-enlistment skill training (at the University of Mississippi) and a longitudinal study of men who had entered the military with a criminal record (the so-termed "preservice offender").

PUBLICATION: Department of Defense, Human Resource Development in the Department of Defense: Issues and Initiatives for Military Selection and Classification, A report to the House and Senate Committees on Armed Services (Washington, D.C.: Office of the Assistant Secretary of Defense [Force Management and Personnel], July 1990).

THESES DIRECTED: J. T. Jackson, CDR, and M.R. Maddox, Lt., USN, "The Role of the Broadened Opportunity for Officer Selection and Training (Boost) Program in Supporting the Navy's Minority Accession Policies," Master's Thesis, December 1990.

V. Moule, LCDR, USN, "Lost Opportunity : The High-Quality, Smaller Military Force Structure of the 1990s and Its Effect on the Nation's Disadvantaged Youth," Master's Thesis, December 1990.

A. Abalos, Lt., USN, "English Language Training for Navy Enlisted Personnel Who Speak English as a Second Language," Master's Thesis, December 1990.

BUDGETING AND ACCOUNTING AT THE CINCPACFLT LEVEL

K.J. Euske, Associate Professor of Accounting
L.R. Jones, Professor of Financial Management
J.L. McCaffery, Professor of Financial Management
Sponsor: Commander in Chief
United States Pacific Fleet

OBJECTIVE: This is an ongoing project to investigate the resource allocation process in the Department of the Navy taking the CINCPACFLT level clemency as a focal point.

SUMMARY: The objective of this project is to document accounting information generation and use in CINCPACFLT and to analyze the effect of the Goldwater-Nichols Act and Department of the Navy budget reduction upon POM and budget preparation at CINCPACFLT. The project also included an analysis of the impact of U. S. - Japanese defense burden sharing on the DON and DOD budgets. Continuing the work initiated last year, documentation and analysis of the POM process at CINCPACFLT and analysis of the accounting and control system has been accomplished. The teaching case developed last year is being revised to increase its value as a classroom tool. An additional teaching case dealing with the issue of compatibility of the accounting and operating system is in the process of final revision. A draft technical report on CINCPACFLT budget review processes and decisions patterns has been prepared and will be released in 1991 after review and comment from the research sponsor (CINCPACFLT). The knowledge gained from this project was central to the revisions of MN 4161, MN 3172 and MN 4302.

OTHER: K. J. Euske and R. Osterhoudt, U. S. Navy medical Financial Controls (UVA-C-2063).

CONTROL OF ILL-DEFINED TECHNOLOGY AND OUTPUT: A FIELD STUDY

K.J. Euske, Associate Professor of Accounting
Sponsor: Harvard University

OBJECTIVE: The purpose of this study was to identify characteristics of evaluation systems that operate in environments with ill-defined technology and output. Institutional theory and the technical-rational models of organizations would lead one to the expectation that the control of ill-defined technology will differ in the for-profit and nonprofit sectors. The control and evaluation system in the for profit organization should be oriented toward efficiency while the control system and evaluation processes in the nonprofit organization would be oriented toward maintaining legitimacy of the organization. The environment studied is similar to DOD and more generally to the federal government. Understanding of the process operating in these organizations should contribute to a better understand of how to effectively operate Navy organizations. The work on this project is directly relevant to the content of MN 4161 Financial Management Control Systems and MN 4122 Planning and Control. Results of the study were presented at the Performance Measurement and Incentive Compensation Colloquium at Harvard University, June 25-26, 1990.

IDENTIFICATION OF INDUSTRIAL PERFORMANCE MEASUREMENT PROCEDURES SUPPORTING THE ACHIEVEMENT OF STRATEGIC OBJECTIVES

K.J. Euske, Associate Professor of Administrative Sciences
M.V. Lebas, Professor, HEC
C.J. McNair, Associate Professor, Babson College
Sponsor: CAM-I

OBJECTIVE: The purpose of the project is to identify how industry develops and uses performance measures to support the achievement of strategic objectives. The objective of the study is to benchmark existing performance measurement practices, detail the linkages to and divergence from "accepted" theory and identify areas where performance management systems can be improved. The project has three phases. Phase I consists of interviews with managers from a stratified sample of firms. The results of these interviews will be used to develop a questionnaire for Phase II of the project. The questionnaire will be distributed to another sample of firms. The results of the questionnaires would then be validated in Phase III with interviews at another sample of firms. The project directly supports DOD efforts to support and improve the stability and competitiveness of the U. S. defense industrial base.

ASSESSING THE EFFECTIVENESS OF OFFICE AUTOMATION SACONS IN THE NAVY

William J. Haga, Adjunct Professor of Administrative Sciences
Sponsor: None
Funding: None

OBJECTIVE: Quantify the productivity impact of the automation of office work procedures using a pretest/posttest one-group research design that measured inputs (size of staff, grade structure, usage of overtime), outputs (workload, quality of service) and social by-products (morale, teamwork, professionalism) using archival data supported (in the case of social by-products) with survey responses.

SUMMARY: This is a follow-on to last year's Davis-Murphy study of the installation of the Standard Automated Contracting System (SACONS) contract-generation system at the Naval Postgraduate School. We continued observing for another year the implementation of the SACONS program in the NPS supply department, the first Navy supply activity to use SACONS. While workload increased slightly the size of the staff also increased after the SACONS automation, although the grade structure remained about the same. *Nonetheless, the procurement action lead time,* the conventional user-oriented measure of the quality of service for supply activities, improved after automation. The Davis-Murphy findings were confounded when the NPS supply activity lost its procurement authority in the early part of the year following an IG inspection. This resulted in a slow-down when purchases were channeled through a special procurement official for the three-month duration of the suspension. When the suspension was lifted in the summer of 1989, there was surge of back-logged procurement activity which was attended by a temporary swell in usage of overtime work. This follow-on study provided a stable basis of comparison to the pre-SACONS period.

THESIS DIRECTED: T. Jeff Summerour, LCDR, USN and Dennis E. Wilson, LCDR, USN, "Automated Contracting: A Productivity Study," Masters Thesis, December, 1990.

ASSESSING THE EFFECTIVENESS OF OFFICE AUTOMATION: APADE IN THE NAVY

William J. Haga, Adjunct Professor of Administrative Sciences
Sponsor: None
Funding: None

OBJECTIVE: Quantify the productivity impact of the automation of office work procedures using a pretest/posttest one-group research design that measured inputs (size of staff, grade structure, usage of overtime), outputs (workload, quality of service) and social by-products (morale, teamwork, professionalism) using archival data supported (in the case of social by-products) with survey responses.

SUMMARY: This is a study of the Naval Supply Command's Automated Procurement and Data Entry (APADE) contract-generation system that parallels the Barclift-Linson, Davis-Murphy and Summerour-Wilson studies of the Standard Automated Contracting System (SACONS) contract-generation system at Fort Ord and at the Naval Postgraduate School. We observed the implementation of the APADE program in the small purchases activity at the Naval Supply Center in Oakland. Data have been collected on the Procurement Action Lead Time (PALT) and procurement work load statistics for the years before and after the APADE installation, data are still being gathered on labor inputs, grade structure, overtime hours and sick leave days. Analysis of the findings has not yet begun.

CORPORATE INFORMATION MANAGEMENT IN DOD

Wiliiam J. Haga, Adjunct Professor of Administrative Sciences
Sponsor: Naval Postgraduate School Case Writing Workshop
Funding: Naval Postgraduate School

OBJECTIVE: Write a case study of the genesis and evolution of the DOD Corporate Information Management (CIM) initiatives to consolidate, rationalize, integrate and unify all information resources that are now spread about among the uniformed services and defense agencies. The teaching of IS strategy lacks cases that are (a) about IS, (b) are strategic and (c) involve DOD. The CIM program provides all three elements.

SUMMARY: Working from archival documents, interviews with CIM officials and information gathered on a visit to the CIM office in Washington, a preliminary version of a case study was written in September 1990. Events surrounding CIM continue to unfold as this summary is written. Nonetheless, the first version of the CIM case will track events through January, 1991.

OTHER: The investigators used a preliminary version of this case in the Marine Corps General Officers Computer Orientation course in September, 1990. A final version of this case will used in IS 4182 in March, 1991.

ECONOMIC ANALYSIS TECHNIQUES IN THE EVALUATION OF INFORMATION SYSTEMS

William J. Haga, Adjunct Professor of Administrative Sciences
David R. Henderson, Associate Professor of Administrative Sciences
Sponsor: None
Funding: Personal

OBJECTIVE: Correct, revise, reformat and update an out-of-print manual on the economic analysis of ADP investments in DOD prepared by the Naval Data Automation Command (NAVDAC) as well as providing an expert system and a decision support system for use by NPS students in the computer systems management curriculum and by IS managers in DOD faced with preparing an economic analysis in accordance with DOD and OMB directives.

SUMMARY: The previous NAVDAC manual has been rewritten and reformatted. Problem sets and solutions have been corrected and revised. An additional problem set has been developed and included for which solutions are not included in the manual but are available to instructors. The NAVDAC treatment of inflation in economic analysis was found by Lang to be erroneous. Haga and Henderson have corrected and rewritten the chapter on inflation based on new calculation examples. Walker has studied the utility of each economic analysis technique (present value, discounted payback period, uniform annual cost, benefit-cost ratio, savings investment ratio, internal rate of return, break even analysis and sensitivity analysis) using comparative four-way data sets that have front-loaded and back-loaded costs and front-loaded and back-loaded benefits. His findings are summarized in a matrix that scores the category of utility for each technique. Using an Intelligence Ware shell, he developed the rule-base and fact-base for COSTEX, an expert system that directs a MIS manager in the selection of appropriate techniques of analysis for a given set of economic analysis contingencies. Walker has also developed the Basic Economic Analysis Decision Support (BEADS) system which provides, separately for each of the eight economic analysis techniques, both a decision support framework and a tutorial on the methodology and virtues for that technique. While COSTEX and BEADS are in the final stage of development, the revised economic analysis manual is being used in current sessions of IS 3170.

PUBLICATIONS: David R. Henderson and William J. Haga, How to Account for Inflation When Taking Present Values, NPS Technical Report NPS-54-90-020, 13 September 1990.

OTHER: William J. Haga and Robert Lang have produced the manual Economic Analysis of ADP Projects (Revised) for sale as a textbook in IS 3170 in February, 1991. Charles Walker has written COSTEX, an expert system for selecting appropriate economic analysis techniques for a given set of contingencies. He has also written BEADS, an decision support system for undertaking specific economic analysis techniques.

INFORMATION SYSTEM EFFECTIVENESS: VALIDITY OF DATA COLLECTION TECHNIQUES

William J. Haga, Adjunct Professor of Administrative Sciences
Gregory Regens, Professor of Administrative Sciences
Sponsor: None
Funding: None

OBJECTIVE: Examine the ways in which studies of information system (IS) effectiveness have dealt with the issue of the validity of their empirical findings.

SUMMARY: 36 empirical studies of IS effectiveness over the past 20 years are being reviewed for the manner in which each dealt with the matter of validity, that is, the extent to which their findings actually revealed what the researchers intended or claimed. A previous study (Haga, Zviran and Mustofa) found 89% of the studies were vulnerable to at least one of eight threats to internal validity. Preliminary findings from the present study are that the majority of empirical studies of IS effectiveness either did not address validity at all or failed to provide evidence of actually possessing the validity that was claimed. This study used behaviorally-anchored predictive validity as a criterion for evaluating the strength of claims that a study employed validated techniques for data collection.

OTHER: The principal investigator is preparing a paper for submission to Management Information Systems Quarterly.

PERSONALITY TYPE AND COMPUTER USAGE

William J. Haga, Adjunct Professor of Administrative Sciences
Jane H. Smith, Professor of Administrative Sciences

OBJECTIVE: Empirically test the folk stereotype of computer people as introverted, cerebral, insensitive and socially inept, using the standard Myers-Briggs Personality Type Indicator (MBTI) along with a survey questionnaire gauging affinity for computers. Indicators are ownership of a PC, use of procedure-oriented programming languages and knowledge of a set of advanced computer procedures scaled for difficulty. The MBTI sorts personality types on four polar dimensions: Introversion-Extroversion, Sensing-Intuition, Thinking-Feeling and Judgment-Perception. The computer affinity survey divides subjects into high affinity and low affinity although responses are recorded on a continuum. We expected subjects with a high affinity for computers to be clustered with personality types that matched the stereotype of the computer nerd: strong introversion/weak extroversion, strong thinking/low feeling and strong judgment/weak perception. We had no prediction about the Sensing-Intuition dimension.

SUMMARY: Following on the work done in 1989, in 1990 we completed the administration of the MBTI instrument and the affinity survey to NPS students. The sample size exceeded 300. Last year, preliminary analysis of early responses found that the distribution of personality types in the NPS sample approximated that of U.S. college graduates. No strong Pearson zero-order correlations were found between any of the MBTI polar types and the continuum of computer affinity. This year, final analysis was undertaken with parametric and nonparametric measures of association between the dependent variable, computer affinity, and its constituent survey items and the independent variable, MBTI, and its four constituent dimensions of personality type. Although the full program of analyses is not complete as this is written, it appears that the preliminary findings will be upheld: there is no relationship between personality type as measured by the MBTI and an affinity for computers. The stereotype of computer users as socially-deficient geeks has no empirical basis. Apparently, all kinds of people like computers just as all kinds of people avoid them. No further analyses were attempted in 1989.

OTHER: The principal investigator is preparing a paper based on this study for submission to ACM's Computer Personnel.

TEN MOST CRITICAL ISSUES IN NAVY I.S. MANAGEMENT

William J. Haga, Professor of Administrative Sciences
Moshe Zviran, Assistant Professor of Administrative Sciences
Sponsor: None
Funding: Personal

OBJECTIVE: Assess the ten most critical issues in managing Navy IS as they are perceived by USN and USMC graduates of the NPS curriculum in computer systems management who have held MIS jobs. This study would be a DOD counterpart to biennial assessments of the ten most critical MIS issues as seen by corporation IS managers.

SUMMARY: Approximately 300 Navy and Marine Corps graduates of the NPS program in computer science management received a first-round survey of their views about the most critical issues faced in DOD IS management. Returned surveys were used only if the respondent had actually served in an MIS billet since graduating from NPS. The findings of the first round surveys were used to prepare a second-round Delphi survey of the same respondents, 100 useful surveys were returned by respondents in the Delphi round. The findings are being compared with earlier surveys of critical MIS issues conducted among corporate MIS managers (particularly the more recent studies by Brancheau and Wetherby) as well as to Marine Corps studies of MIS management issues. Final rankings and analysis are still underway. Preliminary indications are that the Navy and Marine Corps responses echo those of corporate managers surveyed by Brancheau and Wetherby. So far, the perceived difference appears to be that the DON responses focus more on management issues that are strategic in nature compared to the corporation orientation to operational issues.

OTHER: The investigators are preparing a paper for submission to Management Information Systems Quarterly.

AN ECONOMIC ANALYSIS OF NATIONAL SERVICE PROPOSALS

David R. Henderson, Associate Professor of Administrative Sciences
Sponsor: OP-1 (Chief of Naval Research)
Funding: Direct Research

OBJECTIVE: The goal of this study was to use economic analysis to estimate the budget costs and social costs of various national service proposals, and also to estimate the impact of the proposed programs on the U.S. Navy's ability to recruit and retain personnel.

SUMMARY: The cost of a national civilian service (NS) program that would give student aid plus income and vouchers in return for service is likely to exceed the benefits. Computations for a "baseline" NS program show costs of $19.88 billion and benefits of only $16.14 billion. The Nunn-McCurdy version of such a proposal is shown to have costs of $15.44 billion and benefits of only $13.18 billion. The net cost of NS is thus between about $2.26 billion and $3.74 billion. The military component of national service is shown to be more difficult to analyze because of the lack of a market test for the value of military services. There are two ways in which national service could hurt the military. First, the vouchers available to national service volunteers would make the GI bill relatively less attractive and thus reduce the average term of college-bound recruits. Second, the civilian service alternative in national service would cut into the military's target pool of accessions, making recruiting more difficult. On the other hand, national service could help the military, by bringing in people for two years who might not have come in otherwise. The net effect for the military is an empirical issue. The services most likely to lose are the Air Force and the Navy, and the service most likely to gain is the Army. An alternative proposal is made to replace grants and subsidized loans with market-rate loans. That way, those who are given gifts that help them develop their earning power and earn more than those who don't go to college would have to pay the gift back.

PUBLICATIONS: David R. Henderson, "The Case for National Service," a review of A Call to Civic Service by Charles Moskos, Fortune, January 1, 1990, pp. 109-110.
David R. Henderson, "Comment," in Williamson Evers, ed., National Service: Pro and Con, Stanford: Hoover Institution Press, 1990, pp. 209-214.

OTHER: The investigator wrote a long scholarly article on the research results and received a revise and resubmit request from the Journal of Policy Analysis and Management.

NAVY BUDGET JUSTIFICATION AND IMPACT OF BUDGET REDUCTION

Lawrence R. Jones, Professor of Administrative Sciences
Sponsor: NAVCOMPT, Office of Budgets and Reports
Funding: Direct Funded

OBJECTIVE: The goal of this project is to: (a) improve understanding of Navy budget justification and; (b) the impact of Navy budget reductions.

SUMMARY: In the first phase of this project, a Navy budget and program data base was developed and tests were performed to determine the significance of budget and program account variations in the period 1970-1990. In addition, the O&MN account was examined in detail in an attempt to identify major "cost-drivers" as a means for predicting future O&MN budget size and composition. Results were reported to NAVCOMPT and also were sent on request to the General Accounting Office. In the second phase of this project, extensive interviews were conducted and budget materials collected from the OSD Office of Comptroller, NAVCOMPT, the Office of the Comptroller, PACFLT and from the comptrollers of two type commands to evaluate the impact of Navy budget reductions. The initial results of this analysis have been reported to the sponsor and subsequent presentations will be made later in the year as this is an on-going project.

PUBLICATIONS: L. R. Jones, F. Thompson and G. Bixler, Budgeting for National Defense (Wesport, CT: JAI Press 1991 forthcoming).

L. R. Jones, "Strategic Planning and Resource Allocation in National Defense," Public Budgeting and Financial Management, 3/3, 1990.

L. R. Jones, "Public Financial Management Curriculum Reform," in P. Bergstrom, ed., Public Policy Education,, (Wesport, CT: Greenwood Press, 1990).

CONFERENCE PRESENTATIONS: American Society for Public Administration National Conference, panel chairman and presenter, "Public Financial Reform in the 1990's," Los Angeles, CA, April 1990.

Section on budgeting and Financial Management National Conference, panel chair and discussant, "Cutback and Restraint Budgeting in National Defense," Washington, D.C., November 1990.

THESES DIRECTED: M. Seglem, LCDR, USN, and K. Walls, LT, USN, "Trends, Relationships and Intensity Measures: An Analysis of the DON Budget 1962-1990," June 1990, (Advisor).

J. Workman, LT, USN, and R. Williamson, LT, USN, "Budget Reduction in the Navy," December 1990, (Advisor).

R. Guerrero, LT, USN, "Budgetary Implications of US-NATO Burdensharing," June 1990, (Advisor).

B. Stephenson, LT,, USN, "The Role and Functions of the Navy Office of Legislative Affairs in the budget Process," December 1990, (Advisor).

J. Vanscoy, LT, USN, "Congress and the Navy Budget: The Impact of the Budget Process on FY 1990 DON Program and Budget," December 1990, (2nd reader).

OTHER: The investigator is preparing several technical reports to be released in FY 91 resulting from the project or the impact of budget reduction in the Navy and DoD.

DISTRIBUTED DATABASES IN HETEROGENEOUS ENVIRONMENTS: ISSUES AND SOLUTIONS

Magdi N. Kamel, Assistant Professor of Administrative Sciences
Sponsor: Naval Postgraduate School
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project was to establish a multi-level framework of research for interoperability and integration in distributed databases in heterogeneous environments citing at each level of the framework ongoing research, delineating current issues and proposing solutions.

SUMMARY: A preliminary framework based on the degree of access and sharing among the users at the different sites was first developed. A thorough review of literature was conducted to identify the major issues and current research associated with each level of the framework. Solutions to some issues at different levels of the framework were proposed. Using a novel approach, a prototype database system to facilitate interoperability and integration for a level of the proposed framework was designed and implemented.

PUBLICATIONS: Magdi N. Kamel, "Distributed Databases in Heterogenous Environments: A Framework for Research," Information Systems, Forthcoming.

Magdi N. Kamel, "Interoperability and Integration Issues in Heterogeneous Database Environments," in Proceedings of the Seventh Annual Database Colloquium, Database'90, San Diego, CA, June 1990.

Magdi N. Kamel and Nabil N. Kamel, "The Federated Database Management System: An Architecture of Distributed Systems for the 90's," in Proceedings of the Second IEEE Workshop on Future Trends of Distributed Computing Systems, Cairo, Egypt, September 1990, pp. 346-352.

CASES IN CONTRACT NEGOTIATIONS

D.V. Lamm, Associate Professor of Administrative Sciences
Sponsor: National Contract Management Association
Funding: None

OBJECTIVE: The goal of this research is to develop cases to be used in contract negotiation classes in an academic setting in both colleges and universities. The cases are to be used for pricing purposes as well as the actual negotiation environment.

SUMMARY: Actual negotiation situations were researched and cases developed which reflected the essential aspects of the negotiation environment. Cases were developed which addressed new procurement, contract modification, and special contract negotiation conditions. Unique to this work was the development of buyer confidential and seller confidential materials to be used by the buyer and seller teams in preparation for and in the conduct of negotiations. The buyer and seller confidential materials were incorporated into an Instructor's Manual which contains an analysis of the strategies and tactics which could be employed by both sides in negotiations as well as several questions which could be used by the instructor during class discussion or a critique of the case.

PUBLICATIONS: D. V. Lamm, Cases in Contract Negotiations, forth coming publication by Wordcrafters Publications, Inc. D. V. Lamm, Instructor's Manual to accompany Cases in Contract Negotiations.

THESIS DIRECTED: P. J. Fitzsimmons, MAJ, USMC, "Negotiations: Experienced vs Inexperienced Negotiators," Masters Thesis, December 1990.

ARMY RECRUITING IN THE 21ST CENTURY (Phase II)

Stephen L. Mehay, Professor of Administrative Sciences
Mark J. Eitelberg, Associate Professor of Administrative Sciences
George Thomas, Associate Professor of Administrative Sciences
Sponsor/Funding: U.S. Army Recruiting Command
Program Analysis and Evaluation Directorate
Ft. Sheridan, Illinois

OBJECTIVE: To provide an overview of the future environment in which Army recruiting will be conducted in the 1990s and beyond. The project involves an extensive review of the literature and on future trends in social, demographic, labor force, economic, geopolitical and other relevant areas. These trends and projections will be evaluated quantitatively for their impact on Army recruiting requirements and markets.

SUMMARY: (1) We have constructed a computerized bibliographic reference system using the Q&A software package. The database includes over 200 separate sources of information on trends in the relevant subject areas. (2) We have initiated publication of a periodic report ("Trendlines") for high-level Army manpower and recruiting officials. The report highlights selected topics and analyzes various trends for their implications for Army recruiting and manpower policies.

PUBLICATIONS: "Trendlines" -- 5 issues in 1990.

CONFERENCES: One of the objectives of the project is to organize a conference in late 1991 or early 1992 on the topic of recruiting in the 21st Century. The conference will bring together experts from numerous fields and result in the publication of book.

THESES DIRECTED: A. Koch, (LCDR, USN) and E. Anderson (LT, USN), "The Effects of Labor Force, Demographic, and Social Trends on Future Military Manpower Directions," M.S., December 1990

N. Guthrie, (MAJ, Australian Army), "The Impact of Technological Change on Military Manpower in the 21st Century," M.S., June 1990.

V. Moule LCDR, USN), "Lost Opportunity: The Effect of the High-Quality, Smaller Force of the 1990s on the Nation's Disadvantaged Youth," M.S., December 1990.

NAVAL POSTGRADUATE SCHOOL MPT RESEARCH SUPPORT OF OP-01

Stephen L. Mehay, Professor of Administrative Sciences
Loren Solnick, Associate Professor of Administrative Sciences
David Henderson, Associate Professor of Administrative Sciences
Alice Crawford, Adjunct Professor of Administrative Sciences
Sponsor/Funding: Deputy Chief of Naval Operations (MPT)
OP-01/OP-13
Washington, D.C.

OBJECTIVE: This project provided an umbrella research effort within which individual projects were proposed and carried out by individual researchers. Mehay coordinated the project between the individual MPT faculty and OPNAV.

Also, Mehay was principal investigator of a sub-project entitled "An Evaluation of Naval Officer Recruiting Factors." The objective of this project was to investigate the labor market and other factors that affect the accession of Naval Officers via specific programs. In addition, the program examined differences in officer productivity by accession source -- USNA, NROTC, and OCS.

SUMMARY: The project resulted in the construction of a preliminary database for analyzing officer supply conditions in each of the 41 Naval Recruiting Districts. Officer supply models were estimated for several accession programs. In addition, suggested improvements to CNRC's officer goaling models were developed.

THESES DIRECTED: R. Senter (LCDR, USN), "An Analysis of Navy Recruiting Command's Officer Goaling Models," M.S., June 1990.

J. Lenssen (LCDR, German Navy), "An Analysis of Naval Officer Accession Supply," M.S., June 1990.

M. Foster (LT, USN), "An Analysis of the Relative Productivity of Officers from Different Accession Sources," M.S., June 1990.

M. Strano (LT, USN), "A Comparison of the Marginal Cost of Commissioning Officers Through the USNA, NROTC, and OCS," M.S., December 1990.

OTHER: The results of the project were briefed to the Head of CRNC's Research and Studies Division. Also, portions of the database were delivered to CNRC.

STRATEGIC PROFIT ANALYSIS

J.G. Miguel, Professor of Financial Management
Sponsor: None

OBJECTIVE: The aim of this research project is to develop a new approach to profit variance analysis that incorporates new theories concerning cost definitions, aggregation, and competitive analysis.

SUMMARY: Conventional cost-volume-profit analysis and profit variance analysis has been criticized because of the underlying cost behavior assumptions and unrealistic decision horizon. Given recent changes in cost definitions, cost disaggregation theories, and use of value added factors, a new framework is needed to meet the challenges of global competition and information technology. This research project examines emerging concepts for strategic planning and control. These include new costing techniques such as Japanese target costing, use of value chain analysis, and recent approaches for competitive analysis.

THESIS DIRECTED: J.S. Brownsweiger, LT, USN, "The S-3 Viking Weapon System Improvement Program: Financial Management Implications," Master Thesis, December 1990.

RESYSTEMIZATION MODELLING SUPPORT

A. W. McMasters, Professor of Operations Research and Administrative Sciences,
Sponsor: Navy Fleet Material Support Office
Funding: Naval Postgraduate School

OBJECTIVE: To develop a Wholesale level inventory model for the Navy 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 or Inventory Control Point (ICP) level is needed to determine when to replenish repairable items. 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). The intent of this model is to base decisions for replenishment buys and repair inductions into depots upon the Ready - for - Issue (RFI) inventory position (IP). The completion of model development depends on describing the probability distribution of the IP.

Work this past year examined the empirical distributions resulting from the simulation model developed last year. Unexpected extreme values of the resulting distributions were observed. Investigations into their causes led to the need to determine the timing of when an inventory manager knows that an item has been successful repaired. Discussions with the ICP's has led to modifications in the simulation model.

STOCK POINT EXPERT SYSTEMS

A. W. McMasters, Professor of Operations Research and Administrative Sciences,
Department of Administrative Sciences
Sponsor: Naval Supply Systems Command
Funding: Naval Postgraduate School

OBJECTIVE: To develop expert systems to facilitate the decision making of inventory managers at Navy Stock Points.

SUMMARY: For the past five years NPS have been developing expert systems to aid the inventory manager at Navy Stock Points. Systems for deciding how to handle overdue orders from the Defense Logistics Agency (Delinquent Dues) and determining the causes of inventory errors (Causative Research) have been developed. This year a thesis was completed which provides an expert system for the managing of hazardous materials. At present, such materials are stored and managed strictly on an intuitive basis. The danger in this approach is that two materials may be stored together which are dangerous when combined (i.e., could cause an explosion). A major need is for a warehouse person to be able to distinguish the nature of an item's hazard by only knowing its Navy stock number and then be able to immediately decide where to store a shipment received from a supplier.

A second thesis addressed the problem of converting expert systems into new shell formats. This is essential because shells are being continuously improved and new ones developed. As an example, all of the systems developed on this project were converted into the VP Expert shell.

THESES DIRECTED: A. M. Rouska, LT, USN, "Conversion, Integration, and Maintenance Issues of Navy Stock Point Expert Systems," Master's Thesis, March 1990.

D. E. England, SC, USN, "An Expert System for the Management of Hazard Material at Naval Supply Centers," Master's Thesis, June 1990.

SOFTWARE FOR U.S. ARMY TOE RESILIENCY SCREENING

T.P. Moore, Assistant Professor of Management Science
Sponsor: U.S. Army Combat Developements Experimentation Center
Funding: U.S. Army Combat Developments Experimentation Center

OBJECTIVE: This is a continuing project to implement a screening procedure that can be used by Army force structure designers to perform rapid, low cost initial evaluations of the resiliency inherent in specific Table of Organization and Equipment (TOE) designs.

SUMMARY: A simple resiliency screening procedure for Army force structure designers was previously developed. The procedure requires information about the number and the type of occupational specialties and major equipment in the unit. It produces an estimate of the inherent resiliency of the TOE design. This research is intended to develop a prototype computer program to compute resiliency index values. The indexing procedure can then be further tested and refined to determine the extent of its usefulness to the Army.

PUBLICATIONS: T.P. Moore, "An Investigation of the Use of Resiliency Analysis by U.S. Army Force Structure Designers," Naval Postgraduate School Technical Report, in preparation.

COST DRIVERS DURING THE ACQUISITION OF MAJOR WEAPON SYSTEMS

O.D. Moses, Associate Professor of Administrative Sciences
Sponsor: Naval Sea Systems Command,
Cost Estimating and Analysis Division
Funding: Naval Postgraduate School

OBJECTIVE: To identify and examine factors expected to influence year-to-year changes in unit cost of weapon systems.

SUMMARY: This research presented simple functional models relating manufacturing factors to unit production cost. The models were used to identify cost drivers. Actual cost data for a sample of shipboard tactical missiles systems were collected. Empirical models relating changes in system unit cost to the identified cost drivers were constructed. Tests of the nature of the relationships between unit cost and the cost driver variable were conducted under varying circumstances.

PUBLICATIONS: O. D. Moses, "Extensions to the Learning Curve: An Analysis of Factors Influencing Unit Cost of Weapon Systems," Naval Postgraduate School Technical Report No. NPS 54-90-016, May 1990.

O. D. Moses, "Learning Curve and Rate Adjustment Models: Comparative Prediction Accuracy Under Varying Conditions," Naval Postgraduate School Technical Report No. NPS-AS-91-001, November 1990.

O. D. Moses, "Extensions to the Cost Progress Model: An Analysis of Factors Influencing Unit Cost of Weapon Systems," paper submitted to the Journal of Cost Analysis.

CONFERENCE PRESENTATIONS: O.D. Moses, "Extensions to the Learning Curve: An Analysis of Incorporating Production Rate and Other Factors into the Learning Curve Model," 24th annual Department of Defense Cost Analysis Symposium, Washington, D.C., September 5-7, 1990.

ENHANCEMENT OF SCHNEIDEWIND SOFTWARE RELIABILITY MODEL

Norman F. Schneidewind, Professor of Information Sciences
Sponsor: Navy Surface Warfare Center
Funding: Naval Surface Warfare Center, Virginia

OBJECTIVE: In the first phase of the research, develop a methodology for validating software metrics.

SUMMARY: The research lead to the development of a methodology for metrics validation. This research was used by the Naval Surface Warfare Center and by DoD's Software Engineering Institute Measurement Steering Committee for metrics validation and in the development of the IEEE Standard for a Methodology for Software Quality Metrics (Draft).

PUBLICATIONS: Norman F. Schneidewind, "Validating Software Metrics", Technical Report, Naval Postgraduate School, NPS-AS-90-019, September 1990.

Norman F. Schneidewind, "Validating Software Quality Metrics: IEEE Standard for a Software Quality Methodology (Draft) P1061", The International Conference on Applications of Software Measurement, American Society for Quality Control, San Diego, California, 14 November 1990.

Norman Schneidewind, "Validating Software Metrics: Producing Quality Discriminators", International Symposium on Software Reliability Engineering, Austin, TX, May 17-18, 1991, pp. 225-232. Paper submitted: Norman Schneidewind, "Methodoiogy for Validating Software Metrics", IEEE Transactions on Software Engineering.

CONFERENCE PRESENTATIONS: Norman Schneidewind, "IEEE Software Quality Metrics Methodology (Draft) Standard: How it Can be Applied to Maintenance", Conference on Software Maintenance 1990, San Diego, California, November 29, 1990.

Norman Schneidewind, "Overview of the IEEE Standard for a Software Quality Metrics Methodology", Thirteenth Minnowbrook Workshop on Software Engineering, Blue Mountain Lake, New York, July 24-27, 1990.

Norman F. Schneidewind, "Validating Software Metrics", University of California at Berkeley, Department of Electrical Engineering and Computer Sciences, Computer Science Colloquium, 7 November 1990.

SOFTWARE QUALITY METRICS

Norman F. Schneidewind, Professor of Information Sciences
Sponsor: IEEE Computer Society Standards Activity Board
Funding: Naval Air Systems Command

OBJECTIVE: Develop a standard for software quality metrics.

SUMMARY: As Chairman of the IEEE Software Quality Metrics Working Group, led the research effort that produced the final draft and subsequent submission to the IEEE Standards Board for balloting. The draft received the required approval rate and is now undergoing comments resolution. This research has been used by DoD's Software Engineering Institute Measurement Steering Committee. The research lead to the development of a methodology for metrics validation.

PUBLICATION: Norman Schneidewind, Editor, IEEE Standard for a Software Quality Metrics Methodology (Draft), P1061/D21, April 1990.

Norman Schneidewind, "Report on the IEEE Standard for a Software Quality Metrics Methodology (Draft) P1061, with Discussion of Metrics Validation", 4th Software Engineering Application Workshop, San Diego, California, May 21-23, 1991, pp. 155-157.

ISSUES IN ALLOCATING SERVERS AND FILES IN A LOCAL AREA NETWORK

Norman F. Schneidewind, Professor of Information Sciences
Sponsor: Naval Air Systems Command
Funding: Naval Air Systems Command

OBJECTIVE: Develop policies for allocating servers and files in a local area network.

SUMMARY: There are several issues that confront LAN management with respect to allocating servers and files in a LAN. These are: How many servers should be used for a given number of user computers? Should files be replicated on the servers to provide better performance or should the available servers store different files in order to maximize the number and variety of programs on the LAN? What should be the acceptable access times for users, singly and simultaneously, to access an application program, with a given number of servers and user computers? These issues were analyzed as a problem in optimization to determine the optimal server/user computer configuration.

CONFERENCE PRESENTATION: Norman Schneidewind, "Issues in Allocating Servers and Files in a Local Area Network", ORSA/TIMS Joint National Meeting, Philadelphia, Pennsylvania, 29-31, 1990.

PUBLICATIONS: Norman Schneidewind, "Issues in Allocating Servers and Files in a Local Area Network", Silicon Valley Networking Conference, Santa Clara, California, April 23-25, 1991, pp. 449-458.

COGNITIVE FEEDBACK IN KNOWLEDGE ACQUISITION FOR EXPERT SYSTEMS

Kishore Sengupta, Assistant Professor of Administrative Sciences
Sponsor: Office of Research Administration
Funding: Naval Postgraduate School

OBJECTIVE: The objective of this project is to investigate the feasibility of constructing interactive knowledge acquisition mechanisms for building expert systems.

SUMMARY: Knowledge acquisition constitutes a major bottleneck in the development of expert systems. Traditional methods of knowledge acquisition are time consuming, and frequently capture little more than surface knowledge. The development of theory-based interactive tools is seen as a way of accelerating the knowledge acquisition process and ensuring the capture of quality knowledge. This research investigates the feasibility of using cognitive feedback within the lens model framework as a basis for interactive knowledge acquisition in task domains involving inference.

CONFERENCE PRESENTATION: Sengupta, K. Cognitive Feedback as a Tool for Knowledge Acquisition in Expert Systems. ORSA/TIMS Joint National Conference, Philadelphia, October, 1990.

THESES DIRECTED: Charles Patterson, Lieutenant, USN. Cognitive Feedback for Knowledge Acquisition in Expert Systems. Masters Thesis, September, 1990.

James Connor, Lieutenant Commander, USN. An Interactive Knowledge Acquisition Tool for Expert Systems using Cognitive Feedback Techniques. Masters Thesis, March, 1991.

OTHER: Sengupta, K. Using Cognitive Feedback for Knowledge Acquisition: A Conceptual Framework and Initial Results. Working Paper, NPS (in progress).

COGNITIVE FEEDBACK AND THE DETECTION OF RELEVANT INFORMATION

Kishore Sengupta, Assistant Professor of Administrative Sciences
Sponsor: Office of Research Administration
Funding: Naval Postgraduate School

OBJECTIVE: The objective of this project is to evaluate the efficacy of cognitive feedback in detecting relevant information.

SUMMARY: An important component of expert judgment is the ability to use available information which varies in its relevance. Ideally, decision makers would select and use only information that is relevant to the task. However, empirical evidence from a variety of situations indicates that the presence of irrelevant information can influence judgment adversely. The purpose of this project is to evaluate the effectiveness of cognitive feedback mechanisms in helping decision makers detect relevant information.

THESIS DIRECTED: William Durbin, Lieutenant, USN. Cognitive Feedback and the Detection of Irrelevant Information. Masters' Thesis, March, 1991.

OTHER: Sengupta, K. The Impact of Cognitive Feedback on the Detection of Irrelevant Information. Submitted for review to Organizational Behavior and Human Decision Processes.

COMPLEXITY IN THE DESIGN OF USER INTERFACES

Kishore Sengupta, Assistant Professor of Administrative Sciences
Sponsor: Office of Research Administration
Funding: Naval Postgraduate School

OBJECTIVE: The project seeks to develop theory-based guidelines for designing complex user interfaces.

SUMMARY: Complex devices create high cognitive demands on users, often leading to poor performance and accidents, e.g., the Three Mile Island incident. We hypothesize that complexity is a product of two components: the complexity of the device and task complexity. The interaction of two types of complexity can impact users' mental models of a system, and therefore, their performance. This project considers multiple levels of device and task complexity, and examines their effect on the mental models of users.

THESES DIRECTED: Nancy Reinhard, Lieutenant, USNR. The Impact of Multiple Levels of Complexity on the Effectiveness of a User Interface. Masters Thesis, March, 1991.

Barbara Treharne, Captain, US Army. Direct Manipulation and Command Language Interfaces: A Comparison of Users' Mental Models. Masters Thesis, March, 1991.

OTHER: Sengupta, K. and D. Te'eni. Direct Manipulation and Command Language Interfaces: A Comparison of Users' Mental Models, Fourth Annual Conference on Human-Computer Interaction (HCI '91).

Sengupta, K. Task and Device Complexity in User Interfaces. Working Paper, NPS (in progress).

DECISION SUPPORT IN DYNAMIC ENVIRONMENTS

Kishore Sengupta, Assistant Professor of Administrative Sciences
Sponsor: Office of Research Administration
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project was to develop design principles for decision support in dynamic decision making.

SUMMARY: Many important decisions routinely made in organizations are dynamic in nature, i.e., involving multiple interrelated decisions made over several periods in environments characterized by outcome feedback. Decision makers find dynamic environments difficult to cope with, and as a result, their decisions in such environments tend to be poor. Dysfunctionalities in decision making in dynamic environments have led researchers to suggest exploring alternatives to outcome feedback in enhancing decision makers' performance in such environments. This project considers two alternatives for supporting decisions in dynamic environments: cognitive feedback and feedforward, in the context of a dynamic task performed extensively in organizations: managing software projects. The contribution of this project is to extend the concept of cognitive feedback to dynamic environments. We thereby fill an extant gap in research on dynamic decision making, and lay the basis for formulating systematic design principles for decision support in dynamic tasks.

THESIS DIRECTED: Robert Goodwin, Lieutenant, USN. Feedback in Dynamic Decision Making: An Experimental Investigation. Masters Thesis, March, 1991 (Co-Advisor: T.K. Abdel-Hamid).

OTHER: Sengupta, K. and T.K. Abdel-Hamid. An investigation of Alternative Feedback Strategies in Dynamic Decision Making. Submitted for review to Management Science.

INCORPORATING DECISION FEEDBACK IN GROUP DECISION SUPPORT SYSTEMS

Kishore Sengupta, Assistant Professor of Administrative Sciences
Sponsor: Office of Research Administration
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project was to develop design principles for incorporating feedback in group decision support systems.

SUMMARY: Decision feedback has been shown to be highly effective in improving decision making. The potential for incorporating feedback into decision support systems has also been demonstrated. However, research in decision feedback has largely been confined to individual decision making. Decisions in organizations, on the other hand, are increasingly being made in group or committee settings. This project considered the feasibility of incorporating feedback mechanisms in group decision support systems.

CONFERENCE PRESENTATION: Sengupta, K. and D. Te'eni. Reducing Cognitive Conflict through Feedback in GDSS: An Experiment in the Formulation of Group Preferences, 24th Hawaii International Conference on System Sciences.

OTHER: Sengupta, K. and D. Te'eni. Cognitive Feedback in Interpersonal and Collective Decision Making: An Experiment in Computer-Supported Judgment. Submitted for review to Organizational Behavior and Human Decision Processes.

Sengupta, K. and Te'eni, D. Cognitive Feedback in GDSS. Under revision at MIS Quarterly.

MILITARY AVAILABLE

LCDR K. Steiner, Military Instructor of Administrative Sciences
Sponsor: Joint U.S. Army & U.S. Navy Recruiting Commands
Funding: Joint U.S. Army & U.S. Navy Recruiting Command

OBJECTIVE: The goal of this project was to revise the methodology which estimates qualified military available and interested (QMA/I) youth population using previous NPS work (Thomas, November 1989) and projecting the available market out to the year 2010.

SUMMARY: Department of Defense service branches have been faced with recruiting problems in the past years due to the shrinkage of the youth market; most notably the 17-21 year old population. This market will continue to decline until the year 1995 when a semi-steady state will exist. Recruiting commands will continue to face challenges from the civilian labor markets for the most desirable individuals: the high mental aptitude market (mental categories I-IIIA). Research publications and data from other institutions were examincd and obtained which assisted in revising these market estimates.

PUBLICATIONS: G. Thomas and L. Gorman, "Second Generation Estimation of Qualified Military Available /Interested". Publication expected in January 1991.

OTHER: LCDR Steiner has contributed significantly to the above project. He has provided intense computer programming and initial analysis of major input data, and assisted in the analysis of the output estimates.

ANALYSIS OF FIELD AGENTS WRITTEN COMMUNICATION SKILLS

J.E. Suchan, Professor of Administrative Sciences

Sponsor: Defense Personnel Security Research and Education
Funding: DFR

OBJECTIVE: This research is part of a continuing project assessing the impact of field agent's report writing habits on the adjudication process. The project's first objective, which has already been met, was to determine the current organizational and stylistic characteristics of these field reports and to determine how adjudicators processed information and made adjudication decisions based on the style and organization of these reports. The current objective is to empirically test field reports written in different styles and organizational patterns to assess their impact on adjudicators' reading speed, decision quality, decision satisfaction, perception of report completion, perception of field agent thoroughness, and several other dependent variables.

SUMMARY: The following was accomplished. Data was analyzed to determine which derogatory issues caused field agents the most difficulty and field reports were located that contained these multiple issues. Over 50 multi-issued field reports were analyzed to determine those most apropos for revision into different styles and patterns of organization. Four of the reports were revised and reorganized using the independent variables already chosen. Two research instruments were designed to measure adjudicator perception of field agents and the impact that document style and organization has on decision quality, decision satisfaction, decision confidence, and so on. These instruments are currently being field-tested. Finally, adjudicators are being contacted to serve as test subjects for data gathering.

CONFERENCE PRESENTATIONS: J. Suchan, "The Written Communication Habits of Public Sector Professionals: A Case Study," The Association for Business Communication International Conference, Las Vegas, NV, November 9-13, 1989.

J. Suchan, "What Adjudicators Say About Field Agents' ROIs," DIS Regional Management Development Sessions, Monterey, CA, February, 1990.

OTHER: The investigator will present a paper on discourse communities, reader analysis, and organizational structure at the College Conference on Communication in Boston, March 1991. Also, a paper entitled "The Impact of Organizational Structure on Reader Analysis," will be ready for submission in April, 1991.

OPTIMAL CONFIGURATION OF DISTRIBUTED DATABASE SYSTEMS

M.W. Suh, Assistant Professor of Administrative Sciences
Sponsor: Research Administration Office
Funding: Naval Postgraduate School

OBJECTIVE: Design a distributed database system to support real-time transactions processing applications with the purpose of attaining satisfactory performance at the minimum costs.

SUMMARY: Distributed database systems are considered as one of the strategic directions in which transaction processing systems should evolve. Its presumed benefits of high transaction throughput, enhanced data availability, and flexible expansion path have led many MIS practitioners to turn to DDS for an efficient and reliable transaction processing platform. However it is hardly trivial to design a DDS that fully realizes its perceived benefits. For a DDS to be viable economically as well as operationally, its data and data processing resources must be allocated in such a way that the functional requirements of DDS are achieved with minimum overheads. Mathematical models for optimal configuration of DDS are formulated and solution methods are proposed. This research can lead to substantial savings in ADP investments in an increasingly distributed data processing environment of DOD/DON.

PUBLICATIONS: B. Gavish and M. W. Suh, "Optimal Configuration of Replicated Distributed Database Systems," Annals of Operations Research, forthcoming.

CONFERENCE PRESENTATIONS: M. W. Suh, "Optimal Configuration of Distributed Database Systems," the First ORSA Telecommunications Conference, Boca Raton, CA, March 1990.

M. W. Suh, "Optimal Configuration of Two-tiered Distributed Database Systems," the Tenth Symposium on Command and Control Research, Monterey, CA, June 1990.

THESIS DIRECTED: C. Chou, Taiwan Navy, "Analysis of End-to-End Performance of Local Area Networks," March 1990.

Y. G. Hwang, Korean Army, "Optimal Configuration of Private Networks," Master Thesis, December 1990.

ESTIMATION OF QUALIFIED MILITARY AVAILABLE AND INTERESTED

G.W. Thomas, Associate Professor of Economics
Sponsor: U.S. Army Recruiting Command
Funding: U.S. Army Recruiting Command
Naval Postgraduate School

OBJECTIVE: The goals of this project are three-fold. First, to validate current Navy Recruit Command (CNRC) and Army Recruit Command (USAREC) estimates of QMA using methodologies recently developed at the Naval Postgraduate School. Second, to provide enhanced estimates of qualified military available (QMA). Third, to provide estimates of regional variation in enlistment interest. This is part of a continuing project.

SUMMARY: Efficient and effective recruiting resource allocation decisions require current and future recruit market information on the geographic distribution of QMA as function of county level economic variables were estimated for various gender/racial recruit market subgroups. Equations for qualified military interested (QMI) as a function of AFQT and county level economic variables were estimated for the same market subgroups. The equations capture significant regional variations in QMA and QMI.

PUBLICATIONS: L. Gorman and G. Thomas, "Enlistment Motivations of Army Research: Money, Self-Improvement, or Patriotism?" Armed Forces and Society, forthcoming.

CONFERENCE PRESENTATIONS: G. Thomas, "Modeling Local Area Estimates of Qualified Military Available Population," Joint Marketing and Advertising Research Council Winter meeting, February 1990.

G. Thomas, "On Information Systems for Recruit Marketing," Monterey Marketing Analysis Workshop, March 1990.

L. Solnick and G. Thomas, "A Preliminary Model of USAR Unit Success," and G. Thomas and N. Guthrie, "Recruiting in the 21st Century," ORSA/TIMS National Meeting, May 1990.

THESIS DIRECTED: J. Petersen, "AFQT Forecasting Models for Regional Estimation of Qualified Military Available," Master Thesis in Management, June 1990.

R. Snyder, "An Empirical Analysis of Enlistment Intentions and Subsequent Enlistment Behavior," Master Thesis in Operations Research, September 1990.

J.A. Sinkiewicz, "Predicting Enlistment Behavior From Stated Intentions and Demographic Characteristics," Master Thesis in Management, December 1990.

B. Koc, "Markovian Analysis of Youth Labor Force Transition Probabilities," Master Thesis in Management, December 1990.

OTHER: Technical report and computer programs are under preparation.

MODELING RESERVE COMMUTE BEHAVIOR

G.W. Thomas, Associate Professor of Economics
Sponsor: U.S. Army Recruiting Command
Funding: U.S. Army Recruiting Command

OBJECTIVE: The objective of this study is to estimate USAR members commute distance (from home to drill site) distribution functions which can be used to determine the geographic extent of a Reserve Center's recruiting market.

SUMMARY: Commute distance was calculated as the euclidean distance between the geographic centroids of home zipcode of the Reserve members and their associated Reserve Center zipcode. Thirteen families of probability distributions were investigated for appropriate fit to commute distance using Kolmogorov and Cramervon Mises statistics. The normal distribution with a scale parameter was selected. The shift, shape, and scale parameters were estimated for 90 Reserve Centers. This data was used with data on market and Reserve Center characteristics to estimate these parameters as functions of Reserve Center/market characteristics using maximum likelihood techniques. Preliminary results indicate these functions will be useful for determining the geographic extent of the recruiting market at any current or proposed Reserve Center location.

PUBLICATIONS: L. Johnson and G. Thomas, "A Maximum Likelihood Method for Characterizing Part-Time Commute Behavior," Proceedings of the 1990 Joint Statistical Meetings, August 1990.

CONFERENCE PRESENTATIONS: L. Johnson and G. Thomas, "Commute Behavior of Part-Time Workers," Western Regional Science Association, February 1990.

L. Johnson and G. Thomas, "A Maximum Likelihood Method for Characterizing Part-Time Commute Behavior," American Statistical Association, August 1990.

THESIS DIRECTED: S. Gailing, "Estimating Commute Distance of U S Army Reservists by Regional and Unit Characteristics," Master Thesis in Operations Research, September 1990.

OTHER: L. Johnson and G. Thomas, "A Maximum Likelihood Method for Characterizing Part-Time Commute Behavior," Journal of Transportation Research, submitted September 1990.

USAR NURSE RETENTION/ATTRITION STUDY

G.W. Thomas, Associate Professor of Economics
Sponsor: U.S. Army Recruiting Command
Funding: U.S. Army Recruiting Command

OBJECTIVE: The goal of this project was to investigate the relationship of USAR Nurses attrition and retention behavior to socio-economic, organizational, and psychological factors in order to provide policy insight to manage USAR nurse accession, attrition, and retention. This was an on-going project.

SUMMARY: During this period we updated a comprehensive annotated bibliography of nurse retention and finalized technical reports of our analysis of USAR enlistment and retention behavior. Important factors for the retention decision were identified. Accession results indicate that even greater difficulty will be encountered in nurse recruiting and retention over the next decade, especially in critical specialties. Specific working conditions that are closely associated with retention behavior were identified. Difficulties in Active Duty recruit-ment and retention are likely to benefit Reserve recruitment goals.

PUBLICATIONS: G. Thomas and K. Kocher, "A Nurse Turnover Model," Proceedings for the 1990 Western Decision Sciences Institute, March 1990.

M. Texidor and B. Roberts, "Added Perspective, Education, Recognition: Why Nurses Join and Stay," Military Medicine, Spring 1990.

CONFERENCE PRESENTATION: G. Thomas and K. Kocher, "A Nurse Turnover Model," Western Decision Sciences Institute 1990 Meeting, March 1990.

THESIS DIRECTED: R.P. Franco, "An Analysis of the Determinants of Medical Officer Retention," Master Thesis in Management, December 1989.

OTHER: G. Thomas and K. Kocher, "A Nurse Turnover Model," submitted American Academy of Management, August 1990.

BEHAVIOR/ATTITUDINAL SURVEYS OF CIVILIAN PERSONNEL DEPARTMENT AND OF ENGINEERS AT THE NAVAL AVIONICS CENTER

K.W. Thomas, Professor of Management
B.J. Roberts, Associate Professor of Management
Sponsor: Naval Avionics Center
Funding: Naval Avionics Center

OBJECTIVE: To measure key behavioral/ attitudinal factors influencing the effectiveness of the Civilian Personnel Dept. (CPD) and of Engineering units at the Naval Avionics Center (NAC). (This is a sub-project of a larger project, "Administrative Sciences Research Support for CPD," D.R. Whipple, Principal Investigator.)

SUMMARY: In Phase I, a survey questionnaire had been designed and administered to CPD employees in 1989 to provide an internal Organizational Effectiveness audit of the CPD following a recent reorganization. During 1990, a technical report was written to summarize these findings. In Phase II, a second survey questionnaire had been designed and administered to a sample of Engineers at NAC in 1989 to measure factors which might influence key career decisions, including turnover. During 1990, two technical reports were written summarizing these results. A presentation of results was also made to the sponsor. One remaining Phase II study, on the effects of leadership upon performance, is scheduled for this year (1991). Preliminary interviews were conducted during 1990 for the design of this study.

PUBLICATIONS: B.J. Roberts, K.W. Thomas, and M.E. Davis, "1990 Naval Avionics Center Scientist and Engineer Profile," NPS Technical Report, NPS-54-90-010, July 1990.

B.J. Roberts, K.W. Thomas, and M.E. Davis, "An Analysis of the Factors Affecting the Career Orientation of Federal Civilian Engineers," NPS Technical Report, NPS-54-90-015, July 1990.

B.J. Roberts, K.W. Thomas, and M.E. Davis, "1989 Naval Avionics Center Civilian Personnel Department Profile," NPS Technical Report, NPS-54-90-017, July 1990.

STRATEGIC MANAGEMENT FOR THE DEFENSE DEPARTMENT

James Tritten, Associate Professor of Administrative Sciences
Nancy Roberts, Associate Professor of Administrative Sciences
Sponsor and Funding: Director, OSD/Net Assessment,
OSD/Competitive Strategies Office,
Office of the Under Secretary of Defense,
Acquisition/Directorate for Program Integration,
Strategic Planning Branch and Director of Defense Policy on the
National Security Council (NSC) Staff

OBJECTIVE: This project is designed to conduct historical and current research and analysis in the area of strategic management for the Department of Defense. This research will examine two separate areas; first, strategic planning with the goal to define DoD philosophy and mission, to establish long and short-range objectives for the DoD, and to select strategy to be used in achieving those objectives; and second, strategic implementation with the goal to develop an organization strategy, create functional activities necessary to support the strategy, and design control systems to monitor the effectiveness of the strategy in achieving DoD objectives. In addition, this study will determine what aspects of strategic management might be applied to DoD and how gaming, simulations, and other techniques can assist decision-makers in dealing with future uncertainties in the area of strategic management.

SUMMARY: Investigators have visited businesses and government agencies that have strategic planning staffs and programs, interviewed civilian and military personnel connected with the varying aspects of strategic management within DoD, and obtained the cooperation of industrial leaders in the project. They have revised two graduate seminars in strategic planning and strategic management for the National Security and Administrative Sciences Departments and routinely offer these revised courses. They were instrumental in a thorough overhaul of the National Security Affairs Strategic Planning Curriculum. They have developed historical cases for use in these courses. My own particular contribution to this research during the past year has been to write a research monograph on the limitations of strategic management in DoD, initiate a case development program at the Naval Postgraduate School, and to sponsor faculty and student case research.

BURDEN SHARING, INTERNATIONAL ARMAMENTS COOPERATION AND U.S. MOBILIZATION CAPABILITY

D.R. Whipple, Chairman of Administrative Sciences
W.R. Gates, Adjunct Professor of Administrative Sciences
L.R. Jones, Professor of Administrative Sciences
E.J. Laurence, Professor of National Security Affairs
M.G. Sovereign, Professor of Operations Research
K.L. Terasawa, Adjunct Professor of Administrative Sciences
Sponsor: Office of the Chief of Staff of the Army

OBJECTIVE: Determine the extent to which the U.S. can draw on allied industrial capabilities to increase allied contributions to our mutual defense and augment the U.S. mobilization capability. To successfully share the defense burden, we must establish the extent to which such sharing is acceptable to our allies and develop mechanisms which facilitate equitable sharing.

SUMMARY: This research extends earlier work which began creating a framework to analyze burden sharing, international armaments cooperation and U.S. mobilization capability. This year progress was made in several areas. One effort developed a new model of defense alliances to better explain expenditure patterns among alliance members. This model added the members' commitment, threat perceptions, and interactions with adversaries as variables that help explain defense expenditures within an alliance. The resulting model gives plausible explanations for NATO defense expenditures in the 1970s and 1980s. It also provides a structure for examining future developments or proposed policies. Additional work began examining changes in Western Europe and the impact these can be expected to have on burden sharing, U.S. Western European armaments cooperation, and the Western European defense industrial base. Some of the specific changes considered include the decline in the perceived Soviet threat, the European drive to establish a unified market in 1992, and attempts by the Europeans to establish an integrated arms market, excluding the U.S.

PUBLICATIONS: W.R. Gates and K.L. Terasawa, "The Economics of Defense Alliances," in progress.

L.R. Jones and F. Thompson, "Burden Sharing Among America and Its Allies: Tests of Collective Choice and Their Significance," The Western Political Quarterly, 43 (Sept. 1990): 459-77.

L.R. Jones and P.I. Breaker, "U.S. Japan Burden Sharing," in progress.

K.L. Tersawa and W.R. Gates, "Allies, Adversaries and Commitment in Defense Alliances," in progress.

CONFERENCE PRESENTATION: E.J. Laurance, "The Integration of the European Defense Market: Trends and Implications," International Studies Association, Vancouver, Canada, March 19-23, 1991.

THESES DIRECTED: G.J. Bowen II, LT, USACG, "The FSX Project, A Case Study in Burden Sharing And International Armaments Cooperation," Masters Thesis, Dec. 1990.

L. Bowman, LT, USN, "Reduction of U.S. Mobilization Capability due to increased Foreign Source Dependency: New Concerns for the Intelligence Community," Masters Thesis, Dec. 1990.

P.I. Breaker, LT, USN, "The Implications of Alliance Changes for Japan and the U.S., "Masters Thesis, June 1990.

J.D. Carpenter, LCDR, USN, "The U.S. Government's Role in Foreign Trade-What is the Best Approach? A Case Study of the Semiconductor Industry," Masters Thesis, March 1990.

K.M. Emerson, LT, USN, "Defense Procurement in the United Kingdom: Which Way Will It Go?" Masters Thesis, Dec. 1990.

R. Guerrero, LT, USN, "Budgetary Implications of the Changing Relationship within NATO and the WARSAW Pact," Masters Thesis, June 1990.

W.A. Johnson, Capt., USMC, "What Constitutes National Security in the Semiconductor Industry? A look at the Competing Views Surrounding DOD's Support of Semiconductors," Masters Thesis, Dec. 1990.

C.P. Martello, LCDR, USN, "NATO Burden-Sharing: Redefinition for a Changing European

Threat," Masters Thesis, Dec. 1990.

J.C. McMrtry III, LT, USN, "Integration of European Arms Industries: An Analysis of Key Variables and Processes in France, Britain, and the Federal Republic of Germany," Masters Thesis, March 1990.

S.G. Sweatt, Capt., USMC, "The United States/Japan Responsibilities Sharing for the Marine Corps Forces," Masters Thesis, Dec. 1990.

PASSWORD SECURITY: AN EXPLORATORY STUDY

M. Zviran, Assistant Professor of Information Systems
W.J. Haga, Adjunct Professor of Administrative Sciences

OBJECTIVE: Empirically examine what computer users are willing to say about their password practices.

SUMMARY: 1600 NPS students and 400 faculty were surveyed. 997 students and 208 faculty responded. Of these, 860 respondents were password users and constituted the sample for this study. DOD recommends that passwords should use no fewer than six characters. Menkus holds that the ideal number of characters is six to eight. This study found that the mean number of characters in passwords was six. 47% of the respondents failed to meet the DOD standard. 78% of the respondents made up their passwords from meaningful details such as their own names, nicknames, birth dates or names of children, spouses or pets. 80% employed an alphabetic structure for their passwords. Fewer than 1% used the entire ASCII character set in their passwords. While 10% of the respondents reported having difficulty remembering their password, 23% admitted to writing it down. Of these, 42% said they kept their password in their wallet and 21% used their notebooks. While periodically changing a password is a basic security practice, 80% of these users reported that they never changed a password. Fewer than 6% changed a password more often than once a year.

PUBLICATION: Moshe Zviran and William J. Haga, "Password Security: An Exploratory Study," Submitted to Communications of the ACM

CONFERENCE PRESENTATION: Moshe Zviran and William J. Haga, "An Empirical Look at Password Usage" Annual meeting of IFIP/*sec 91*, Brighton, England, May, 1991

EVALUATION OF DATA INTEGRITY MODELS

M. Zviran, Assistant Professor of Information Systems
Sponsor: Computer Systems and Architecture Branch
Space and Naval Warfare Systems Command

OBJECTIVES: This research has three objectives:

1. Identify the characteristics of alternative data integrity models and evaluate their advantages, disadvantages and feasibility in a military environment.

2. Design a framework for evaluation and comparison of these data integrity models.

3. Evaluate the available data integrity models in accordance with the proposed framework.

SUMMARY: Several formal models, addressing the issue of data integrity, have been proposed in the literature. The main usefulness of these models is in predicting system behaviors and aid in the design and understanding of complex systems. However, they tackle the data integrity issue from different perspectives and each of them seems to have some strengths and weaknesses, which will either facilitate or hinder its successful application to the DoD environment. A comparison and evaluation of these models will, thus, aid in the selection of an appropriate model for military applications.

PUBLICATION: N/A. Research is in progress.

THESIS DIRECTED: T. Ivan, "Evaluation of Data Integrity Models", Master's Thesis, expected completion: March 1991.

DEPARTMENT
OF
COMPUTER SCIENCE

DEPARTMENT OF COMPUTER SCIENCE

Research in the Department of Computer Science is carried out by faculty, research professionals and by students at both the M.S. and Ph.D. levels. All funded research is conducted under the supervision of a faculty member serving as principal investigator. The research activities of the department can be grouped into five areas roughly corresponding to the specialization tracks of our curriculum. A summary of activities in each of these areas follows. When individual faculty members are cited, it is to be understood that the work described also involves research carried out by students and staff under the supervision of the faculty member.

1.0 Artificial Intelligence and Robotics

Professor McGhee investigated basic technologies related to the real time control, artificial intelligence and computer architectures needed for the support of autonomous underwater vehicles (AUV). In the current year, a visual simulation of the AUV was developed and a second generation testbed vehicle was built and launched in the NPS swimming pool. Professor McGhee also investigated the use of terrain data from an optical radar system to automatically determine suitable footholds for a hexapodal walking machine. Starting his regular professorships on October 1, Professor Kanayama worked on research problems of the autonomous underwater vehicle project and the Yamabico autonomous mobile robot project. In the first project, he worked on 3D environmental description, path planning, sonar data interpretation, graphics simulation, and real-time control of the AUV. In the second, he has been working on revision of motion functions, designing of high-level sonar data interpretation, and designing an image understanding system. Professor Rowe investigated a new kind of map for the planning of military operations, maps that show the best way to travel. He also worked on the design of multimedia databases that exploit English captions to store and find data. Professor Shing investigated efficient algorithms for finding optimal paths and layouts. Such algorithms find applications in many critical military functions, ranging from navigation of autonomous vehicles to the layout of VLSI circuits. His research includes work in the areas of searching through an unknown maze, finding optimal paths for the weighted region shortest-path problem, and planning optimal strategies for the path-constraint search of a moving target. Professor Lee continued his work on the artificial intelligence and real-time computer system aspects of the autonomous underwater vehicle project. The requirements of computer hardware and software architecture for AUV control have been modified to accommodate AUV's real-time constraints. In cooperation with Professor Kanayama, a local path planner was designed and implemented. The path planner feeds cubic spiral data to a stepper which calculates the desired postures to follow between waypoints. Some preliminary work has also begun to investigate the following issues: (1) automating AUV software construction through a formalized prototyping model CAPS (Computer Aided Prototyping System), (2) designing an on-board expert system for mission execution and control, and (3) designing collision avoidance algorithms using Ada as the implementation language. Professor Lee also investigated issues related to applying artificial intelligence and software engineering methodologies to the design and development of military training and simulation systems. Three prototype intelligent computer-assisted instruction (ICAI) systems, map reading tutor, pilot emergency procedure tutor, and aircraft recognition tutor, were developed based on a generic intelligent computer-assisted instruction model. All the systems have a graphics-based user interface, object-oriented program structure, predetermined tutoring rules, and a set of diagnostic routines for interactive instruction. Ongoing work is focused on generalizing the current model to develop an ICAI shell, designing high level tutoring strategies, and incorporating multiple knowledge representation and processing capabilities, including model-based reasoning. Professor Se-Hung Kwak continued his work with Professor McGhee on rule based motion coordination for a hexapodal walking machine. Additionally, he worked on a mission planning expert system for the NPS autonomous underwater vehicle. Professor Erickson worked on developing algorithms for the school scheduling problem. The scheduling system he developed is based on simulated annealing and performs significantly better than previous solutions utilizing traditional optimization techniques.

2.0 Military Database Systems

Professor Lum investigated issues and solutions for managing multimedia data (text, images, and sound) in a database management system. Search of data on the basis of content is the norm for normal data but is difficult for multimedia data. Working together with Professor Rowe, he proposed to enhance multimedia data with natural language descriptions which will be used for content search. With the use of this technique, a demonstrable prototype was built to store and retrieve both normal data as well as images

and sound. Professor Hsiao performed work in both database systems and in database security. His work includes database-system support for the software engineering environment, applications of the multi-model, multi-lingual and multi-backend database system, architectures for real-time database access, and effective access control and efficient database security. Professor Wu continued work on the design and development of a multimedia database system in support of the paperless ship (Argos System). Additional modules for the prototype multimedia interface and information management system were implemented. These modules include the training, acoustic, and MDS modules. Professor Wu's implementation efforts clearly indicate the object-oriented approach is effective in rapidly developing a prototype information management system. Adhering to the project's development standards, all modules were implemented in a modular fashion. Based on this project's comparative studies, quasi-object-oriented systems (Guide, HyperCard, Toolbook, etc.) have been shown to be not as powerful and flexible as true object-oriented systems (C++, Actor, Smalltalk, etc.). Nonetheless such quasi-object-oriented systems have been found to be quite effective in producing certain types of software. Professor Kyung-Chang Kim performed work on multimedia databases with Professor Lum. His work was on the retrieval of images and sound from those databases. The specific focus of that effort was on devising a general approach to multimedia data retrieval through the integration of both object-oriented and natural language understanding techniques.

3.0 Software Engineering

Professor Berzins continued his work on specifications and computer aided design for Ada. The main part of this work consists of two projects sponsored by the Office of Naval Research. The first project is developing both fundamental theory and practical algorithms for combining changes to software systems, a central problem in software maintenance with additional applications to view integration in software specifications, organization of software design databases, and the semantics of programming languages with multiple inheritance. The second project covers specification-bases software tools for the design and analysis of Ada software. This work includes tools for checking the internal consistency of behavioral specifications, automatically generating information for design review meetings, automatically generating Ada interface code, and automatically generating Ada test harnesses that produce test inputs and determine whether test outputs conform to the behavioral specifications. He has also worked on the specification and design of an Ada prototype for a generic C3I system in a project funded by the Office of the Chief of Naval Operations and the specification and design of an Ada prototype of a low-cost combat direction system, in a project funded by the Naval Sea System Command. In the calendar year, Professor Luqi won a five year Presidential Young Investigator Award from the National Science Foundation to continue her work on computer-aided prototyping of real-time Ada software. Additionally, she completed her three year project on an automated prototyping environment, also funded by the National Science Foundation. Professor Luqi also heads two projects funded by the Navy. The first project has the goal of creating Ada prototypes for a generic C3I workstation. The second project has the goal of creating a low cost combat direction system on a commercially available workstation. Both projects have taken advantage of her computer aided prototyping system and serve as case studies for testing, evaluating, and improving the suite of computer-aided design tools being developed in companion projects. Professor Luqi also heads a project sponsored by the Office of Naval Research for developing execution support for a computer aided prototyping system for real-time software. For this project, she has developed and evaluated several real-time scheduling algorithms as well as improved tools for generating prototype Ada code. Professor Luqi and Professor Berzins co-authored a comprehensive book on software engineering with abstractions, which presents an integrated approach for developing reliable Ada software via formal specifications and computer-aided design techniques. Professor Shimeall is investigating several software testing theories. His work includes development of tools for analyze software to determine the set of inputs that generate program failures, evaluation of different test prediction metrics, and, with Professor Luqi, exploration of how to reduce test effort by closely tracking rapid-prototype development. Professor Shimeall is also working on evaluating the safety of life-critical software, by integrating and extending proof-based analysis methods.

4.0 Computer Systems and Architectures

Professor Kodres continued his work on real-time prototyping on a multiple transputer system. This project is exploring the use of a single chip computer, the transputer, as a component of a larger multi-computer, real-time network. In the calendar year, Professor Kodres completed the design of the communications systems for the network of transputers. The implementation of that system is underway. The current system is fault tolerant, communications dead-lock free and dynamically adjustable to any

communications link failure. Professor Lundy performed work in computer networks. His interests include the formal specification and analysis of communications protocols, the testing of protocol implementations, and the development of new protocols. Professor Zaky investigated efficient fine-grained scheduling of recurrence loops on VLIW architectures. This project is currently being extended to scheduling more general classes of loops on VLIW/Superscalar architectures. The significance of this work lies with the fact that such architectures are becoming the architectures of choice for the new generation of high performance workstations.

5.0 Computer Graphics and Visual Simulation

Professor Zyda continued his work on real-time techniques useful for the development of inexpensive, three-dimensional visual simulation systems. Over the last year, there has been an effort at integration of Professor Zyda's Army-sponsored and Navy-sponsored work. That integration revolves around building a ground-based and ocean-based simulator from identically formatted databases. The databases used are in an NPS developed intermediate format, a format generatable from standard SIMNET-SIDS and from DMA products DTED levels 1/2 and ITD. Professor Zyda continued his work on the production of techniques guides for inexpensive 3D visual simulation systems and graphics workstation performance measurements. The work has been specifically on the NPSNET system, a low-cost, commercially available workstation-based version of the DARPA SIMNET system. In the past year, that project has explored on-ground featuring and the graphics techniques necessary for their real-time display. The project has also studied hierarchical data structures useful for the rapid generation of 3D visual displays. Additional work has gone into assembling and managing large 3D weapons model databases. Professor Zyda's command and control workstation of the future (CCWF) project continued its work on 3D visual displays and additionally explored user interface design. During the current year, that project designed, implemented and tested a system called NPSPANEL, an interactive panel designer and toolbox useful for the rapid production of graphical interfaces. NPSPANEL was tested through its use by several master's level students for their theses. The work being carried out by Professor Zyda has generated a substantial interest in the DoD community for a Computer Graphics and Visual Simulation track as part of the Computer Science Department's offerings. A draft track specification has been generated and forwarded to the Tactical Technologies Office of DARPA. Professor Pratt's primary research area is real-time networked 3D vehicle simulations. Of particular interest is the management and representation of complex terrain, vehicular and feature databases. Professor Pratt is also interested in user interfaces as it affects the user's ability to discern motion clues from the simulation. His user interface interests are also with respect to the improvement of man-machine interaction. The use of AI techniques to control vehicles is an area of additional interest of Professor Pratt.

FUNDAMENTAL THEORY FOR AUTOMATICALLY COMBINING CHANGES TO SOFTWARE SYSTEMS

V. Berzins, Associate Professor of Computer Science
Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: We seek to develop fundamental theory and practical methods for combining several changes to a software system with mathematically provable guarantees of correctness. The main goal of this research effort is to enable a higher level of computer aided design in the development of large Ada software systems. Combining changes to software is a fundamental problem in software engineering. This process is important in all phases of developing large software system, where multiple changes must be developed concurrently and then combined. This work has important potential applications to software maintenance, view integration in specifications, version control in design databases, and multiple inheritance in specification or programming languages.

SUMMARY: We have developed a semantic model and automatable methods for combining changes to programs and specifications. We have extended previous semantic models of programs by embedding approximation lattices in a new class of completed, countably-based Boolean algebras. This structure provides a difference operator on programs, which was used to formalize the semantics of an ideal operator for combining changes to programs. This ideal operator produces results that are semantically correct with respect to a natural criterion, and which locate inconsistencies in cases where two changes produce incompatible results for the same design decision. We have derived some of the general properties of the change merging operation, and have developed new methods for practically merging such changes for a simple imperative programming language and for the real-time prototyping language PSDL.

PUBLICATIONS: V. Berzins, "Software Merge: Models and Methods for Combining Changes to Programs", submitted to the International Journal on Systems Integrations. (an initial version of this paper is available as Technical Report NPS 52-91-5).

V. Berzins, "Software Merge: Semantics of Combining Changes to Programs", submitted to ACM TOPLAS. (an initial version of this paper is available as Technical Report NPS 52-91-4).

V. Berzins, "Formalizing Modifications to Software Objects", Technical Report NPS 52-90-29, Computer Science Department, Naval Postgraduate School, 1990.

THESES DIRECTED: D. Dampier, "A Model for Merging Different Versions of a PSDL Program", M.S. Thesis, completed June, 1990 (thesis supervisor).

I. Mostov, "A Model of Software Maintenance for Large Scale Military Systems, M.S. Thesis, completed June, 1990, (second reader).

AUTOMATED SOFTWARE TOOLS FOR THE DESIGN OF LARGE ADA SOFTWARE SYSTEMS

V. Berzins, Associate Professor of Computer Science
Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: Our goal is to develop new technologies for computer aided design of Ada software systems. A set of software tools for validating requirements and formalizing design efforts of Ada Software Systems are under design and development by applying and extending state of the art research results in software engineering and in artificial intelligence to automate a larger part of the effort in software development. This project emphasizes the refinement of a formal specification tool set suitable for supporting computer-aided development of large Ada programs. To meet urgent needs of DOD, the primary goals of this work are to improve programmer productivity and the quality, reliability, and flexibility of software systems.

SUMMARY: We have refined our previous work on developing a formal specification language and explored the use of formal specifications to support the design of Ada software via case studies. The specification language complements Ada in the design of large systems, and supports descriptions of distributed and real-time systems on a large scale, and is supported by a set of tools for computer-aided software design.

We have developed techniques for modeling changes to software systems that can serve as the basis for automated tools for managing and coordinating changes to a software system. Our approach views the evolution of a software system as a partially ordered collection of transformations that reflects the semantics of the set of design decisions leading to the design of the software system. This structure can be exploited by computer-aided design tools addressing some of the problems of software maintenance.

PUBLICATIONS: V. Berzins, Luqi, "An Introduction to the Specification language Spec", IEEE Software, March 1990, pp. 74-84.

V. Berzins, "Black-Box Specification in Spec", to appear in Computer Languages.

V. Berzins, R. Kopas, "Specification of a Robust Network", Proceedings of the Hawaii International Conference on system Sciences, Jan. 1990.

R. Kopas, V. Berzins, The Design and Implementation of a Specification Language Type Checker", Proceedings of the Hawaii International Conference on system Sciences, Jan. 1990.

V. Berzins, "Distributed Algorithms for Generating Unique Identifiers", revised for IEEE Transactions on Computers.

V. Berzins, B. Kopas, Luqi, A. Yehudai, "Transformations in Specification-Based Software Evolution", submitted to the European Conference on Software Engineering. (an initial version of this paper is available as Technical Report NPS 52-90-034).

THESES DIRECTED: J. Depasquale, "Design and Implementation of Module Driver and Output Analyzer Generation", M.S. Thesis, completed June, 1990 (thesis supervisor).

B. Fan "Evaluations of Some Scheduling Algorithms for Hard Real-Time Systems", M.S. Thesis, completed June, 1990 (thesis supervisor).

R. Rachal, "Design and Implementation of a Concrete Interface Generation System", M.S. Thesis, completed December, 1990 (thesis supervisor).

J. Cervantes, "An Optimal Scheduling Algorithm for Hard Real-Time Systems Specified in a Prototyping Language", M.S. Thesis, completed January, 1990, (second reader).

H. Hsu, "Multi-processor Scheduling for Hard Real-Time Software", M.S. Thesis, completed June, 1990. (second reader).

J. Huskins, Issues in Expanding the Software Base Management System Supporting the CAPS", M.S. Thesis, completed June, 1990, (second reader).

OTHER: We have designed and partially implemented several software tools for performing computer-aided design functions using the formal specifications. These tools include a type checker for specifications, a tool for automatically generating the Ada specification parts from behavioral specifications of a module, and a tool for generating a test result analysis program from a formal specification of a function. The Ada

program generated by this last tool automatically runs test cases, determines whether the results conform to the behavioral specification or not, and generates an error report containing statistics about the number of test cases that passed and failed, and for each test case that discovered a failure, identifies the input and output values exhibiting the failure as well as the requirement constraints that were not satisfied. Such a tool enables high-volume automated software testing driven by random input generators, and helps achieve high reliability levels because people need examine only the small fraction of the test cases that exhibit failures of the software under test. The number of test cases is chosen automatically based on the desired mean interval between failures relative to a specified input distribution. The desired degree of reliability is achieved when the generated test set runs without discovering any failures.

THE NPS ACADEMIC COURSE SCHEDULER

D.A. Erickson, Adjunct Professor of Computer Science
Sponsor: NPS Research Council

OBJECTIVE: To develop algorithms for the school scheduling problem; to create a working school scheduling program for use at NPS.

SUMMARY: During 1990, the school scheduling program (SSP) received the following modifications: A new approach based on simulated annealing was investigated. The investigation included comparisons with traditional local optimization techniques, as well as comparisons of several different means of producing neighboring solutions. The results were very encouraging. The solution quality of the best simulated annealing approach was superior to all known local optimization methods for the problem. A schedule with 0.25% residual conflicts was producted for NPS. During the Fall Quarter, the model was extended to include room assignments, and a new user-interface was designed and partially implemented. That work is continuing during 1991.

PUBLICATIONS: D.A. Erickson, School Scheduling, a Stochastic Approach, Ph.D. thesis, Stanford University, September 1990.

DATABASE SECURITY

David K. Hsiao, Professor of Computer Science
Sponsor: Naval Research Laboratory
Funding: Naval Postgraduate School

OBJECTIVE: The aim of the project was to investigate data models and access control mechanisms which will support the DoD multilevel security policy for classified databases.

SUMMARY: This is the last year that we have been conducting the investigation. We have had some definitive results over the years. Since the multilevel security policy is a DoD requirement for classified databases, we have proposed a multilevel secure data model for the generation of classified databases which not only conform with the multilevel security policy, but also can eliminate the pass-through problem associated with multilevel secure databases. We have also proposed and implemented an access control mechanism, known as query modifications, in our experimental database system for controlling accesses to multilevel secure databases with high access precisions.

PUBLICATIONS: D.K. Hsiao, M.J. Kohler, and S.W. Stround, "Query Modifications as a Means of Controlling Accesses to Multilevel Secure Databases," Proceedings of the 4-th IFIP WG 11.3 (Database Security) Conference, September 18-21, 1990; Halifax, England. (To be re-published as a hardcover book by North-Holland for IFIP in 1991 with the title, Database Security IV.)

CONFERENCE PRESENTATION: D.K. Hsiao, "Query Modifications as a Means of Controlling Accesses to Multilevel Secure Databases, "The 4th IFIP WG 11.3 Database Security Conference, September 19, 1990; Halifax, England.

OTHER: The published work is based on the Master Thesis completed in 1989 by M.J. Kohler and S.W. Stround of the same title of which Professor Hsiao was their thesis adviser.

DATABASE SYSTEMS IN SOFTWARE-ENGINEERING ENVIRONMENTS

David K. Hsiao, Professor of Computer Science
Sponsor: Naval Research Laboratory
Funding: Naval Postgraduate School

OBJECTIVE: The aim of these two projects are the same. It has been our belief that modern software engineering environments are data-intensive. Thus, the capability and architecture of an advanced database system may play an important role in the construction of modern software engineering environments. At NADC, there is an in-house software engineering environment. NADC plans to develop a modern one. At NOSC, plans are being made to develop a new software engineering environment, known as the SEATECS. Both Centers need our input to their efforts.

SUMMARY: For these two projects, this is the last year that we have been conducting the investigation. We have had some definitive inputs to their efforts. We have found that the multi-model, multi-lingual, and multi-backend capabilities of an advanced database system may well be a necessary requirement for a modern software engineering environment which tends to be data-intensive in its applications.

PUBLICATIONS: J.E. Hall, D.K. Hsiao, and M.N. Kamel, "the Multi-backend Database System (MDBS): A Performance Study, "Proceedings of International Conference on Databases, Parallel Architectures, and Their Applications (PARBASE-90), March 7-9, 1990; Miami Beach, Florida. (The proceedings are published by IEEE Computer Society Press.)

CONFERENCE PRESENTATION: D.K. Hsiao, "Performance Data of MDBS, "The PARBASE-90 Conference, March 8, 1990. Also, D.K. Hsiao, "The Future Architecture of Parallel Database Systems," as a panelist in the Panel on Future Database System Architecture, The PARBASE-90 Conference, March 9, 1990; Miami Beach, Florida.

OTHER: The published work is based on the Master's Thesis completed in 1989 by J.E. Hall of the same title of which Professor Hsiao was the thesis adviser.

APPLICATIONS OF MODERN DATABASE-SYSTEM CAPABILITIES FEDERATED DATABASES AND SYSTEMS

David K. Hsiao, Professor of Computer Science
Sponsor: Naval Pacific Missile Test Center
Funding: Naval Postgraduate School

OBJECTIVE: The aim of this new project was to identify the database-system issues in the 21st Century in the light of present database practices and conventional system architectures, to research into solutions which will resolve these issues, and to apply some of the newly found solutions to a Navy database application for the future.

SUMMARY: An examination of the proliferation of databases and their database systems has been completed. The use of a large number of stand-alone database systems in an organization is prompted by the desire of the organization to automate database management for diverse database applications for record keeping, product assemblies, inventory control, inference making, design automation, and others. Each of these applications has resulted in a homogeneous database and its database system which requires the support of a set of computer hardware, a system of computer software, and a team of computer professional. As the applications proliferate, the number of different databases and their database systems will also increase, resulting in a large number of heterogeneous databases and database systems. Research issues are focusing on two important areas: data sharing among heterogeneous databases and systems in a federation without compromising the local autonomies of various database applications and resource consolidation of all the supporting hardware, software, and personnel for more effective and efficient database management in the federation.

PUBLICATION: D.K. Hsiao, "Federated Databases and Systems - A Tutorial, "Proceedings of Tutorial Notes of the 16th International Conference on Very Large Data Bases (VLDB Conference), August 13-16, 1990; Brisbane, Australia.

D.K. Hsiao, M.N. Kamel, and C.T. Wu, "The Federated Databases and Systems: A New Generation of Advanced Database Systems," Proceedings of the International Conference on Database and Expert Systems Applications (DEXA 90), August 29-31, 1990; Vienna, Austia.

D. K. Hsiao, "Databases and Database Systems in the 21st Century," Proceedings of the Conference on Very Large Scale Computing for the 21st Century (VLSC-21), October 1-3, 1990; Cape Cod, MA.

CONFERENCE PRESENTATION: D.K. Hsiao, "Federated Heterogeneous Databases," The 16th VLDB Conference, August 16, 1990; Brisbane, Australia.

D.K. Hsiao, "Database Machines," and Federated Databases and Systems," Computer Science Colloquium, La Trobe University, August 17, 1990; Melbourne, Australia.

D.K. Hsiao, "Text-Retrieval Computers," "Objects-Oriented Database Management," and "Federated Databases and Systems," The Distinguished Tutorial Series, Beijing Information Technology Institute, November 12-22, 1990; Beijing, China.

REAL-TIME PROTOTYPING ON A MULTIPLE TRANSPUTER SYSTEM

Uno R. Kodres, Professor of Computer Science
Sponsor: Naval Postgraduate School
Funding: Naval Postgraduate School

OBJECTIVE: This project explores the use of a single chip computer, the so-called transputer, as a component of a larger multi-computer real-time network. The software and hardware design to make such a network a reliable as well as fault-tolerant system is the main long-term objective of this project.

SUMMARY: In FY90 we have completed the design of a communication system in the network of transputers. The implementation is still not complete. The testing of the implemented system is still a subject of a further thesis topic for FY91. The presently designed system is fault tolerant, communications dead-lock free and dynamically adjustable to any communications link failure.

THESIS DIRECTED: M. Esposito, "Fault tolerant Communications Interface on a Network of Transputers on a B-012 Crossbar Switch Host Hardware". M.S. Thesis in Computer Science, June 1991.

A MODEL FOR COMPUTER-ASSISTED MISSILE FLIGHT SIMULATION

Y. Lee, Assistant Professor of Computer Science
Sponsor: Pacific Missile Test Center
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project was to investigate the application of fundamental techniques in Artificial Intelligence and Software Engineering to missile flight simulation and related problems. Issues related to Artificial Intelligence include expert system knowledge acquisition, knowledge representation, automated reasoning, and decision support systems. From the perspective of Software Engineering, this project was to study issues related to applying Software Engineering methodologies in the design and implementation of simulation systems.

SUMMARY: Current problems and models of missile flight simulation were examined and analyzed. It was determined that current simulation systems are extremely difficult to understand, maintain, and modify, mainly due to the methods (or more accurately the lack of) and languages used to design and implement the simulations. Usually, simulations are developed by personnel not familiar with Software Engineering methodologies with the goal of "just to get something up and running", resulting in poorly structured simulations that violate most commonly accepted programming principles. We explored the use of object oriented techniques using the Ada Programming Language, in conjunction with contemporary software engineering principles. to implement a missile flight simulation that could be easily understood and modified, and is efficient and reliable. We also studied the incorporation of knowledge bases in simulations.

THESES DIRECTED: M.-H. Wang, "A Rule-Based System for Shipboard Air Defense", aster of Science in Computer Science, December 1989.

R.S. Dixon, "Short Range Air Defense Defense Planner", Master of Science in Computer Science, June 1990.

W.-I. Weng, "A Rule-Based Weapon Suggestion System for Shipboard Three Dimensional Defense", Master of Science in Engineering Science, December 1990.

J.V. Waite, "An Ada Implementation of a Simple Missile Flight Simulation", Master of Science in Computer Science, in progress.

DESIGN AND APPLICATION OF INTELLIGENT COMPUTER-BASED TRAINING SYSTEMS

Y. Lee, Assistant Professor of Computer Science
Sponsor: Naval Research Laboratory
Funding: Naval Postgraduate School

OBJECTIVE: The primary goal of the work for this project is to investigate fundamental issues related to the advancement and application of Intelligent Computer-Assisted Instruction (ICAI) technology to military training. In addition to requirement analysis, the design and implementation of an authoring environment for building military object recognition training systems will also be performed. This authoring environment is to be used to construct intelligent tutors for specific domains such as aircraft recognition.

SUMMARY: We analyzed fundamental features that are required for military training systems. This involved the specification, for each application environment, of: (1) the knowledge structure and reasoning mechanisms, (2) the development tools, and (3) the delivery apparatus. From this we designed a generic ICAI system, implemented knowledge representation schemes. We also developed three prototype ICAI systems: Map Reading Tutor, Pilot Emergency Procedure Tutor, and Aircraft Recognition Tutor. In addition to the training manuals available, we relied heavily on the knowledge and experience of our resident officer students for the construction of these systems. All the systems have a graphics based user interface, object-oriented program structure, a predetermined tutoring rules, and a set of diagnostic routines for interactive instruction. Ongoing work is focused on generalizing current model to develop an ICAI shell, designing high level tutoring strategies, and incorporating multiple knowledge representation and processing capabilities, including model-based reasoning.

PUBLICATION: Y. Lee and L. Campbell, "A Computer Based Training System for Visual Aircraft Recognition", in preparation for submission to the journal of Interactive Learning Environments.

CONFERENCE PRESENTATION: Y. Lee, "Design and Application of Intelligent Computer-Based Training Systems", Presented to Naval Center for Applied Research in Artificial Intelligence, Naval Research Laboratory, Washington D.C., 25 May 1990.

THESES DIRECTED: L.W. Campbell, "An Intelligent Tutor System for Visual Aircraft Recognition", Master of Science in Computer Science, June 1990.

D.J. Ragsdale and J.P. Tidd, "Designing Intelligent Computer Aided Instruction Systems with Integrated Knowledge Representation Schemes", Master of Science in Computer Science, June 1990.

M.-T. Ling, "An Intelligent Tutoring System for Warship Identification", Master of Science in Computer Science, in progress.

E.M. McGinn, "Using Hypermedia/Hypertext for training system construction", Master of Science in Computer Science, in progress.

R.E. Scurlock, "An Approach to Developing an Intelligent Tutoring System Shell", Master of Science in Computer Science, in progress.

J.F. Stascavage, "A Qualitative Physics Model for Engineering Plant Operational training", Master of Science in Computer Science, in progress.

MULTIMEDIA DATABASE MANAGEMENT SYSTEM

V.Y. Lum, Professor of Computer Science
N. Rowe, Associate Professor of Computer Science
B. Holtkamp, Adjunct Professor of Computer Science (Jan-Apr, 1990)
K.C. Kim, Adjunct Professor of Computer Science (June-Dec, 1990)
Sponsor: NOSC
Funding: Naval Postgraduate School

OBJECTIVE: The objective is to investigate and find solutions for the different issues on managing multimedia data like text, images, graphics, and sound, that come with advanced applications. The proposed solutions are to be incorporated into a prototype DMBS to demonstrate feasibility.

SUMMARY: As stated in the last report, a major problem in handling multimedia data is in addressing their contents which are frequently most complex.

Automatic extraction by computers is seen to be infeasible for any foreseeable future. We proposed to store multimedia data enhanced by their content descriptions in natural language forms. These descriptions are to be given by the users at input time or any time afterward.

A simple parser for parsing phrases was initially constructed on the assumption that captions to describe multimedia data generally come in phrase form. A survey of the captions describing images in books showed that our conjecture is wrong and that captions come in different forms: short phrases, sentences, and paragraphs. As a result, the parser was greatly redesigned and rewritten to have the capability to parse complete sentences, a long with the many different way of writing sentences. For example, dates can be written in a variety of ways and commas are used for many different purposes.

Moreover, as the parser was written to be used in the Prologue environment, an. Prologue processes its predicates and literals very slowly, much time was spent to tune the parser to parse the sentences efficiently.

Concurrently functions were being built on the database system side. The design to store the catalog information was first done and procedures were written for catalog management. Subsequently other functions like data insertion and retrieval were built. At this time, the prototype can create tables, store the traditional and multimedia data, and retrieve them. Users can specify the matching criteria either in the normal way of matching formatted data to a query or in the natural language forms to describe the multimedia data contents.

At this time, additional functions like the modification of the data and the specification of complex retrievals are being defined for implementation. In addition, the user interface is being investigated. We think that a graphical user interface would be much more friendly and make the system more usable.

PUBLICATIONS: A Multimedia Database Management System Supporting Contents Search in Media Data, Lum and Meyer-Wegener, Advances in Computing and Information - Proceedings of International Conference on Computing and Information, ICCI90, Niagara Falls, Canada, May 23-26, 1990.

OTHER: A Description Based Media Object Data Model, Holtkamp, Lum and Rowe, Proceedings of the Computer Software & Applications Conference, Chicago, Oct. 29 - Nov 2, 1990.

Integration of Alphanumeric and Media Data, Holtkamp and Lum, University of Dortmund Technical Report, Memo Nr. 48, July 1990.

M3DBS: A Multimedia/Multidatabase System, Holtkamp, Lum & Meyer-Wegener, paper submitted for publication.

A Description Based Media Object Data Model, Holtkamp and Lum, Proceedings of the Computer Software & Applications Conference, Chicago, Oct. 29, - Nov 2, 1990.

An Architecture for Multimedia DBMS to Support Content Search, Seminars at University of Technology Sydney, Australia, August 22, 1990, and University of Sydney, Australia, August 23, 1990.

CONFERENCE PRESENTATIONS: A Multimedia Database Management System Supporting Contents Search in Media Data, Lum and Meyer-Wegener, Advances in Computing and Information - Proceedings of International

FORMAL MODELING OF LOCAL AREA NETWORKS AND MILITARY NETWORKS

G. M. Lundy, Assistant Professor of Computer Science
Sponsor: NPS Research Council
Funding: Naval Postgraduate School

OBJECTIVE: (1) To develop a clear, precise and formal specification of several major local area networks protocols. This includes the IEEE standard protocols and several military protocols. (2) For each specification, if possible, give a formal analysis of the protocol. The analysis should prove that the protocol is free from deadlocks (if applicable), and other errors; and, that the desired functions of the protocol are indeed accomplished. These functional properties are referred to as 'liveness' in the literature.

SUMMARY: During 1990, specifications were developed for the token bus. The results of this were reported in the SDNC Conference paper (listed in publications).
Second, a specification and analysis was done of a military protocol, the 1553 network. The results were reported in a MILCOM conference paper (see publications).

PUBLICATIONS: Lundy, G.M. , "Specification of a Token BUS Protocol Using Systems of Communicating Machines," Systems Design and Networks Conference, Santa Clara, CA May 23-25, 1990.

Lundy, G.M. and Christensen, P.H., "Specification and Analysis of the MIL-STD 1553 Protocol," MILCOM 90, Monterey, CA, Oct 1-3 1990.

FORMAL MODELING OF HIGH SPEED (FIBER OPTIC) NETWORKS

G.M. Lundy, Assistant Professor of Computer Science
Sponsor: NPS Research Council

OBJECTIVE: (1) To develop a precise and formal specification of future optical fiber network protocols. (2) For each specification, if possible, give a formal analysis of the protocol. The analysis should prove that the protocol is free from deadlocks (if applicable), and other errors; and, that the desired functions fo the protocol are indeed accomplished.

SUMMARY: During 1990, specifications were developed for the FDDI Network Protocol, and analysis was also done. The results of this were reported in the journal paper below.

PUBLICATIONS: Lundy, G.M. and Akyildiz, I.F., "A Formal Model of the FDDI Network Protocol," submitted for publication.

NEW OR IMPROVED NEW PROTOCOLS FOR HIGH SPEED (FIBER OPTIC) NETWORKS

G.M. Lundy, Assistant Professor of Computer Science
Sponsor: NPS Research Council

OBJECTIVE: To develop new or improved protocols for high speed networks.

SUMMARY: A way to improve throughput in the FDDI optical fiber protocol was suggested which improves throughput from approximately 100 Mbps to 300-400 Mbps -- that is by a factor of 3 or 4.

PUBLICATIONS: Lundy, G.M., "Improving Throughput in the FDDI Network Protocol," published at the Second IFIP Workshop on Protocols for High Speed Networks, Palo Alto, CA, November 1990.

TESTING OF PROTOCOL IMPLEMENTATIONS

G.M. Lundy, Assistant Professor of Computer Science
Sponsor: NPS Research Council

OBJECTIVE: To develop An algorithm to generate test procedures from a formal specification of a protocol.

SUMMARY: Such a procedure was developed and published.

PUBLICATIONS: Lundy, G.M. and Miller, R.E., "Testing Protocol Implementations Based on a Formal Specification," published at the Third International Workshop on Protocol Test Systems, McLean, VA, November 1990.

COMPUTER AIDED PROTOTYPING OF REAL-TIME SYSTEMS

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

OBJECTIVE: The goal of this research is to enable rapid prototyping of hard real-time systems via a computer aided prototyping systems (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 interface; and establishing a convenient graphical interface for design and debugging.

SUMMARY: Rapid prototyping is a means for stabilizing and validating the requirements for complex systems by helping customers visualize system behavior prior to detailed implementation, e.g. for embedded control systems with hard real-time constraints. CAPS supports an iterative prototyping process characterized by exploratory design and extensive prototype evolution. This should enable the first implemented version of the system to match user needs and reduce the need for expensive modifications after delivery. The current version of CAPS has been used to generate a software prototype of a C3I system with hard real-time constraints. The preliminary result of such an approach has shown great promise. It also reveals extreme difficulties in many sub-areas which are due to gaps in the state of the art in many inter-disciplinary subjects of fundamental science. Both theoretical and practical research effort has to been devoted with careful strategies in order to make further progress on the subject. The significance and impact of this research to the national economy and to the history of science and engineering makes the success of the project the only possible choice for the researchers.

THESES DIRECTED: M. Cummings, "The Development of User Interface Tools for the Computer Aided Prototyping System", M.S. Thesis, December 1990.

G. Manley, "Rapid Prototyping Tools and Techniques", (completed September, 1990).

Luqi, "Systematic Generation of Application Expert Interface", Final report for the Naval Surface Warfare Center, December 1990.

AN AUTOMATED PROTOTYPING ENVIRONMENT

Luqi, Assistant Professor of Computer Science
Sponsor: National Science Foundation
Funding: National Science Foundation

OBJECTIVE: Our research is aimed at developing an automated rapid prototyping environment to practically validate the requirements, specification and design of large and embedded software systems. Effectively and efficiently validating requirements is an important unsolved problem in software engineering. We use executable prototypes and Computer-Aided tools for ensuring that the requirements accurately reflect the real needs of the user, increasing reliability and reducing costly requirements changes.

SUMMARY: Our objective is to make it practical to validate software requirements via rapid prototyping. Effectively and efficiently validating requirements is an important unsolved problem in software engineering. Prototyping is particularly effective for ensuring that the requirements accurately reflect the real needs of the user, increasing reliability and reducing costly requirements changes. However, current prototyping methods require an impractical amount of time and effort. We use computer-aided prototyping methods to address this problem. In our approach, program construction is sped up by taking advantage of reusable software components retrieved from the software base, automatic generation of code for interconnecting available modules, and static task scheduling. Our research has contributed to the development of a rapid prototyping language and a rapid prototyping environment. The necessary characteristics, features, and difficulties with the development of such a language and environment have been refined as a result of the project. The support for software development and evolution which a rapid prototyping environment may or should provide, and some of the important issues encountered with its development, have also been better defined. We have done work to assemble the previously developed individual tools into one integrated environment. A top-down view of the environment necessitated a much more comprehensive understanding of the major issues of a rapid prototyping environment than is required for a bottom-up view of a particular tool. As the integration progressed more and more knowledge of the design, structure and implementation of previously developed tools and knowledge of the technologies used in their implementation was required to enable the redesign, partial implementation and adaptation into an integrated environment. The integrated implementation makes use of Ada, C, Pascal, Unix, Kodiyak, SSL and Sunview Graphics.

PUBLICATIONS: B. Kraemer, Luqi, "Towards Formal Models of Software Engineering Processes", to appear in Journal of Systems and Software, 1991.

Luqi, "A Graph Model for Software Evolution", IEEE Transactions on Software Engineering, Vol. 16. No. 8., pp. 917-927, August, 1990.

T. Bihari, R. McGhee, Luqi, & Y. Lee, "Applying of a Computer Aided Prototyping System to the Software of an Autonomous Underwater Vehicle", Position paper at Workshop on Software Tools for Distributed Intelligent Control, July 17-19, 1990, Pacifica, California.

Luqi, "Rapid Software Prototyping", in Proceedings of 23rd Annual Hawaii International Conference on System Sciences, Kailua-Kona, Hawaii, January 1990, pp. 198-201.

B. Kraemer, Luqi, "Specification Based Software Development", in Proceedings of 23rd Annual Hawaii International Conference on System Sciences, Kailua-Kona, Hawaii, January 1990, pp. 150-152.

B. Kraemer, Luqi, "Petri Net-Based Models of Software Engineering Processes", in Proceedings of 23rd Annual Hawaii International Conference on System Sciences, Kailua-Kona, Hawaii, January 1990, pp. 104-112.

Luqi, "Automated Rapid Prototyping Environment", Progress report for the National Science Foundation, January 1990.

Luqi, "Automated Rapid Prototyping Environment", Final report for the National Science Foundation, November 1990.

Luqi, "Evolutionary Software Engineering at the Naval Postgraduate School" Technical Document 1924, Naval Ocean Systems Center, San Diego, October 1990.

V. Berzins, B. Kopas, Luqi, A. Yehudai,

"Transformations in Specification-Based Software Evolution", Technical Report NPS 52-90-034, Computer Science Department, Naval Postgraduate School, 1990.
I. Mostov, Luqi, K. Hefner, "A Graph Model for Software Maintenance", Technical Report NPS 52-90-014, Computer Science Department, Naval Postgraduate School, 1990.

B. Kraemer, Luqi, "Petri Net-Based Models of Software Engineering Processes", Technical Report NPS 52-90-011, Computer Science Department, Naval Postgraduate School, 1990.

W. Yin, Luqi, M. Tanik, "Rapid Prototyping for Software Evolution", Technical Report NPS 52-90-009, Computer Science Department, Naval Postgraduate School, 1990.

CONFERENCE PRESENTATIONS: T. Bihari, R. McGhee, Luqi, and Y. Lee, "Applying a Computer Aided Prototyping System to the Software of an Autonomous Underwater Vehicle", Position paper at Workshop on Software Tools for Distributed Intelligent Control, July 17-19, 1990, Pacifica, California.

Luqi, "Rapid Prototyping of Real-Time Systems", Invited Talk At Research Seminar, Department of Electrical Engineering And Computer Science, University of California, Berkeley, May, 1990.

Luqi, "Rapid Prototyping of Real-Time Systems", Invited Talk At Boston University, Boston, March, 1990.

Luqi, "Rapid Prototyping of Real-Time Systems", Invited Talk At OACIS - Oregon State Software Industrial Consortium, Beaverton, OR, March 1990.

Luqi, "Rapid Prototyping of Real-Time Systems", Invited Talk At Computer Science Department, Oregon State University, Corvallis, OR, March 1990.

Luqi, "Rapid Prototyping of Real-Time Systems", Invited Talk At HP by NASA Ames Real-Time Interest Group and IEEE Santa Clara Real-Time Group, June, 1990.

Luqi, "Rapid Software Prototyping", in Proceedings of 23rd Annual Hawaii International Conference on System Sciences, Kailua-Kona, Hawaii, January 1990, pp. 198-201.

B. Kraemer, Luqi, "Specification Based Software Development", in Proceedings of 23rd Annual Hawaii International Conference on System Sciences, Kailua-Kona, Hawaii, January 1990, pp. 150-152.

Luqi, P. Barnes, M. Zyda, "Graphical Support for Reducing Information Overload in Rapid Prototyping", in Proceedings of 23rd Annual Hawaii International Conference on System Sciences, Kailua-Kona, Hawaii, January 1990, pp. 514-522. (An initial version of this paper appeared as NPS TR 52-89-028.)

B. Kraemer, Luqi, "Petri Net-Based Models of Software Engineering Processes", in Proceedings of 23rd Annual Hawaii International Conference on System Sciences, Kailua-Kona, Hawaii, January 1990, pp. 104-112. (An initial version of this paper appeared as NPS TR 52-89-016).

THESES DIRECTED: H. Fountain, "Rapid Prototyping: A Survey and Evaluation of Methodologies and Models", (completed March, 1990).

I. Mostov, "A Model of Software Maintenance for Large Scale Military Systems", (completed June, 1990).

J. Huskins, "Issues in Expanding the Software Base Management System Supporting the CAPS", (completed June, 1990).

D. Dampier, "A Model for Merging Different Versions of a PSDL Program", (completed June, 1990).

SOFTWARE PROTOTYPES OF C3I SYSTEMS

Luqi, Associate Professor of Computer Science
G. Hughes, Military Instruction, USN, Computer Science
V. Berzins, Associate Professor of Computer Science
Sponsor: Chief of Naval Operations
Funding: Chief of Naval Operations

OBJECTIVE: One of the major requirements for modern C3I stations is the capability to process, in real-time, tactical data from many interfaces. The demands for efficient computation and reliable real-time behavior in such sophisticated systems have greatly increased the difficulties and development cost. Consistent with the Navy's Next Generation Computer Resource (NGCR) program, experimentation with prototyping C3I station on commercial, microprocessor-based workstations may demonstrate a low cost approach to providing state of the art computers in the 1990's. This project will establish the feasibility of this approach by implementing a prototype containing the basic features of a C3I station based on an existing Prototyping Language PSDL and its Computer Aided Prototyping System. This project provides the opportunity to utilize the thesis efforts of the students at NPS, fully funded by their sponsor organizations, as well as the research results and software tools generated by project sponsored by the National Science Foundation and the Office of Naval Research.

SUMMARY: One of the major requirements for modern C3I station is the capability to process, in real-time, tactical data from many interfaces. The demands for efficient computation and reliable real-time behavior in such sophisticated systems have greatly increased the difficulties and development cost. At the current time high cost has limited the introduction of sophisticated C3I capabilities to combatant ships. Consistent with the Navy's Next Generation Computer Resource (NGCR) program, experimentation with prototyping C3I stations on commercial, microprocessor-based workstations may demonstrate a low cost approach to providing state of the art computers in the 1990's.

PUBLICATIONS: Luqi, "Software Prototype of C3I Systems", Progress report for the Office of the Chief of Naval Operations, June 1990.

Luqi, "Software Prototype of C3I Systems", Final report for the Office of the Chief of Naval Operations, December 1990.

T. Shimeall, "TWIRP: Testing Within Iterative Rapid Prototyping", Technical Report NPS 52-90-030, Computer Science Department, Naval Postgraduate School, 1990.

Luqi, "Models for Evolutionary Software Development", Technical Report NPS 52-90-012, Computer Science Department, Naval Postgraduate School, 1989.

I. Mostov, Luqi, K. Hefner, "A Graph Model for Software Maintenance", Technical Report NPS 52-90-014, Computer Science Department, Naval Postgraduate School, 1989.

Luqi, T. Davis, "A Software Prototype of the Message Processor in a Navy C3I Station - Modeling and Specification of Hard Real-Time Systems in PSDL", Technical Report NPS 52-90-010, Computer Science Department, Naval Postgraduate School, 1989.

I. Mostov, Luqi, "Maintenance Problems in Military Software Systems", Technical Report NPS 52-90-004, Computer Science Department, Naval Postgraduate School, 1990.

THESES DIRECTED: S. Anderson, "Requirements Models of Generic C3I Stations", (completed September, 1990).

C. Kesoglu, V. Coskun, "Software Prototypes of C3I Stations", (completed Dec., 1990).

E. Davis, "Software Testing for Evolutionary Iterative Rapid Prototyping", (completed Dec., 1990).

Our efforts resulted in the successful generation of Ada C3I software using the Computer Aided Prototyping System (CAPS) at low cost, with higher efficiency, and greater reliability than Ada code generated manually. The resulting Ada prototype executes through a color graphic multi-window user interface and provides all essential functions defined in the prototype specification. One of the most important results is that all of the hard real-time constraints placed on the software components based on the criterion in a wind range C3I definition from sensor to weapon are completely met by our experimentation result.

NAVY ADA FOR COMBAT DIRECTION SYSTEMS

Luqi, Assistant Professor of Computer Science
Uno Kodres, Professor of Computer Science
Valdis Berzins, Associate Professor of Computer Science
Yuh-Jeng Lee, Assistant Professor of Computer Science
Gary Hughes, CDR, USN, Military Instructor of Computer Science
Patrick Barnes, CAPT, USAF, Military Instructor of Computer Science
Michael Nelson, MAJ, USAF, Assistant Professor of Computer Science
Department of Computer Science
Sponsor: Naval Sea System Command
Funding: Naval Sea System Command

OBJECTIVE: The objective of the project is using Navy Ada fortranslating CDS prototypes to AN/UYK machines. Modern Combat Direction Systems (CDS) require the capability to process real-time tactical data from multiple weapons interfaces, electronic warfare and multiple tactical data link systems. The demands for efficient computation and lucid display in such sophisticated systems have greatly increased the development cost of CDS. Our group at the Navy Postgraduate School has provided an experimental CDS project with opportunity to utilize the thesis efforts of the students and advanced software research results at NPS. The implementation of CDS in Ada has an experimentation phase to translate the Ada code to UYK machines via the Navy Ada Compiler. The project will demonstrate a low cost approach to providing state of the art software for shipboard use. This proposal addresses the needs for translating the Ada CDS prototypes containing the basic features of a Combat Direction System to target AN/UYK code.

SUMMARY: We have completed a requirements analysis for a low cost combat direction system. This has involved the initial design of a user interface for the LCCDS that utilizes the capabilities of commercial workstations such as graphical displays, multiple windows, and pointing devices. We have chosen a computer system and operating system to host the prototype CDS, and a portable graphical interface package. We have also evaluated several object-oriented database systems and software packages for generating graphical interfaces for use in the implementation of the prototype CDS, and worked out a way to interface programs written in Ada to graphics packages written in C.

THESES DIRECTED: J. Seveney, G. Steinberg, "Requirements Analysis for a Low Cost Combat Direction System", M.S. Thesis, completed June, 1990.

J. Sun, "Developing Portable User Interfaces for Ada Command Control Software", (completed June, 1990).

W. Weng, "A Rule-Based Weapon Suggestion System for Shipboard Three Dimensional Defense", (completed December, 1990).

E. Dapaula, "Design of a Object-Oriented Database for LCCDS", (completed December, 1990).

R. Adams, "Assessment of the Feasibility of SDI", (completed June, 1990).

G. Slyman, "System Engineering Analysis and Acquisition Strategy to Obtain Battle Group Organic Reprogramming", (completed September, 1990).

M. Wang, "A Rule-Based System for Shipboard Air Defense", Master's Thesis, Naval Postgraduate School, December, 1989. (completed December, 1989).

D. Ross, "Object Oriented Database Manager for a Low Cost Combat Direction System", (completed December, 1989).

R. Dixon, "A Defense Planner for Short Range Air Defense", (completed June, 1990).

SYSTEMATIC GENERATION OF APPLICATION EXPERT INTERFACE

Luqi, Associate Professor of Computer Science
Patrick Barnes, CAPT, USAF, Military Instructor of Computer Science
Sponsor: Naval Surface Warfare Center
Funding: Naval Surface Warfare Center

OBJECTIVE: Development of a human-computer interface for an application has become a major issue in Software Engineering. By using an interface tool kit, such as InterViews, the systematic generation of an expert interface has become much simpler. InterViews provides the basis for an environment that allows an application to be separated into levels. This environment generally consists of five levels. The innermost level contains the host operating system. The next level contains X-Windows, a windowing system. Above this lies InterViews, a user interface tool kit. The next level contains the application's set of tools. The outer level contains the user interface which provides a user view of the application. Because an expert interface can be built for many types of applications, it will aid in the development of Fire Control software for the SLBM submarine and the development of SLBM simulation software built for in-house systems such as mainframes, workstations and desktop systems. This interface will improve a programmer's productivity, and establish an usable human-computer interface for the end user of the SLBM software.

SUMMARY: This project provides the result of development of a human-computer interface since such an application has become a major issue in Software Engineering. By using an interface tool kit, such as InterViews, the systematic generation of an expert interface on X-Windows has become much simpler. The process improves programmer productivity, and establish an usable human-computer interface for the end user. This project has developed a user interface for CAPS. The user interface supports the design, modification and execution of the software prototype throughout the entire prototyping life cycle. It makes use of X Windows and advanced windowing techniques and allows the user to run the tools concurrently. The user interface incorporates a separate tool interface which controls the interaction between the CAPS tools and the user interface. We have developed a graphic editor which uses advanced graphics capabilities to give the user more flexibility in editing a graphical representation of the prototype. This project establishes the feasibility of computer-aided software development by implementing an expert interface for a rapid prototyping system as well as provides important results for evaluating its effectiveness. It indicates that we may eliminate many costly man-years of programming and contracting in building application user interfaces for software systems at DOD.

PUBLICATIONS: Luqi, P. Barnes, M. Zyda, "A Graphical Tool for Computer-Aided Prototyping", Vol 36, No. 9, April 1990, Information and Software Technology, England.

Luqi, P. Barnes, M. Zyda, "Graphical Support for Reducing Information Overload in Rapid Prototyping", in Proceedings of 23nd Annual Hawaii International Conference on System Sciences, Kailua-Kona, Hawaii, January 1990, pp. 514-522.

"Environmental Model of CAPS Interface", Progress report 1 to Naval Surface Warfare Center, March, 1990.

"Behavioral Model of the CAPS User Interface", Progress report 2 to Naval Surface Warfare Center, July 1990.

"Systematic Generation of Application Expert Interface", Final Report to Naval Surface Warfare Center, December, 1990.

THESES DIRECTED: Mary Ann Cummings, "The Development of User Interface Tools for the Computer Aided Prototyping System", M.S. Thesis, December, 1990.

Approximately 20,000 lines of executable online code in Ada and C++ have been produced under the project and magnetic tapes have been delivered to the sponsor.

EXECUTION SUPPORT OF A COMPUTER AIDED PROTOTYPING SYSTEM FOR REAL-TIME SYSTEMS

Luqi, Associate Professor of Computer Science
Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: A computer aided rapid prototyping system to support the development of software systems with hard real-time constraints is especially important for the critical early stages of software design. This research focuses on formal techniques for specifying such complex systems using a Prototype System Description Language and the associated tools for the further analysis and design. A major goal 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 used to treat the hard real-time constraints and to integrate guidelines beyond conventional compiler technology.

SUMMARY: This project studied automated tools for designing and constructing large real-time software systems. Specific subjects that were addressed include: (1) Providing the conceptual design of CAPS tools, e.g., static scheduler, dynamic scheduler, run-time debugging system, etc., (2) The application of CAPS tools to the specification of real-time systems to establish its ability to handle practical problems, (3) Proposing simplifications and extensions to the PSDL language to improve the treatment of hard real-time constraints, (4) Developing execution support tools to handle a subset of the PSDL language constructs sufficiently rich to illustrate the feasibility of automatic generation of executable prototypes for the specified systems. This research uniquely links the two major research flows on modeling of real-time systems and complexity studies on scheduling algorithms in this research area. The hard real-time computational model used and specification based prototyping language provide systematic and unified constructs for modeling, specifying, designing and testing software systems with hard real-time properties.

PUBLICATIONS: V. Berzins, Luqi, "An Introduction to the Specification language Spec", IEEE Software, March 1990, pp. 74-84.

Luqi, "Real-Time Constraints in a Rapid Prototyping Language", revised for Journal of Computer Languages, 1991.

B. Kraemer, Luqi, V. Berzins, "Denotational Semantics of a Real-Time Prototyping Language", Technical Report NPS 52-90-033, Computer Science Department, Naval Postgraduate School, 1990.

THESES DIRECTED: L. White, "The Development of a Rapid Prototyping Environment" (completed January, 1990). Received Grace Hopper Award.

J. Cervantes, "An Optimal Scheduling Algorithm for Hard Real-Time Systems Specified in a Prototyping Language", (completed January, 1990).
M. Kilic, "Transputer Based System, the Application of Real-Time Distributed Processing Using Ada", (completed December, 1989).

D. Ross, "Object Management in a Combat Direction System", (completed December, 1989).

F. Palazzo, "CAPS Execution Support System", (completed September, 1990).

H. Hsu, "Multi-processor Scheduling for Hard Real-Time Software", (completed June, 1990).

COMPUTER VISION AND RULE-BASED CONTROL FOR ROBOTIC VEHICLES

R.B. McGhee, Professor of Computer Science
S.H. Kwak, Adjunct Research Professor
Department of Computer Science
Sponsor: Ohio State University

OBJECTIVE: Investigate the use of terrain data from an optical radar system to automatically determine suitable footholds for a hexapod walking machine. Use this data to develop rule-based control of stepping involving adaptation of rules to terrain types, including at least ditch crossing and negotiation of random obstacle fields. Participate in planning and evaluation of testing of the Adaptive Suspension Vehicle (ASV) walking machine at Ohio State University.

SUMMARY: Hexapod walking machines have demonstrated an ability to negotiate rough terrain unmatched by any other vehicle of comparable size. However, the problem of best utilizing vehicle legs to make use of available footholds while moving the vehicle body in a desired direction and speed has proved to be too difficult for human solution in real time. Experiments with the ASV vehicle at Ohio State University have proved conclusively that this problem can be solved by a computer using terrain data from an optical radar system. However, the algorithms used to date are limited to random obstacle fields and are very difficult to understood or modify. In this research project, the algorithms used by OSU have been recast into rule-based form and coded in Prolog. This has greatly facilitated understanding and has also resulted in improved performance. A paper detailing this work has been published. A technical report describing a successful extension of this work to include large obstacles such as ditches has been completed.

PUBLICATIONS: S.H. Kwak and R.B. McGhee, "Rule-Based Motion Coordination for a Hexapod Walking Machines", Advanced Robotics Vol. 4, No.3, pp. 263-282, December 1990.

S.H. Kwak and R.B. McGhee, Rule-based Control of Stepping for a Hexapod Walking Machine with Ternary Terrain Classification, NPS Technical Report No. NPS-CS-91-006, December 1990.

COMPUTER PLANNING OF SAFE MISSILE PATHS USING DISCRETE REGIONS

Neil C. Rowe, Associate Professor of Computer Science
Sponsor: Naval Air Systems Command, Washington, DC
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project was to investigate knowledge-based approaches to computerized planning of missile routes that maximize concealment and minimize energy cost by maneuvering close to the ground.

SUMMARY: We extended our preliminary work of FY89 by studying ways of summarizing the results of a thorough analysis of the best paths for a missile to an objective. Our approach introduced the concept of "optimal-path maps" for this, maps that show the best direction to go at every point in space. We explored how to store such maps efficiently, since a simple approach of storing path samples can have much redundancy.

PUBLICATIONS: N.C. Rowe and R.S. Ross, "Optimal grid-free path planning across arbitrarily contoured terrain with anisotropic friction and gravity effects," IEEE Transactions on Robotics and Automation, 5 October 1990, 540-553.

N.C. Rowe and R.F. Richbourg, "An efficient Snell's law method for optimal path planning across multiple two dimensional irregular homogeneous cost regions," International Journal of Robotics Research, 6 December 1990, 48-66.

N.C. Rowe, "Plan fields and real-world uncertainty," Proceedings of the AAAI Spring Symposium on Planning in Uncertain, Unpredictable, or Changing Environment, Stanford, CA March 1990. Proceedings edited by J. Hendler and published as technical research report SRC TR 90-45, Systems Research Center, University of Maryland.

R.S. Alexander and N.C. Rowe, "Path planning by optimal path map construction for homogeneous cost two dimensional regions," Proceedings of IEEE International Conference on Robotics and Automation, Cincinnati, OH, May 1990, 1924-1929.

N.C. Rowe, "Means-ends tutoring, multi-tutuoring, and metatutoring, "Technical Report NPS-52-90-003, Computer Science Department, U.S. Naval Postgraduate School, February 1990.

ENVIRONMENT FOR SOFTWARE FAILURE REGION ANALYSIS

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

OBJECTIVE: The goal of this project was to refine testing theories by development of tools to study the failure behavior of software.

SUMMARY: The problem of selecting software test data is how to select the fewest necessary data sets to obtain a good assurance of the correctness of a piece of software. Current techniques require so many data sets that complete applications of these techniques on non-trivial software is impossible. This research focuses on selecting software test data by examination of the failure behavior of software. In 1990, this project expanded on previous research by applying the software failure region analysis method to a set of software, characterizing quantitatively the conditions under which the software will fail, and by developing automated tools to apply the analysis method. Major new results indicate that software failure regions tend to be composed of multiple distinct subregions, indicating the multiple cases are needed for effective regression testing; failure regions tend to be non-convex, indicating that effective test case selections is not dependent strictly on textual program properties, but must incorporate application information; failure regions tend to overlap, indicating that effective fault tolerant or self-checking software must deal with multiple simultaneous causes for erroneous program states, which has implications in the design of exception-handling structures.

PUBLICATIONS: T. J. Shimeall, R. Griffin, J.M. Bolchoz, "Analytical Derivation of Software Failure Regions", In preparation for IEEE Transactions on Software Engineering.

T.J. Shimeall, "Testing Implications of Software Failure Regions", In preparation for the Fourth Workshop on Software Testing, Analysis and Verification.

T.J. Shimeall, "CONFLICT Specification", NPS Technical Report NPS CS-91-001, Computer Science Dept., October 1990.

T.J. Shimeall, "A Library of Software Failure Regions", NPS Technical Report NPS CS-91-002, Computer Science Dept., October 1990.

CONFERENCE PRESENTATIONS: None.

THESES DIRECTED: J.M. Bolchoz, MAJ, "The Identification of Software Failure Regions", Master Thesis, June 1990.

V.S. Abel, LCDR, and M. Monti, CAPT, "VIEWER: A User Interface for Software Failure Region Analysis", Master Thesis, December 1990.

PATENT: None.

OTHER: None.

EFFICIENT ALGORITHMS FOR FINDING OPTIMAL PATHS AND LAYOUT

M.T. Shing, Associate Professor of Computer Science
Sponsor: NPS Research Council
Funding: Naval Postgraduate School

OBJECTIVE: To develop new efficient algorithms and data structures for finding optimal paths and layouts.

SUMMARY: The problem of finding optimal paths and layouts is very important to many critical military functions, ranging from the navigation of autonomous vehicles to the layout of VLSI circuits. In 1990, research was conducted in the following three areas: (1) a good approximate algorithm for the WRSP using simulated annealing (joint work with Mark Kindl, MAJ, USA), (2) efficient algorithm for searching through an unknown maze (joint work with Michael Mayer, LT, USN), (3) efficient algorithms for the path-constraint search of a moving target (joint work with Professor James Eagle of the OR Department). The first and the second projects have been completed and technical papers containing results of these research activities have been submitted to the 1991 IEEE International Conference on Robotics and Automation. Preliminary research for the third project has also been completed and we are now in the processes of implementing the algorithms on the SUN workstation.

PUBLICATIONS: M.R. Kindl, N.C. Rowe and M.T. Shing, "Solving The Weighted Region Problem With Simulated Annealing," submitted to the 1991 IEEE International Conference on Robotics and Automation.

M.T. Shing and M.M. Mayer, "Searching Through An Unknown Maze by Persistent Search," submitted to the 1991 IEEE International Conference on Robotics and Automation.

DESIGN AND IMPLEMENTATION OF MULTIMEDIA INFORMATION SYSTEM USING OBJECT-ORIENTED DEVELOPMENT TOOLS

C.T. Wu, Associate Professor of Computer Science
Sponsor: NAVSEA, Chief Engineer of the Navy for Logistics
Funding: Naval Postgraduate School

OBJECTIVE: To extend our previously developed prototypes ARGOS and GLAD. To study the effectiveness of object-oriented programming tools in creating an easily modifiable and extensible software.

SUMMARY: Additional modules for ARGOS are implemented. They are training, acoustic, and MDS modules. Our implementation effort clearly indicates the object-oriented approach is very effective in rapidly developing a prototype information management system. Adhering to our development standard, all modules are implemented in a modular fashion. They can be executed either as a stand-alone system or as a part of integrated ARGOS system.

PUBLICATIONS: C.T. Wu, "Development of a Visual Database Interface -- An Object-Oriented Approach" Chapter 4 in Applications of Object-Oriented Programming, Lewis Pinson and Richard Wiener (Editors), Addison-Wesley, 1990, 101-138.
C.T. Wu, "Benefits of Object-Oriented Programming in Implementing Visual Database Interface," in Journal of Object-Oriented Programming, Vol 2, No 6, Mar/Apr 1990, 8-16.

C.T. Wu and D.G. Antonopoulos, "Development of the Training Module for the ARGOS System," NPS Technical Report, NPS 52-90-032, May, 1990.

THESIS DIRECTED: Deborah Kern, Design and Implementation of the Acoustic Database and Acoustic Trainer Modules for ARGOS, MS, June 90, advisor.

EFFECTIVE USE OF OBJECT-ORIENTED DEVELOPMENT TOOLS

C.T. Wu, Associate Professor of Computer Science
Sponsor: Naval Weapons Station Concord
Funding: Naval Weapons Station Concord

OBJECTIVE: Exploring the effectiveness of object-oriented programming tools in creating easily modifiable and extensible software.

SUMMARY: We compared and analyzed true object-oriented system (e.g. Smalltalk, C++, Actor, etc.,) and object-like system (Guide, HyperCard, Toolbook, etc.). Although some tools are not object-oriented systems, they nonetheless are quite effective in producing certain types of software.

PUBLICATIONS: C.T. Wu, "A Better Browser for Object-Oriented Programming," in Journal of Object-Oriented Programming, Vol 3, No. 4, Nov/Dec 1990, 22-28.

C.T. Wu, "Object-Oriented Programming Environment Actor" (in Japanese) Nikkei Byte Magazine, March, 1990.

C.T. Wu, "A Better Browser for Object-Oriented Programming," NPS Technical Report, NPS 52-90-031, May 1990.

THESES DIRECTED: Heung-Taek Kim, Interface-Driven Software Development Tool, MS, December 90, advisor.

Partoyo, The Implementation of Form-Based Interface for Relational Database, December 90, advisor.

SUPERSCALAR PROCESSORS

Amr M. Zaky, Assistant Professor of Computer Science
Department of Computer Science
Sponsor: NPS Research Council

OBJECTIVE: To extend the methodology developed for scheduling recurrence loops to a more general class of loops, and to probe the applicability of these techniques for scheduling on superscalar processors.

SUMMARY: Superscalar processors are becoming common as the processors of choice for computer workstations. A superscalar processor has more than one functional unit, and can fetch and execute - given the right conditions - more than one instruction per instruction cycle. The advances in VLSI technology are likely to make superscalar processors, with their ability to exploit the natural fine-grained parallelism, an obvious choice for high performance workstations. This project investigates the efficient execution of loops on superscalar processors. This research will adapt the methods developed in the principal investigator's doctoral dissertation to deal with scheduling nested loops on superscalar processors. The issues which are candidate for study are: developing a nested loop scheduler for superscalar processors, and investigating the role of the cache memory in superscalar processors. We intend to build both a simplistic data dependence analyzer for nested loops, and a simulator for a simplified superscalar processor to test the proposed scheduling methodology.

INEXPENSIVE, THREE-DIMENSIONAL VISUAL SIMULATION FOR THE COMMAND AND CONTROL WORKSTATION OF THE FUTURE - YEAR 2

Michael J. Zyda Associate Professor of Computer Science
Sponsor: Naval Ocean Systems Center, San Diego, CA

OBJECTIVE: The Graphics and Video Laboratory in the Department of Computer Science at the Naval Postgraduate School is designing and implementing a prototype command and control system utilizing three-dimensional, real-time interactive graphics on high-performance, commercially available graphics workstations. The primary goal of this work is to develop real-time visualization tools and techniques useful for rapidly producing three-dimensional scenes such as would be seen from the bridge of a surface ship, the cockpit of an airplane, the periscope of a submarine and the bridge of a submarine (synthetic view). An additional goal of this project is a continuation of the development of a software architecture for interactive, real-time graphics between workstations on the same network.

SUMMARY: The work performed for this project in the current year was to study the variety of user interfaces already in use for command and control workstations. A system, NPSPANEL, was then developed to rapidly produce such interfaces interactively. A code generator was developed for the interactively specified interface. Applications were retrofitted and new applications were begun using NPSPANEL to validate its implementation. Additional work was performed on generating reduced polygon 3D icons.

PUBLICATIONS: DeHaemer, Michael J., and Zyda, Michael J., "Simplification of Objects Rendered by Polygonal Approximations," Computer & Graphics, Vol. 15, No. 2, 1991, Great Britain: Pergamon Press.

Luqi, P.D. Barnes and M. Zyda "Graphical Tool for Computer-Aided Prototyping," Information and Software Technology, Vol. 32, No. 3, April 1990, Great Britain: Butterworth & Co., Ltd.

CONFERENCE PRESENTATIONS: Zyda, Michael J., and Pratt, David R., "NPSNET: A 3D Visual Simulator for Virtual World Exploration and Experimentation," in preparation for submission to the Virtual Reality Applications Gallery to be held at SIGGRAPH '91, Las Vegas, 28 Jul - 2 Aug 1991. Submission consists on a 1 page abstract and a videotape. The final presentation at SIGGRAPH will be a live demonstration.

THESES DIRECTED: King, David Maurice and Prevatt III, Richard Montgomery, "Rapid Production of Graphical User Interfaces," Master's Thesis, Naval Postgraduate School, December 1990.

Jurewicz, Thomas A., "A Real-Time Autonomous Underwater Vehicle Dynamic Simulator," Master's Thesis, Naval Postgraduate School, December 1990.

DEVELOPMENT OF A SIMNET-COMPATIBLE, NON-LINE-OF-SIGHT, 3D VISUAL SIMULATOR

Michael J. Zyda, Associate Professor of Computer Science

Sponsor: U.S. Army Test and Experimentation Command, Fort Ord, California

OBJECTIVE: The Graphics and Video Laboratory of the Department of Computer Science at the Naval Postgraduate School has developed expertise in constructing SIMNET compatible 3D visual simulators on commercially available graphics workstations (NPSNET). USATEC has the requirement for the addition of a FOG-M missile component into that simulator. The goal of this project is to provide that capability within the current NPSNET system.

SUMMARY: The work accomplished so far for this project has been the study of the SIMNET-SDIS database for Fort Hunter-Liggett and the integration of that database into our NPSNET system. We have also begun to study the SIMNET packet formats for networking multiple NPSNET workstations together.

PUBLICATIONS: Zyda, Michae J. and Pratt, David R., "Performance Measurements for A Selection of Workstation-Based 3D Visual Simulators," submitted to the Society for Information Display Symposium scheduled for 6-10 May 1991, Anaheim, California.

Zyda, Michael J. and Pratt, David R. "Inexpensive 3D Visual Simulation as Workstation Exhaustion," substantially revised from the Ausgraph paper and submitted to Computer Graphics International '91: Visualization of Physical Phenomena, 25-28 June 1991, MIT, Cambridge, Massachusetts.

LINE-OF-SIGHT AND VISUAL ENHANCEMENTS TO THE MOVING PLATFORM SIMULATOR

Michael J. Zyda, Associate Professor of Computer Science
Sponsor: U.S. Army Test and Experimentation Command, Fort Ord, California

OBJECTIVE: The Graphics and Video Laboratory of the Department of Computer Science at the Naval Postgraduate School is currently conducting research on terrain visualization through the production of a system called the Moving Platform Simulator (MPS). That simulator uses Defense Mapping Agency digital terrain elevation data on commercially available, high-performance, graphics workstations. The thrust of the current effort is to enhance the MPS-2 system by adding in TEC position=location data streams. An additional set of tasks concerns the computation of player visibilities from each vehicle in the simulator.

SUMMARY: The work accomplished for this project so far is the design of a merged version of the Moving Platform Simulator, MPS-3 is a version of our vehicle simulator containing the best features of MPS-1 and MPS-2. Graphics workstation performance measurements have been made and published for both MPS-1, MPS-2 and MPS-3.

PUBLICATIONS: Zyda, Michael J. and Pratt, David, "3D Visual Simulation as Workstation Exhaustion," Proceedings of Ausgraph 90, Melbourne, Australia, 10-14 September 1990, pp. 313-328.

Zyda, Michael J., "3D Visual Simulation for Graphics Performance Characterization," NCGA '90 Conference Proceedings, Vol I., 22 March 1990, pp. 705-714.

Zyda, Michael J., Fichten, Mark A., and Jennings, David H., "Meaningful Graphics Workstation Performance Measurements," Computers & Graphics, Vol. 14, No. 3, 1990, Great Britain: Pergamon Press, pp. 519-516.

Zyda, Michael J., McGhee, Robert B., McConkle, Corinne M., Nelson, Andrew H., and Ross, Ron S., "A Real-Time, Three-Dimensional Moving Platform Visualization Tool," Computers & Graphics, Vol. 14, No. 2, 1990, Great Britain: Pergamon Press, pp. 321-333.

Nizolak, Joseph P. Jr., Drummond, William T. Jr., and Zyda, Michael J., "FOST: Innovative Training for Tomorrow's Battlefield, "*Field Artillery, HQDA* PB 6-90-1, February 1990, pp. 46-51.

CONFERENCE PRESENTATIONS: September 10-14, 1990: Invited speaker and tutorial presenter at Ausgraph '90, Melbourne, Australia. Talk title "Inexpensive 3D Visual Simulation as Workstation Exhaustion". Tutorial title "How to Teach Computer Graphics".

March 1990: "3D Visual Simulation for Graphics Performance Characterization," invited talk at Computer Graphics '90 Conference, Anaheim, California.

THESIS DIRECTED: Cheeseman, Curtis, "Moving Platform Simulator III: An Enhanced High-Performance Real-Time Graphics Simulator with Multiple Resolution Display and Lighting", Master's Thesis, Naval Postgraduate School, June 1990.

INEXPENSIVE, REAL-TIME 3D TERRAIN VISUALIZATION-YEAR 2

Michael J. Zyda, Associate Professor of Computer Science
Sponsor: DARPA through the U.S. Army Engineer Topographic Laboratories, Fort Belvoir, Virginia

OBJECTIVE: The main project goals are the development of real-time data management techniques for visual simulation, rendering and control of 3D icons traversing fully featured terrain databases. An additional goal of this project was to investigate the proposed SIMNET database interchange standard's applicability to the development of low-cost, 3D visual simulation systems.

SUMMARY: Various formats of data storage and interchange were investigated. Techniques for the representation of on-ground features were developed. Of particular interest was the use of texturing to represent different soil types and materials. Also of interest was the implementation of a record and playback system for simulated engagements. Recordings made by that system could then be played back and interacted with real-time. Different vehicular control methods and user interfaces were investigated to determine which would be the most applicable for the NPSNET simulator.

PUBLICATIONS: Zyda, Michael J. and Pratt, David R., "Performance Measurements for A Selection of Workstation-Based 3D Visual Simulators," submitted to the Society for Information Display Symposium scheduled for 6-10 May 1991, Anaheim, California.

Zyda, Michael J. and Pratt, David, "3D Visual Simulation as Workstation Exhaustion," Proceedings of Ausgraph 90, Melbourne, Australia, 10-14 September 1990, pp. 313-328.

Pratt, D.R. and Zyda, M.J., "Some Comments on SDIS Version 3.0," working paper for sponsor, Department of Computer Science, Naval Postgraduate School, August 1990.

Pratt, D.R. and Zyda, M.J., "Report on the Use of SIMNET Encoded Data for the Storage of On Ground Features," working paper for sponsor, Department of Computer Science, Naval Postgraduate School, June 1990.

Pratt, D.R., Dulle, J.D. and Zyda, M.J., "Report on the Development of a Simple 3D Simulator Using SIMNET Encoded Data," working paper for sponsor, Department of Computer Science, Naval Postgraduate School, April 1990.

Zyda, Michael J., "3D Visual Simulation for Graphics Performance Characterization," NCGA '90 Conference Proceedings, Vol. I, 22 March 1990, pp. 705-714.

CONFERENCE PRESENTATIONS: September 10-14, 1990: Invited speaker and tutorial presenter at Ausgraph '90, Melbourne, Australia. Talk title "Inexpensive 3D Visual Simulation as Workstation Exhaustion". Tutorial title "How to Teach Computer Graphics".

March 1990: "3D Visual Simulation for Graphics Performance Characterization," invited talk at Computer Graphics '90 conference, Anaheim, California.

January 15-17, 1990: Attended Second Workshop on Standards for Interoperability of Defense Simulations, Orlando, Florida at the request of USAETL sponsor. Brought videotape of latest results.

THESIS DIRECTED: Anderson, Wilhelm Friedrich "NPSME - An Interactive Tool for Material Characteristics Specification," Master's Thesis, Naval Postgraduate School, December 1990.

REAL-TIME, INTERACTIVE VISUAL SIMULATION FOR THE FUTURE COMMAND AND CONTROL WORKSTATION - YEAR 2

Michael J. Zyda, Associate Professor of Computer Science
Sponsor: Naval Postgraduate School Direct Funding
Reviewer: Naval Underwater Systems Center, Newport, Rhode Island

OBJECTIVE: The Graphics and Video Laboratory in the Department of Computer Science at the Naval Postgraduate School is designing and implementing a prototype command and control system utilizing three-dimensional, real-time interactive graphics on high-performance, commercially available graphics workstations. The primary goal of this work is to develop real-time visualization tools and techniques useful for rapidly producing three-dimensional scenes such as would be seen from the bridge of a surface ship, the cockpit of an airplane, the periscope of a submarine and the bridge of a submarine (synthetic view).

SUMMARY: The work performed for this project in the current year was to study the variety of user interfaces already in use for command and control workstations. A system, NPSPANEL, was then developed to rapidly produce such interfaces interactively. A code generator was developed for the interactively specified interface. Applications was retrofitted and new applications were begun using NPSPANEL to validate its implementation. Additional work was performed on generating reduced polygon 3D icons.

PUBLICATIONS: DeHaemer, Michael J. and Zyda, Michael J., "Simplification of Objects Rendered by Polygonal Approximations," Computer & Graphics, Vol. 15, No. 2, 1991, Great Britain: Pergamon Press.

Zyda, M.J., McGhee, R.B., Kwak, S., Nordman, D.B., Rogers, R.C., and Marco, D., "3D Visualization of Mission Planning and Control for the NPS Autonomous Underwater Vehicle," IEEE Journal of Oceanic Engineering, Vol. 15, No.3 July 1990, pp. 217-221.

Zyda, Michael J., "3D Visual Simulation for Graphics Performance Characterization," NCGA '90 Conference Proceedings, Vol. I, 22 March 1990, pp. 705-714.

CONFERENCE PRESENTATIONS: Zyda, Michael J. and Pratt, David R., "NPSNET: A 3D Visual Simulator for Virtual World Exploration and Experimentation," in preparation for submission to the Virtual Reality Applications Gallery to be held at SIGGRAPH '91, Las Vegas, 28 Jul - 2 Aug 91. Submission consists on a 1 page abstract and a videotape. The final presentation of SIGGRAPH will be a live demonstration.

THESES DIRECTED: King, David Maurice and Prevatt III, Richard Montgomery, "Rapid Production of Graphical User Interfaces," Master's Thesis, Naval Postgraduate School, December 1990.

Jurewicz, Thomas A., "A Real-Time Autonomous Underwater Vehicle Dynamic Simulator," Master's Thesis, Naval Postgraduate School, December 1990.

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

The research program of the Department of Electrical and Computer Engineering involves projects in the following areas: Communications, Computer Engineering, Electromagnetics, Electro-Optics, Power Systems, Radar and Electronic Warfare, Signal Processing, Systems and Controls, and Underwater Acoustics.

Some research projects span one or more of these areas, although they are listed here in only one category. Graduate students are involved in many efforts, as indicated by the titles of published theses which are listed with the project descriptions.

COMMUNICATIONS

Professor Alex Lam investigated direct-sequence spread-spectrum multiple-access communications employing complex signature sequences. A unified performance analysis was performed. Professor Lam also researched direct-detection ADP-based optical code-division multiple-access communications using avalanche photodiode photodetection. Professor John Powers initiated the study of acousto-optic principles to divide the spectrum of a wide-band spread-spectrum signal into subchannels. Simulation of channelization and recombination were simulated on a computer.

Professors Tri Ha and Glen Myers investigated performance characteristics of frequency hop spread spectrum receivers for use with tactical low-altitude satellites (LASAT).

Professor Clark Robertson examined the effects of capture phenomenon on the performance of mobile communication applications. Use of a pseudo-Bayesian based algorithm is considered for increasing stability of communications.

Professor Paul Moose considered the development of high-speed, bandwidth efficient digital communications modulation and coding methods that can use economical DSP chips and associated integrated components.

Professor Richard Adler is evaluated the viability of using active (amplified) antennas for Navy high-frequency (HF) signal intelligence (SIGINT) sites worldwide.

COMPUTER ENGINEERING

Professor Herschel Loomis conducted research into computer algorithms and architectures for the processing of tactical information, including the case of spaceborne computer systems.

Professor Loomis also investigated computer aided design (CAD) techniques for complex VLSI chips to achieve high performance or special functionality. Architectures using application specific integrated circuits (ASIC's) for a special SPAWAR project are being designed.

Professor Chin-Hwa Lee considered ASIC implementation using programmable gate arrays for tactical image processing. Nonlinear algorithms, such as similarity counting and dynamic programming are being considered.

Professors Jon Butler and Chyan Yang developed logic synthesis techniques and computer aided design (CAD) tools for multiple-valued combinational logic with focus on providing extremely compact and highly reliable circuits for future Navy electronic systems.

Professor Shridhar Shukla has continued his work on mapping real-time applications onto loosely coupled multiprocessors to guarantee performance. Emphasis is on task allocation to minimize contention-free communication cost.

ELECTROMAGNETICS

Professor Richard Adler is considering the effects of nearby ground conditions on the low-angle performance of a new class of complex HF communication antennas. Extensive computer modeling is being validated by on-site field measurements.

Professors Morgan and Janaswamy are developing a CAD-based finite element computer program for use in designing a new class of inhomogeneous missile radomes which minimize boresight tracking errors at low frequencies. Radiation boundary condition methods are being investigated for implementation in the CAD program.

Professor Jeffrey Knorr continued his development of CAD circuit models for finline and finline discontinuities, such as the inductive strip. Numerical data derived from spectral domain programs is being used to determine parameter values for equivalent circuit elements.

Professor Rama Janaswamy investigated the possibility of using new structures for the tapered slot antenna. A rigorous model based on the Wiener-Hopf theory has been developed and validated.

Professor Janaswamy also began the development of an integral equation algorithm, with boundary element solution, for use in evaluating the shape and material constants for improved anechoic chambers.

Professor David Jenn initiated a study of improvements to method of moment integral equation modeling of complex microwave antennas used in radar, communication and EW applications. All characteristics of antennas are being considered, including radiation, EM compatibility and radar cross section of the antenna structure.

Professor Hung-Mou Lee continued his investigation of the excitation of internal resonant modes of a cavity by an incident plane wave. Analytical results on the scattering by a tubular cylinder of finite length were obtained and compared with experimental data.

ELECTRO-OPTICS

Professor John Powers continued development of electro-optical techniques to measure particle size data within the combustor and across the exhaust nozzle of solid propellant rocket motors. Both experimental and computational aspects were considered for retrieval of particle size from holograms.

Professor Ron Pieper is investigating the use of image visibility as an estimator of image quality to characterize depth-of-focus for incoherent and periodic sources.

RADAR AND ELECTRONIC WARFARE

Professor Michael Morgan continued research in radar target identification using aspect-independent annihilation filtering of natural resonances. Novel and robust signal processing algorithms are being considered for estimation of resonances in transient impulse radar scattering data using scale model aircraft targets.

Professor Hung-Mou Lee continued his investigation of the effects of ducting and the curvature of Earth on sea clutter up to the vicinity of the radar horizon. The results will support tactical operation of a fleet and the local defense of individual ships.

Professor Harold Titus investigated the simulation of designated Soviet missiles and missile radars in support of the Crossbow committee and several of their intelligence teams.

Professor Titus also investigated optimal methods of chaff placement and ship maneuver for ship defense against anti-ship cruise missiles. A simulation was developed to investigate the effectiveness of the NULKA chaff system.

SIGNAL PROCESSING

Professor Ralph Hippenstiel investigated the estimation of non-stationary processes using the Instantaneous Power Spectrum estimator. Representative signals with additive noise were used and the imaginary part of the Rihaczec distribution was used in an attempt to enhance the time-definition of transients.

Professor Monique Fargues continued studies of optimization of an order-recursive generalized eigendecomposition algorithm. Easily computable bounds to eigenvalues of Hermitian pencils were derived and validated during this phase of the effort. A second technique employing extensions to the C-RITE algorithm was also further considered.

Professors Murali Tummala and Charles Therrien further investigated high-resolution spectral estimation algorithms based upon block matrix methods. Applications include estimation of the direction-of-arrival of point sources in low signal-to-noise ratio environments by processing signals received by an array of sensors.

Professors Therrien, Tummala and Roberto Cristi continued their investigation of several techniques for the detection and estimation of multidimensional signals. Work included estimation of parameters, classification of transients, and state-space modeling of stochastic non-Gaussian signals.

Professor Chin-Hwa Lee studied image processing techniques as applied to sensor data. A graph theoretical tracker approach was compared to two other lofargram trackers and the Hough transform technique was evaluated as a possible processing step in a tracker.

Professor Herschel Loomis continued investigations in advanced signal processing algorithms and architectures for the detection and characterization of broadband communications signals in noise and interference.

SYSTEMS AND CONTROLS

Professor Jeffrey Burl continued to advance the theory, practice, and application of estimation and control of distributed parameter systems and large scale space systems. Parameters estimated from an orbiting platform will be compared with a finite element computational algorithm being developed in this effort.

Professor Monique Fargues considered the effects of clock jitter in switched capacitor filters. A review was conducted of previous work and new results were obtained showing that output noise levels may be quite sensitive to jitter perturbations.

Professor Sherif Michael continued research on photovoltaic power technology. Investigation was made of the possibility to anneal a satellite's InP and GaAs solar cells while in orbit using new minority carriers annealing techniques.

Professor Michael also investigated the advantage of applying new composite operational amplifier techniques for radiation hardening of analog networks, using the NPS Linear Accelerator.

In addition, Professor Michael continued the development of a microprocessor based portable tester for monitoring and detecting individual devices with degraded parameters in submarine power supplies.

Professor Titus continued his development of smoothing algorithms to the Kalman filter tracking of torpedoes by acoustic arrays located in a grid on the ocean bottom.

UNDERWATER ACOUSTICS

Professor John Powers and Dr. Rajendar Bahl modeled on a microcomputer the underwater acoustic images produced by a sector-scanning sonar. This included variable target and source characteristics as well as backscatter effects of the sea floor.

Professor Powers also continued design efforts for a multi-channel fiber optic data link from undersea experiments to shore using three approaches: (1) an analog link using FM optical carrier modulation; (2) a high-speed A/D converter to digitize data and; (3) use of code division multiplexing.

Professor Lawrence Ziomek continued the development of both a mathematical and a numerical ocean acoustic pulse-propagation model based on the principles of linear, time-variant, space-variant, random filter theory and the physics of wave propagation in random media.

Professors Miller and Chui continued their feasibility study for an acoustic tomography experiment aimed at monitoring the circulations in the adjacent Norwegian Sea and Barents Sea. They are investigating the viability of using acoustic tomography in such a coastal environment. Development of 3-D sound propagation models is being undertaken.

LOW ANGLE HF COMMUNICATION ANTENNA PERFORMANCE PREDICTION AND VALIDATION

Richard W. Adler, Adjunct Professor of Electrical and Computer Engineering
Sponsor: Naval Engineering Logistics Office

OBJECTIVE: The goal of this third year of a continuing project was to evaluate the effects of finitely conducting ground on the radiation pattern performance mance of a complex HF communication antenna. Numerical modeling provided the predicted patterns and fly-by-measurements were used to obtain the measured radiation fields.

SUMARY: Extensive computer modeling of a conical monopole/log-periodic dipole array antenna system revealed possible pattern degradation in low-angle coverage. The effects of lossy ground on the patterns was calculated. The need to validate these predictions resulted in two month - long field measurement exercises. The ground constants of the terrain surrounding a remote test site was determined by several methods, and was used in computer models via the NEC antenna modeling program. Measured and calculated patterns were in close agreement, validating the computational electromagnetic approach and led to a suggested operational partial fix to the pattern degradation observed.

THESIS DIRECTED: P. Blais, MAJ, USMC, "Validation of the Numerical Electromagnetics Code (NEC3) for a High Frequency Monopole/Log-Periodic Antenna System", Master Thesis, September 1990.

ACTIVE HF ANTENNA EVALUATION

Richard W. Adler, Adjunct Professor
Electrical and Computer Engineering Department
Sponsor: Naval Security Group

OBJECTIVE: The goal of this project is to evaluate the viability of using active (amplified) antennas for Navy HF SIGHT sites worldwide.

SUMMARY: The cost of maintaining the 22 Navy HFDF antenna systems worldwide is becomming excessive. Proponents of active antenna technology cite the many advantages of replacing the huge existing circular arrays of monopoles with compact amplified short monopoles. This study will provide an unbiased test in-situ of all available active HF antennas and will compare them to existing antennas in the real-world signal environments found at operational sites. This first year's effort was devoted to acquiring the antennas for test and developing critical instrumentation.

MODELING AND CONTROL OF LARGE SPACE STRUCTURES

Jeff B. Burl, Assistant Professor of Electrical and Computer Engineering
Sponsor: Naval Research Laboratories
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this research is to minimize and quantify errors in models used for distributed parameter system controller design.

SUMMARY: The modelling and control of large space structures was investigated in this research. Methods of refining model parameters on orbit were studied and developed. Uncertainties due to both the initial finite element modelling and subsequent reduced order modelling were considered. The LACE satellite was used as a testbed for this research. The LACE spacecraft was modelled. A system identification algorithm was developed for processing laser radar measurements of LACE orbit. The parameters estimated on orbit will be compared to those obtained with the finite element model. The resulting estimate of model uncertainty will form an input to control system designers of follow on LACE related spacecraft.

OTHER: Actual measurements of LACE have only recently been obtained due to delays in launching LACE and delays in allowing the spacecraft to be maneuvered for use in this experiment. The processing of these measurements is currently being accomplished by myself and a thesis student, Navy Lt. Thorngren.

J.B. Burl, "Reduced Order System Identification Using the Karhunen-Loeve Transform", IEEE Trans. on Acoustics, Speech, and Signal Processing, 1990, submitted for publication in relation to this research.

ON THE USE OF MULTIPLE-VALUED LOGIC IN THE DESIGN OF DIGITAL SYSTEMS

J.T. Butler, Professor of Electrical and Computer Engineering
C. Yang, Assistant Professor of Electrical and Computer Engineering
Sponsor: Naval Research Laboratory
Funding: Naval Postgraduate School

OBJECTIVE: Develop logic synthesis techniques and computer-aided design tools for multiple-valued logic circuits, and ultimately to produce extremely compact and reliable circuits for use in Navy electronics systems.

SUMMARY: A significant accomplishment this year was the completion of HAMLET [YURC90-1, YURC90-2], a computer-aided design tool for 4-valued current-mode programmable logic arrays (PLA). PLA's are useful as the basis for complete multiple-valued systems. For example, certain binary micro-processors are designed using (2-valued) PLA's exclusively. HAMLET is only the second multiple-valued CAD tool, but is the first tool with wide applicability. It has the further advantage that it is modular, easy to modify (as new technologies evolve), and compatible with the widely used MAGIC VLSI design tools. HAMLET is also a analysis tool for PLA design heuristics. At least four other research groups have used HAMLET for analyzing heuristics. Another significant accomplishment was the development of a new PLA minimization technique, the neighborhood decoupling algorithm [YANG90]. This was shown to be superior to all other existing algorithms, and led to insights on the minimization of functions with a large number of inputs. Progress was made on the cost-table technique [BUT90-1, BUTL90-2, SCHU90] and on the enumeration of paths that sound waves can take in sea water [BUTL90-3].

PUBLICATIONS: J. Yurchak and J.T. Butler, "HAMLET - An Expression Compiler/Optimizer for the Implementation of Heuristics to Minimize Multiple-Valued Programmable Logic Arrays", Proceedings of the 20th International Symposium on Multiple-Valued Logic, May 1990, pp. 144-152.

J.M. Yurchak and J.T. Butler, "HAMLET User Reference Manual", Naval Postgraduate School Technical Report NPS-6290-015, July 1990 (unrefereed).

C. Yang and Y. Wang, "A Neighborhood Decoupling Algorithm for Truncated Sum Minization", Proceedings of the 20th International Symposium on Multiple-Valued Logic, May 1990, pp. 153-160.

J.T. Butler, K.A. Schueller, "On the Equivalence of Cost Functions in the Design of Circuits by Cost Tables", IEEE Transactions on Computers", C-39, June 1990, pp. 842-844.

J.T. Butler, H.G. Kerkhoff and S. Onneweer, "A Comparative Analysis of Multiplexer Techniques for the Minimization of Function Cost Using the Cost table Approach", Proceedings of the 20th International Symposium on Multiple-Valued Logic, May 1990, pp. 286-291.

K.A. Schueller and J.T. Butler, "The Cost Table Problem is NP-Complete", Proceedings of the 28th Annual Allerton Conference on Communication, Control and Computing, Oct. 1990, regular (full) paper (unrefereedd).

J.T. Butler, "On the Number of Propagation Paths in Multilayer Media", Fibonacci Quarterly, Vol. 28, No. 4, November 1990, pp. 334-339.

CONFERENCE PRESENTATION: C. Yang, "A Neighborhood Deoupling Algorithm for Truncated Sum Minimization", the 20th International Symposium on Multiple-Valued Logic, 23 May 1990.

J.T. Butler, "HAMLET - An Expression Compiler/Optimizer for the Implementation of Heuristics to Minimize Multiple-Valued Programmable Logic Arrays", 20th International Symposium on Multiple-Valued Logic, Charlotte, NC, 23 May 1990.

J.T. Butler, "A Comparative Analysis of Multiplexer Techniques for the Minimization of Function Cost Using the Cost-table Approach", the 20th International Symposium on Multiple-Valued Logic, Charlotte, NC, 24 May 1990.

K.A. Schueller, "The Costtable Problem is NP-Complete", the 28th Annual Allerton Conference on Communication, Control, and Computing, 31 Oct. 1990.

THESIS DIRECTED: A. W. Watts, CPT, USA,

"The Use of Searching Algorithms for the Minimization of Multivalued Functions", Master Thesis, June 1990.

U. Ozkan, LTJG, Turkish Navy,
"Application of the Constrained Implicants Set Concept to the Minimization of Binary Functions", Master Thesis, September 1990.

FEASIBILITY STUDY FOR A NORWEGIAN CONTINENTAL SHELF - BARENTS SEA ACOUSTIC TOMOGRAPHY EXPERIMENT

Ching-Sang Chiu, Assistant Professor of Oceanography
James H. Miller, Assistant Professor of Electrical and Computer Engineering
Sponsor: Office of Naval Research

OBJECTIVE: Our primary objective is to assess the adequacy of ocean acoustic tomography for monitoring the circulations in the adjacent Norwegian Sea and Barents Sea. The Barents Sea is a complex acoustic environment. It contains variable shallow bathymetry as well as different water mass types. The transmission of sound there is expected to be highly three-dimensional. An outstanding question is whether acoustic tomography, traditionally used in deep water, is applicable in such coastal area. The understanding of both the forward and inverse problems requires the use three-dimensional (3-D) sound propagation models. The development of 3-D acoustic models appropriate for investigating ray/mode indentifiability and stability and ocean-acoustic interactions in long ranges constitute the other near-term objective.

SUMMARY: The design of a full-scale Norwegian Continental Shelf - Barents Sea tomography experiment requires, as an important first step, a systematic feasibility study. This study consists of three phases. In the first phase, tomography array performance in the Norwegian Sea was simulated in the computer. These simulations gave estimates of system resolution and variance for various array geometries and were essential for assessing the adequacy of acoustic tomography and the selection of optimal configurations in the deep locations. The second phase addresses the acoustic issues of ray/mode identifiability, resolvability, and stability in the Barents Sea. These issues are critical for solving the forward problem of acoustic tomography in this coastal environment and can be investigated through data-model comparisons. Preliminary data will be collected in a transmission test in the spring of 1992. Three-dimensional acoustic models with environment input data will be required in the comparisons. Once the forward problem is understood, synthetic and real-data inversions will be conducted to evaluate system performance in the Barents Sea in the final phase. The first phase of this systematic feasibility study was completed in 1990. In addition, we have made progress in the second phase. The progress includes the development/upgrade of two 3-D sound propagation models and a linear predictive filter to track arrival times of partially resolved acoustic rays. The two acoustic models, a mode and a ray code, are useful for the quantification of 3-D environmental effects on the acoustic wavefield and for ray identification in shallow, bathymetry-varying environments, respectively. The predictive filter is useful for providing additional travel time data from partially resolved rays in coastal tomography experiments.

CONFERENCE PRESENTATIONS: D.F. Smith, L.L. Ehret, J.H. Miller, and C.S. Chiu, "Eigenray Solutions for Cross-Shelf Propagation," San Diego ASA Meeting, November 26-30, 1990. (with published abstract)

R.T. Barock, C.S. Chiu, J.H. Miller, and J.F. Lynch, "Acoustic Tomographic Measurement of Oceanic Advective Heat Flux," 119th ASA Meeting, 1990. (with published abstract)

J.F. Lynch, A.E. Newhall, J.H. Miller, C.S. Chiu, R.C. Dees, K.P. Schaff, and S. Paulsen, "Surface Wave, Wave Group, and Internal Wave Observations In the 1988 Monterey Bay Tomography Experiment," 119th ASA Meeting, 1990. (with published abstract)

THESES DIRECTED: R. Timothy Barock, LCDR, U.S. Navy, "Acoustic Tomographic Estimate of Ocean Advective Heat Flux: A Numerical Assessment in the Norwegian Sea," Master's Thesis, June 1990.

Donald F. Smith, 1st LT, Canadian Navy, "Acoustic Modeling of the Monterey Bay Tomography Experiment," Master's Thesis, December 1990.

BOUNDS ON THE EXTREME GENERALIZED EIGENVALUES OF HERMITIAN PENCILS

Monique P. Fargues, Assistant Professor of Electrical and Computer Engineering
Sponsor: Research Initiation Program
Funding: Naval Postgraduate School

OBJECTIVE: The project is part of an on-going work studying the optimization of an order-recursive generalized eigendecomposition algorithm. The goal of the work to be accomplished this year was to derive easily computable bounds to the extreme eigenvalues of Hermitian pencils, and to compare them to results already known in the literature.

SUMMARY: We derived easily computable bounds on the extreme generalized eigenvalues of Hermitian pencils (R,B) with finite eigenvalues. The bounds were derived in terms of the generalized eigenvalues of the subpencil of maximum dimension (Rn,Bn) contained in (R,B) and were compared with previously derived results. Simulations showed that the tightness of the proposed bounds depends on the pencil considered. However, they are tighter in an average sense, not as restricted, and easier to compute than those derived using previously known results.

PUBLICATIONS: M.P. Fargues, "Bounds on the Extreme Generalized Eigenvalues of Hermitian Pencils," NPS TECHNICAL REPORT, No. NPS62-90-016, December 1990.

OTHER: M.P. Fargues, "Bounds on the Extreme Generalized Eigenvalues of Hermitian Pencils," submitted to IEEE Transactions on Acoustics, Speech, and Signal Processing, December 1990.

EXTENSIONS OF THE C-RITE ALGORITHM TO THE GENERALIZED HERMITIAN EIGENPROBLEM

Monique P. Fargues, Assistant Professor of Electrical and Computer Engineering
Sponsor: Research Initiation Program
Funding: Naval Postgraduate School

OBJECTIVE: The project is part of an on-going work studying the optimization and extension of an order-recursive algorithm designed to compute the generalized eigendecomposition of Hermitian Toeplitz pencils. The goal of the work investigated this year was to study the extensions to more general Hermitian pencils.

SUMMARY: The Hermitian (regular or generalized) eigenproblem occurs in a variety of applications in signal processing. It is commonly encountered in array processing, spectral estimation, filtering and other areas. The classical eigendecomposition techniques are very computationally intensive. As a consequence, techniques capable of highly parallel and localized data flow, taking advantage of VLSI capability, have become an active domain of research. In this project we looked at the extension of an order recursive generalized Hermitian Toeplitz eigendecomposition algorithm with high parallel capabilities (C-RITE) to Hermitian pencils. This extension load to the derivation of the Colored Recursive/Iterative Self-adjoint Eigendecomposition (C-RISE) algorithm inconjunction with A.A. Beex of Virginia Tech and D.M. Wilkes of Vanderbilt University. An important feature of the C-RISE is the inherent computational parallelism of the resulting algorithm. One important advantage of the C-RISE lies in its potentials to solve problems of, an a priori unknown, adequate minimal size rather than a maxmium size only. Results showed that the recursive nature of the algorithm is not detrimental to numerical performances, as it is competitive with standard algorithms solving the single maximum size problem only.

CONFERENCE PUBLICATION: A.A. Beex, D.M. Wilkes, and M.P. Fargues, "The C-RISE Algorithm and the Generalized Eigenvalue Problem," IEEE ICASSP-91, Toronto, Canada, May 14-17, 1991, accepted for publication in the Conference Proceedings, Nov, 1990.

PUBLICATION: M.P. Fargues and A.A. Beex, "Fast Order-Recursive Generalized Hermitian Toeplitz Eigenspace Decomposition, "Mathematics of Control, Signals, and Systems, Vol. 3, No. 4, pp. 65-95, 1990.

OTHER: A.A. Beex, D.M. Wilkes, and M.P. Fargues, "The C-RISE Algorithm and the Generalized Eigenvalue Problem," submitted to IEEE Transactions on Acoustics, Speech, and Signal Processing, December 1990.

ANALYSIS OF CLOCK JITTER IN SWITCHED-CAPACITOR SYSTEMS

Monique P. Fargues, Assistant Professor of Electrical and Computer Engineering
Sponsor: Research Initiation Program
Funding: Naval Postgraduate School

OBJECTIVE: This work is part of an on-going effort which looks at the effect of clock jitter in Switched Capacitor Filters. The goal of the work accomplished this year was to review and to correct previous work done in this area.

SUMMARY: Switched Capacitor (SC) Filters have been of much interest in the last decade due to the extensive range of applications of these circuits in emulating digital filters. Although numerous SC analysis methods have been presented, only a few deal with the problem of noise. This on-going work studies the potential sensitivity of noise levels in SC networks to periodic clock jitter as it may appear from interactions between the power supply and clock phase generator subsystems. The work accomplished this year reviewed and corrected work previously done in this area. It showed that the output noise level may be very sensitive to jitter perturbations and emphasized the need for isolating the clock circuitry from any kind of periodic interference.

PUBLICATION: A.A. Beex and M.P. Fargues, "Analysis of Clock Jitter in Switched-Capacitor Systems," submitted to IEEE Transactions on Circuits and Systems, July 1990, in revision.

RESEARCH IN LOW-ALTITUDE SATELLITE COMMUNICATIONS AND NETWORKS

Tri T. Ha, Porfessor of Electrical and Computer Engineering
Glen A. Myers, Associate Professor Electrical and Computer Engineering
Funding: Naval Postgraduate

OBJECTIVE: The goal of this continuing project was to investigate the performance of various types of frequency hop spread spectrum receivers suitable for satellite communications in low earth orbits.

SUMMARY: Three types of frequency hop spread spectrum receivers were investigated. The first type of receiver employs binary orthogonal frequency shift keying with self-normalization combining to minimize interference effects. Diversity is performed using multiple hops per data bits. The second type of receiver employs M-ary orthogonal frequency shift keying with noise normalization combining to minimize intererence effects. Diversity is performed using multiple hops per data symbols. Error probability analyses were performed for a fading channel with partial band interference. Both types of receiver perform well. The noise normalization combining receiver performs better than the self-normalization combining receiver but is more difficult to implement. The third type of receiver employs a new form of frequency hop, called frequency hop sequence (FHS). With FHS, the data mixes the hop sequences rather than simply offsetting the carrier hop by hop. Error probability analysis was performed in the presence of broadband interference and synchronization error in a Guassian channel.

CONFERENCE PRESENTATION: R.C. Robertson and T.T. Ha, "Error Probabilities of Frequency-Hopped FSK with Self-Normalization Combining in a Fading Channel with Partial-Band Interference", MILCOM '90, Monterey, CA, September 30 - October 3.

T.M. Clemons, R.C. Robertson, and T.T. Ha, "Error Probabilities of Frequency-Hopped MFSK with Noise Normalization Combining in a Fading Channel with Partial-Band Interference", GLOCOM '90, San Diego, CA, December 2-5.

THESES DIRECTED: M.W. Briske, CPT, USA, "Error Probabilities of Frequency-Hopped MFSK with Self-Normalization Combining in a Fading Channel with Partial-Band Interference", Master Thesis, June 1990.

N. Tumok, LT, Turkish Navy, "Voice Communication Using Variable Bit Width Delta Modulation", Master Thesis, December 1990.

T. Ozden, LT, Turkish Navy, "Calculated Noise Performance of a Frequency Hop Sequence Systems with Applications to Low Attitude Satellite Communications", Master Thesis, March 1990.

SPECTRAL ESTIMATION ON NON-STATIONARY PROCESSES

Ralph D. Hippenstiel, Associate Professor of Electrical and Computer Engineering
Sponsor: Naval Ocean System Center
Funding: Naval Postgraduate School

OBJECTIVE: Evaluate the performance of the Instantaneous Power Spectrum (IPS) estimator on some representative signals. Assess if the imaginary part of the Rihaczec Distribution (RD) contains additional information that could enhance the time definition of transients.

SUMMARY: The performance of the IPS relative to WD was presented for signals in Guassian white noise. The performance at the endpoints of the time segment and the lack of segment and the lack of spectral inter-modulation that occurs with the Wigner-Ville Distribution (WD) was demonstrated. The imaginary part of the RD was shown to provide additional information about the time behavior of Frequency Shift Keyed (FSK) signals.

PUBLICATIONS: R.H. Hippenstiel and P.M. Oliveira, "Time Varying Spectral Estimation Using the Instantaneous Power Spectrum (IPS)" IEEE Transaction on Acoustics, Speech, and Signal Processing, Vol. 38, No. 10, pp. 17521759, October 1990.

THESIS DIRECTED: E.H. Stitz, LT, USN, "Instantaneous Power Spectrum", Master Thesis, March 1990.

NEW STRUCTURES FOR THE TAPERED SLOT ANTENNA

R. Janaswamy, Assistant Professor of Electrical and Computer Engineering
Sponsor: Naval Weapons Center, China Lake
Funding: Naval Postgraduate School

OBJECTIVE: To investigate new structures for implementing the tapered slot antenna for microwave and millimeter wave integrated circuits.

SUMMARY: The tapered slot antenna is a wideband travelling wave antenna that is finding increase use in microwave and millimeter wave integrated circuits. Alternate structures were explored for making these antennas compatible with integrated circuits. Two structures have been identified as potential alternatives for implementing the tapered slot antenna. The asymmetric slotline consisting of conductors on opposite sides of a dielectric substrate was analyzed rigorously using the Wiener-Hopf theory. Design data for the slot wavelength and the characteristic impedance were developed.

PUBLICATION: R. Janaswamy, "Wiener Hopf Analysis of the Asummetric Slotline", Radio Science, Vol. 25, No. 5, pp. 699-706, September 1990.

CONFERENCE PRESENTATIONS: R. Janaswamy, "Comparison of Slotlines for Planar Antennas," 1990 Microwave Integrated Circuit Workshop, San Diego, CA, March 19-21, 1990.

R. Janaswamy, "Dominant Mode Characteristics of the Asymmetric Slotline," 1990 IEEE AP-S/URSI Meeting, Dallas, TX, May 7-11, 1990.

THESES DIRECTED: Y.S. Seok, "Comparison of Slotline Characteristics", MSEE, June 1990.

G. Lambrakakis, "Experimental Investigation of a MM-Wave Planar Antenna", MSEE, June 1990.

ON THE DESIGN OF ANECHOIC CHAMBERS

R. Janaswamy, Assistant Professor Electrical and Computer Engineering
Sponsor: Naval Weapons Center, China Lake
Funding: Naval Postgraduate School

OBJECTIVE: To provide a fully validated computer aided software for designing the shape and/or material constants of absorbers for use in anechoic chambers.

SUMMARY: Currently there is a need to study the absorber reflection characteristics with respect to the absorber material shape and its constituent parameters. Analysis and computer codes are being developed to study the reflection characteristics from shaped absorber materials. Integral equations are being solved using the boundary element method. The study will culminate better CAD design of absorber materials lining the walls of an anechoic chamber.

RADIATION AND SCATTERING STUDIES USING THE METHOD OF MOMENTS

David C. Jenn, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Research Initiation Program
Funding: Naval Postgraduate School

OBJECTIVE: The goal is to accurately model various complex microwave antennas used in high performance radar, communication and EW systems. All aspects of antenna design are considered: radiation characteristics, electromagnetic compatibility in the system's operating environment and radar cross section issues.

SUMMARY: During the reporting period an integral equation solution to Maxwell's equations has been applied to cavitybacked wire antennas such as spirals and dipoles. These antennas are in common use as radiating elements in many Navy communication and EW systems. They are also used as feed elements for large radar reflector antennas. The solution was computer coded and the code verified by comparing the results with those from other analytical solutions and measurements. Several important matrix symmetries have been uncovered that allow for a significant reduction in the amount of computer memory required for a given antenna size. Antenna design studies are in progress, and the solution is being extended to include large reflecting surfaces such as those used for satellite dishes.

PUBLICATION: David C. Jenn, "Method of Moments Analysis of Cavity-Backed Wire Antennas", Applied Computational Electromagnetic Society (ACES), The Seventh Annual Review of Progress in Applied Computational Electromagnetics, March, 1991.

OTHER: David C. Jenn, "Method of Moments Analysis of Symmetric Dual Reflector Antennas Including the Feed", North American Radio Science Meeting, June 24-28, 1991.

CIRCUIT MODELING FOR MICROWAVE COMPUTER-AIDED-DESIGN

J.B. Knorr, Professor of Electrical and Computer Engineering
Sponsor: Naval Ocean Systems Center
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project was to develop CAD compatible equivalent circuit models for finline and the inductive strip in finline.

SUMMARY: Equivalent circuit models for homogeneous finline and the inductive strip in homogeneous finline were developed. An analytical procedure for synthesizing an equivalent circuit for an inductive strip in homogeneous finline was derived. The synthesis procedure used numerical data from a spectral domain electromagnetic model to determine equivalent circuit element values. Curve fitting procedures and the scaling principle were used to create a unified equivalent circuit model which was valid for any frequency band and a wide range of structural parameters. The model was shown to accurately predict insertion loss and return loss when used for finline filter simulation.

PUBLICATION: J.B. Knorr, "CAD Models for Inductive Strips in Homogeneous Finline: The Methodology", NPS Technical Report NPS 62-90-007, Naval Postgraduate School, Monterey, CA, March 1990.

J.B. Knorr, "Finline Modeling for Computer-Aided-Design", Proc. 9th Annual Microwave Integrated Circuit Workshop, March 18-21, 1990, San Diego, CA.

J.B. Knorr, "Synthesis of Equivalent Circuits for Inductive Strips in Finline: W/b=1", International Journal of Microwave and Millimeter-Wave Computer-Aided Engineering", forthcoming.

CONFERENCE PRESENTATIONS: J.B. Knorr, "Finline Modeling for Computer-Aided-Design", 9th Annual Microwave Integrated Circuit Workshop, March 18-21 1990, San Diego, CA.

J.B. Knorr, "Recent Advances in Finline Modeling for Computer-Aided-Design", 1990 Microwave Hybrid Circuits Conference, Apache Junction, AZ, November 11-14, 1990.

THESES DIRECTED: T.A. Bush, CAPT, USA, "An Equivalent Rectangular Waveguide Model for Finline", MSEE Thesis, December 1989.

G. Karaminas, LT, RHN, "Circuit Model for an Inductive Strip in Homogeneous Finline", MSEE Thesis, June 1990.

M. Morua, LT, USN, "A Circuit Model for an Inductive Strip in Homogeneous Finline", MSEE Thesis, June 1990.

L. Kurtoglu, LTJG, Turkish Navy, "Analysis of Loss for the Inductive Strip in Finline", MS (Systems Engineering) Thesis, September 1990.

D. Dariotis, LT, Royal Hellenic Navy, "A CAD Model for the Axial Inductive Strip with Finite Thickness Centered in Homogeneous Finline", MSEE Thesis, December 1990.

DIRECT-DETECTION APD-BASED OPTICAL CDMA

Alex W. Lam, Assistant Professor of Electrical and Computer Engineering
Sponsor: Research Initiation Program
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project was to investigate direct-detection APD-based optical code-division multiple-access communications.

SUMMARY: Direct-detection optical code-division multiple-access (CDMA) communication systems with avalanche photodiode (APD) photodetections were investigated. Chernoff upper bound, modified Chernoff upper band, and Gaussian approximation of the probability of bit error (p.b.e.) were presented for general APDS and {0,1}- valued optical signature sequences. Multiple-user interference, shot-noise, and receiver thermal noise effects on the p.b.e. were derived for shot-noise limited systems with geometric-gain distribution APDS. Optical orthogonal codes and modified prime codes were considered. Equal-weight orthogonal signaling formats that do not require dynamic estimation of the receiver threshold were proposed. Our results suggested that equal-weight orthogonal signaling schemes are more preferable to the on-off orthogonal schemes commonly employed in the literature. It was also shown that prime codes are much better than the optical orthogonal codes for optical code-division multiplexing.

PUBLICATIONS: A.W. Lam and A.M. Hussian, "Performance Analysis of Direct-Detection Optical CDMA Communications System with Avalanche Photodiodes", submitted.

CONFERENCE PRESENTATIONS: A.W. Lam, "Direct-Detection APD-Based Optical CDMA Using Orthogonal Signalings". To appear in the Proceeding of the International Phoenix Conference on Computer and Communications, Arizona, March 1991.

DIRECT-SEQUENCES SPREAD-SPECTRUM MULTIPLE-ACCESS COMMUNICATIONS WITH COMPLEX SIGNATURE SEQUENCES

Alex W. Lam, Assistant Professor of Electrical and Computer Engineering
Sponsor: Research Initiation Program
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project was to investigate direct-sequence spread-spectrum multiple-access communications that employ complex signature sequence.

SUMMARY: An unified performance analysis of direct-sequence spread-spectrum multiple-access communications with deterministic complex signature sequences was investigated. The probability density function (p.d.f.) of the multiple-user interference was determined. Using a round-down and round-up procedure on the p.d.f., arbitrarily tight lower and upper bounds on the probability of bit error (p.b.e.) were obtained. Results based on the Gaussian approximation method were also presented. It was shown that complex sequences could yield better p.b.e. performance than binary sequences. Using complex sequences, the number of signature sequences they have good auto/and crosscorrelation properties are greatly enlarged. New users that employ complex or binary signature sequences can be added into existing systems with graceful performance degradation.

PUBLICATIONS: A.W. Lam and F.M. Ozluturk, "Performance Bounds for DS/SSMA Communications with Complex Signature Sequences", submitted.

CONFERENCE PRESENTATIONS: F.M. Ozluturk and A.W. Lamb, "DS/SSMA Communications with Nonbinary Polyphase Signature Sequences", Proceeding of Conference on Information Sciences and Systems, Princeton University , pp 68-73, March 1990.

A.W. Lam and F.M. Ozluturk, "Performance Bounds for Direct-Sequence Spread-Spectrum Communications with Complex Signature Sequences". To appear in the Proceeding of the International Phoenix Conference of Computers and Communications, Phoenix, AZ, March 1991.

COMPUTER AIDED VLSI DESIGN FOR TACTICAL IMAGE PROCESSING

C. -H. Lee, Associate Professor of Electrical and Computer Engineering
Sponsor: Naval Research Laboratory
Funding: Naval Postgraduate School

OBJECTIVE: In this research image processing algorithms were implemented directly onto ASIC chips, using programmable gate arrays (FPGA). Nonlinear algorithms such as similarity counting and dynamic programming will be studied. Emphasis is concentrated on an integrated CAD environment using VHDL for ASIC chip modeling. Particular interests will be the behavioral modeling of programmable VLSI chips with timing elements. This is the first year effort of a three year program.

SUMMARY: The research results can be divided into the following areas:

(1) Algorithms Study: The CAM correlator algorithm was implemented in the Valid Logic environment. We have successfully identified the gate requirements for the three subsystems. Implementations using the Xilinx 3000 chips are definitely achievable. Unless we use the TRW chip, breadboarding the CAM correlator is not possible. We did design with the TRW chip, but reject using it because it is not an optimum choice in our problem.

(2) CAD Environment: The ALTERA design environment has been successfully installed and studied at the Naval Postgraduate School.

(3) Behavioral Modeling of the PLD: The EP1810 and EP310 devices were modeled and simulated. The results were presented in the 1989 VHDL User's Group Meeting, October 22-25, 1989. The complete experience and VHDL source codes are described in the student thesis by S.M. Shu dated December 1989.

(4) System Implementation: The implementation of the CAM correlator was done in the VALID CAD environment. In general, we have learned much from the FY90 efforts. The inadequate speed of the intermetrix VHDL tools in the compilation process is well recognized. The performance
deteriorates especially for large scale systems having over two thousand gates. The simulation time is trivial in the interactive simulation mode. In order to speed up the compilation process we much either use a SUN workstation or model the functional behavior at a higher hierarchy.

PUBLICATIONS: C.-H. Lee and G.P. Quek, "Partial Matching of Two-dimensional Shapes",

Journal of Information Science and Engineering, Vol. 6, No. 4, December 1990.

CONFERENCE PRESENTATIONS: C.-H. Lee, "Functional Verification of Control Synthesis in EPLD Using VHDL", First Europe Conference on VHDL Methods, September 4-7, 1990.

C.-H. Lee, "Testbench of Control Synthesis in EPLD", VHDL Group's Meeting, October 15, 1990.

THESES DIRECTED: I. Ming, LCDR, Royal Tai Navy, "VHDL Simulation of an Implementation of Hardware Cost Function", Master Thesis, September 1990.

T.H. Hu, CPT, Taiwan Army, "Cosine Transform Implementation in VHDL", Master Thesis, December, 1990.

I.L. Lo, LCDR, Taiwan Navy, "Data Flow Description with VHDL", Master Thesis, December, 1990.

OTHER: A EP1800 model written in VHDL has been requested by the Texas Instruments Inc., ASIC applications, Defense Systems and Electronics Group, on October 26, 1990 for internal use and evaluation.

IMAGE PROCESSING APPLIED TO SENSOR DATA

C.-H. Lee, Associate Professor of Electrical and Computer Engineering
Sponsor: Naval Research Laboratory

OBJECTIVE: In this proposal image processing techniques applied to sensor data are studied. The dynamic programming and simulated annealing techniques for image processing are of particular interest. Specific experiments are planned to process acoustic lofargrams to reveal the characteristics of these techniques. On the other hand, other image processing techniques for sensor data will also compared.

SUJMARY: The progress of FY90 can be divided into the following areas:

(1) Comparison of graph theoretical tracker (GTT) with two other lofargram trackers. In terms of superior sensitivity GTT performs better than the other two algorithms. It can also detect swept tonals more accurately than the MAPLE and MTRACK. But, GT yields results more like a detector output. It does not produce track graphics. GTT output has also been fed into the MTRACK. The results were discouraging that does not warrant additional effort to pursue.

(2) Hough transform technique as a possible processing step in a tracker. Hough transform technique seems to show potential as a processing step in the tracker. But, further improvement of cluster analysis is essential to achieve that goal.

(3) Hardware implementation of GTT: The limitation of the GTT algorithm is the long processing CPU time. We did a cost function simulation in VHDL. The clock period is 300ns as compared to 60ns in the NRL hardware. Conclusion is that we can not use PLD for implementation.

(4) Simulated Annealing (SA) technique: We have built a general edge detection simulated annealing algorithm. The algorithm relied too much on an enhancement operation that sets the signal to noise detection cost. We found that the complicated cost factors for processing the lofargram are not necessary. A new cost function needs to be derived.

PUBLICATIONS: C.-H. Lee, "Simulated Annealing Applied to Acoustic Signal Tracking", 24th Annual Asilomar Conference on signals, Systems, and Computers, November 5-7, 1990.

THESES DIRECTED: G.T. Michael, CPT, USA, "Terrain Analysis Using Landsat Thermatic Mapper Imagery", Master Thesis and Electrical Engineer Degree, March 1990.

S.Y. Yang, LT, Korean Navy, "Relaxation Techniques Applied to Acoustic Signals", M.S., June 1990.

C.S. Wang, LCDR, Taiwan Navy, "Acoustic Track Detection by Hough Transform", Master Thesis, September 1990.

A. Ross, LT, USN, "Automatic Lofargram Tracking an Analysis of Two Algorithms", Master Thesis, September 1990.

SHORT RANGE ANTI-AIR RADAR PROPAGATION

H. -M. Lee, Associate Profess of Electrical and Computer Engineering
Sponsor: Office of the Chief of Naval Operations (OP-03B)
Funding: Naval Postgraduate School

OBJECTIVE: To investigate the effects of ducting and the curvature of Earth on sea clutter up to the vicinity of radar horizon. The results will support tactical operation of a fleet and the local defense of individual ships.

SUMMARY: A new earth-flattening approximation based on the differential equations governing wave propagation was found to be consistent with the integral formulation derived and reported earlier. The differential formulation allows ready solution of the fields in the air. The effects of the rough surface can then be coupled into these fields consistently through the integral equations. The M(ulti)-Layer waveguide propagation program developed by NOSC had been investigated. A thorough update of the documentation of this FORTRAN program including a critical review of its theoretical background was completed. This program was installed and has been running at NPS under Microsoft FORTRAN compiler, version 5. Improvements on the program by NPS is being proposed. Experimentally measured data are needed to evaluate the predictions of the theories. Work has been in progress to assemble test equipment for propagation and sea clutter data acquisitions.

PUBLICATION: L.W. Yeoh, "An Analysis of MLAYER: A Multiayer Tropospheric Propagation Program, NPS Technical Report, NPS 62-90-009, June 1990.

H.-M. Lee, "Low Altitude, Over-the-Horizon Propagation Factors: EREPS vs. M-Layer", NPS Technical Report, forthcoming.

THESES DIRECTED: C.-C. Feng, LT, Taiwanese Navy, "Design of a High Power Amplifier", Master Thesis, June 1990.

K.-H. Yen, LT, Taiwanese Navy, "A Digital Radar Receiver", Master Thesis, September 1990.

C.-K. Yu, LCDR, Taiwanese Navy, "Short Range Missile Defense Simulation", Master Thesis, September 1990.

RAY-MODE COUPLING

H. -M. Lee, Associate Professor of Electrical and Computer Engineering
Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: To understand the excitation of internal resonant modes of a cavity by an external plane wave.

SUMMARY: Analytic results on the scattering of a tubular cylinder of finite length was obtained by this investigator. The theory gave extremely accurate results over an extended frequency range even with the presence of internal resonance modes when checked against experimental data. In 11989, the investigator agreed to cooperate with MIT to obtain ONR funding in 1990 to support one and a half man-years of MIT graduate students to utilize the Mellin transform technique to solve problems of more complex geometries. Due to the delay at ONR and the funding cut back at NPS, this effort will not be continued beyond FY91. Experimental investigation is currently being conducted at NPS to measure the resonances in a slotted cylindrical cavity. The efficiencies of slots of various widths to couple electromagnetic energy from plane waves into the cavity will be investigated over several cavity resonances.

AUTOMATED DESIGN OF VLSI DEVICES FOR NAVY SPACE APPLICATIONS

H.H. Loomis, Jr., Professor of Electrical and Computer Engineering
Sponsor: Assistant Secretary of Air Force

OBJECTIVE: To investigate computer aided design (CAD) techniques for complex VLSI chips to achieve high performance or special functionality. To provide a vehicle for the evaluation of Application Specific Intergrated Circuits (ASICs) to the problems of SPAWAR.

SUMMARY: The Silicon Compiler is a complex item of system software which takes as an input system level descriptions of digital systems. The output of the software are detailed layouts of a VLSI chip suitable for fabrication in any of a number of possible technologies. The applicability of a specific Silicon Compiler to the Navy's ASIC needs, in particular in spaceborne systems has been investigated. The tool has also been used to evaluate the effect of different technologies on performance of ASIC's.

Finally, testing and design-for-test systems and design procedures for VSLI have been developed. Custom chip architectures for portions of a Spaceborned processor being developed for SPAWAR are being designed.

PROJECT GUSTY ORIOLE

H.H. Loomis, Jr., Professor of Electrical and Computer Engineering
Sponsor: Secretary of 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 operational problems concerned with the employment of tactical information for decision making and targeting.

THESES DIRECTED: "A Study of the Concept of Operations and Future Direction of the Tactical Receive Equipment (TRE) and Related Applications (TRAP) Broadcast", Jeremy L. Panoff, LT USN, Master of Science in Telecommunications Systems Management, March 1990.

"Noise Adaptation and Correlated Maneuver Gating of an Extend Kalman Filter", Stephen L. Stephen, CAPT, USMC, Electrical Engineering, March 1990.

"Satellite servicing Using the Orbital Maneuvering Vehicle in Low Earth Orbit", Anthony D. Cutri, LCDR USN, Master of Science in Systems Technology (Space Systems Operation), June 1990.

ADVANCED SIGNAL PROCESSING TECHNIQUES

H.H. Loomis, Jr., Professor of Electrical and Computer Engineering
Sponsor: Assistant Secretary of the Air Force

OBJECTIVE: To investigate advanced signal processing algorithms and architectures for the detection and chracterization of broadband communications signals in noise and interference.

SUMMARY: The efforts under this project have been concentrated in the investigation of the performance of algorithms for the detection, location and characterization of broadband signals in strong noise and interference, and of the design of digital architectures for the implementation of the more promising algorithms. This work has involved significant cooperation with Dr. W.A. Gardner, which has provided a rich fabric of theoretical results in candidate algorithms for student thesis work. Also as a part of this project, a special workshop in "Quadratic Signal Processing" was organized and held in Washington, DC at NRL in February 1990. Currently, the third annual such workshop is being organized for April 1990 at NPS.

PUBLICATIONS: Michael A. Soderstrand, H.H. Loomis, Jr., and R. Gnanasekaran, "Pipelining Techniques for IIR Digital Filters", Proceedings of the 1990 International Symposium in Circuits and Systems, May 1990, New Orleans, LA.

Randy S. Roberts, W.A. Brown, H.H. Loomis, Jr., "Computationally Efficient Algorithms for Cyclic Spectral Analysis", Accepted for Publication in Signal Processing Magazine, March 1991.

SUBMITTED: M.A. Soderstrand, H.H. Loomis, K.V. Rangarao, "Elimination of Narrow-Band Interference in BPSK-Modulated Signal Reception", submitted to the 1991 IEEE International Symposium Circuits and Systems, Singapore, June 1991.

THESES DIRECTED: "Despreading of Spread Spectrum Signals", Gregory Point, LT, USN, Master of Science in Electrical Engineering, June 1990.

"Spread Spectrum Implications in Radar", William A. Hartung, LT USN, Master of Science in Systems Technology (Space Systems Operations), September 1990.

"Detection of a Frequency Hopped Direct Sequence Hybrid Signal with Cyclic Spectrum Analysis", Danny G. Farley, LCDR USN, Master of Science in Systems Engineering (Electronic Warfare), December 1990.

OTHER: H.H. Loomis, Jr., Organizer, Quadratic Signal Processing, Representatives of SPAWAR 004, Naval Security Group Command, Naval Postgraduate School and Contractors, Naval Research Lab, February 1990.

ON-ORBIT ANNEALING OF SATELLITE SOLAR PANELS

Sherif Michael, Associate Professor of Electrical and Computer Engineering
Sponsor: Space and Naval Warfare Command (SPAWAR)
Funding: Naval Postgraduate School

OBJECTIVE: Investigate 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, and incorporating the system proposed in FY 89 research. The tasks also include investigation of Photovoltaic current annealing processes and other related topics of radiation effects on GaAs, InP and Si devices.

PUBLICATIONS: S. Michael, C. Cypranowski and B. Anspaugh, "Forward-Biased Current Annealing of Radiation Degraded Indium Phosphide and Gallium Arsenide Solar Cells", the proceedings of the 21st IEEE Photovoltaic Specialists Conference, Kissimmee, Fl, May 1990.

CONFERENCE PRESENTATION: S. Michael, "On-Orbit Annealing of Satellite Solar Panels", The Interagency Advanced Power Group Workshop, Orlando, FL, April 1990.

S. Michael, "Forward-Biased Current Annealing of Radiation Degraded Indium Phosphide and Gallium Arsenide Solar Cells," the proceedings of the 21st IEEE Photovoltiac Specialists Conference, Kissimmee, Fl, May 1990.

RADIATION INSENSITIVE SEMICONDUCTOR NETWORKS

Sherif Michael, Associate Professor of Electrical and Computer Engineering
Sponsor: NRL, Naval Research Laboratories
Funding: Naval Postgraduate School

OBJECTIVE: Investigate the advantage of applying the new Composite OPAMP techniques for radiation hardening of analog networks, using the NPS Linear Accelerator.

SUMMARY: In this research a novel technique for reducing active device sensitivity to radiation is investigated. 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 ORION satellite hardware survivability in space.

PUBLICATIONS: S. Michael and W. Conklin, "LINAC Experimental Results Demonstrating a Novel General Approach to Radiation Insensitive Linear Network Design", Proceedings of the Hardened Electronics and Radiation Technology Conference (HEART), Monterey, CA, Feb. 1990.

S. Michael and R. Cristi, "Integrated Programmable Operational Amplifiers With Improved Characteristics," Proceedings of the 1990 European Conference on Applied Specific Integrated Circuits (EURO ASIC), Paris, France, May 1990. pp. 74-79.

C. Cameron and S. Michael, "An Elliptic Filter Design for the Space Shuttle Vibro-Acoustic Experiment", the Proceedings of the 1990 Midwest Symposium on Circuits and Systems, Calgary, Canada, August 1990.

CONFERENE PRESENTATIONS: S. Michael, "Integrated Programmable Operational Amplifiers With Improved Characteristics," the 1990 European Conference on Applied Specific Integrated Circuits (EURO ASIC), Paris, France, May 1990.

AN AUTOMATED MONITORING SYSTEM FOR SUBMARINE POWER SUPPLY

Sherif Michael, Associate Professor of Electrical and Computer Engineering
Sponsor: Naval Sea System Command (NAVSEA)
Funding: Naval Postgraduate School

OBJECTIVE: Developing a Microprocessor-Based Portable Tester for monitoring and detecting individual devices with degraded parameters in submarine power supplies.

SUMMARY: This research is proposed to investigate the possibility of developing a Microprocessor based system to monitor individual device performance in submarine power supplies. The research is also intended to investigate alternative spectral analysis techniques that could be of benefit in determining degraded performances of various power supply active devices.

PUBLICATIONS: R. Cristi and S. Michael, "An Estimation Theoretic Approach to the Asynchronous Detection of PSK Signals", Proceedings of the 1990 IEEE International Symposium on Circuits and Systems, New Orleans, LA, May 1990, pp. 1788-1792.

COMMUNICATIONS DIGITAL SIGNAL PROCESSING MULTI-FREQUENCY MODULATION

Paul H. Moose, Associate Professor of Electrical and Computer Engineering
Sponsor: Naval Ocean Systems Center
Funding: Naval Postgraduate School

OBJECTIVE: The objective of this project is to develop high-speed, bandwidth efficient digital communications modulation and coding methods that can be implemented utilizing low cost, widely available DSP chips and associated integrated circuits components.

SUMMARY: Multi-Frequency Modulation (MFM) has been determined to be one of the most efficient digital modulation techniques for high-speed communication of data and digital signals. Furthermore, the carrier modulation and synthesis at the transmit node, and optimal carrier detection and demodulation at the receiver node, is particularly well suited to DSP implementation. During 1990, we have concentrated on developoing methods of differentially encoding MFM to make it suitable for transmission over unequalized channels. We have also adapted trellis coded modulation (TCM) to MFM which, when combined with time/frequency domain interleaving, makes MFM particularly suitable for high bit rate transmission in the presence of sever multi-path channels such as will occur in mobile RF and in most acoustic channels.

PUBLICATIONS: P.H. Moose, "Differentially Coded Multi-Frequency Modulation for Digital Communications", Signal Processing V: Theories and Applications, L. Torres, E. Masgrau, and M.A. Lagunas (eds.), Elesvier Science Publishers B.V., 1990.

P.H. Moose, "A Progress Report on Communications Digital Signal Processing: Theory and Performance of Frequency Domain Differentially Encoded Multi-Frequency Modulation", NPS62-90-012, Naval Postgraduate School, Monterey, CA, 1990.

CONFERENCE PRESENTATION: P.H. Moose, "Differential Modulation and Demodulation of Multi-Frequency Digital Communications Signals", MILCOM 90, Monterey, CA, 1990.

THESES DIRECTED: Peter G. Basil, LT, USCG, "Real-Time Multi-Frequency Modulation Using Differentially-Encoded Signal Constellations", MSEE, June 1990.

Robert W. Ives, LT, USN, "Error-Control Coding For Multi-Frequency Modulation", MSEE, June 1990.

Charles P. Salsman, LCDR, USN, "Application of Multi-Frequency Moduation (MFM) for High-Speed Data Communications to a Voice Frequency Channel", MSEE, June 1990.

James T. Nickerson, LCDR, USN, "Application of Multi-Frequency Modulation (MFM) to Facsimile Machines", MSEE, September 1990.

PATENT: P.H. Moose, "Multi-Frequency Differentially Encoded Digital Communications For High Data Rate Transmission Through Unequalized Channels", application submitted 6 March 1990.

RADAR TARGET IDENTIFICATION USING NATURAL RESONANCES

Michael A. Morgan, Professor of Electrical and Computer Engineering
Sponsor: DARPA Tactical Technology Office

OBJECTIVE: Investigate new signal processing and filtering methods for the identification of radar targets using aspect-independent complex resonances.

SUMMARY: Target Identification using annihilation filtering of natural resonances was investigated. Two new signal processing algorithms were considered for estimation of complex natural resonances in experimental radar scattering data. Target pole invariance to aspect was demonstrated for metallic scale model tactical aircraft. An inverse ARMA resonance annihilation filter was developed which provides increased discrimination potential by canceling the entire scattering signal of matched targets. A new discrete interaction concept for computing natural resonances of electromagnetic and acoustic scattering structures was investigated. The transient electromagnetic scattering laboratory was upgraded using dual transmission power amplifiers to double the measurement bandwidth to 1 to 12 GHz and increase typical SNR to 30 dB.

PUBLICATION: M.A. Morgan and N.J. Walsh, "Ultra-Wideband Transient Electromagnetic Scattering Laboratory", submitted to IEEE Trans. Antennas and Propagation, March 1990.

CONFERENCE PRESENTATIONS: M. A. Morgan and N.J. Walsh, "Ultra-Wideband Impulse Electromagnetic Scattering Laboratory ," Los Alamos Symposium on Ultra-Wideband Radar, March 5 - 8, 1990, Los Alamos, NM.

M.A. Morgan and P.D. Larison, "Natural Resonance Extraction from Ultra-Wideband Scattering Signatures," Los Alamos Symposium on Ultra-Wideband Radar, March 5 - 8, 1990, Los Alamos, NM.

M.A. Morgan, "Research in Natural Resonance Radar Target Indentification," 1990 Nuclear EMP Meeting, May 21 - 25, University of New Mexico.

THESES DIRECTED: T.J. Murphy, CAPT, USMC, "Natural Resonance Extraction and Annihilation Filtering Methods for Radar Target Identification", M.S.E.E., September 1990.

P.C. Reddy, CAPT, USMC, "Radar Target Classification by Natural Resonances: System Analysis", M.S.E.E., September 1990.

Yuval Cohen, LCDR, Israeli Navy, "Discrete ARMA Model for Natural Resonances in Electromagnetic and Acoustic Scattering", M.S.E.E., September 1990.

COMPUTER AIDED DESIGN OF NAVY MISSILE RADOMES

M.A. Morgan, Professor of Electrical and Computer Engineering
R. Janaswamy, Assistant Professor of Electrical and Computer Engineering
Sponsor: Naval Weapons Center, China Lake
Funding: Naval Postgraduate School

OBJECTIVE: To provide fully validated computer aided design software for Navy and DoD use in designing missile radomes.

SUMMARY: This research is directed towards development of finite element computer programs for evaluating the radiation patterns of radome enclosed antennas on Navy missiles. Efforts by Morgan were directed towards immediately usable software while those of Janaswamy considered advances in basic research whose future application will provide enhanced capabilities. An axisymmetric radome finite element program was developed along with a 3-D graphics display program. Testing was accomplished for simple radome shapes. Future validations include comparisons with experimental data to be provided by the sponsor. A computer program was also developed to compute the radar cross section of arbitrarily shaped lossy dielectric cylinders using the On-Surface Radiation Condition (OSRC) method. A second order radiation boundary condition in scattering by homogeneous cylinders was investigated. It was round, contrary to previous claims, that the OSRC method does not always yield acceptable results even for electrically large cylinders.

PUBLICATIONS: M.A. Morgan and T.B. Welch, "Field Feedback Computation of Scattering by 2-D Penetrable Objects," submitted for publication, IEEE Trans. Antennas and Propagat., April 1990.

R. Janaswamy, "On the Application of Second Order Radiation Boundary Condition to Scattering by Homogeneous Cylinders," submitted for publication, IEEE Trans. Antennas Propagat., July 1990.

CONFERENCE PRESENTATION: R. Janaswamy, "Scattering by Homogeneous Cylinders Using Surface Radiation Conditions," to be presented at the 1991 IEEE Antennas Propagation/URSI Meeting, Ontario, Canada, June 24-28, 1991.

THESES DIRECTED: R.J. Vince, LT, USN, "An Electromagnetic Radome Model Using an Interactive Computer Finite Element Algorithm," M.S.E.E, January 1990.

R. Rostant, LT, USN, "Efficient Computation of Near-Fields Due to 2-D Sources," M.S.E.E., December 1990.

S.M. Ali, LCDR, Pakistan Navy, "Plane Wave Scattering from Circular and Hollow Circular Slit Cylinders Using the On-Surface Radiation Boundary Condition Method," M.S.E.E., December 1990.

SOLID PROPELLANT COMBUSTION/AUTOMATED DATA RETRIEVAL FROM HOLOGRAMS

David Netzer, Professor of Aeronautics and Astronautics
John Powers Professor of Electrical and Computer Engineering
Sponsor: Air Force Astronautics Laboratory

OBJECTIVE: To develop techniques to obtain particle size data within the combustor and across the exhaust nozzle of solid propellant rocket motors.

SUMMARY: This continuing investigation consists of two main studies: (1) experimentally measuring particulate sizes using measurements of forward scattered light, holography, high speed motion pictures and SEM evaluation of residue collected in an exhaust probe; and (2) development of techniques for computer-aided automatic retrieval of particulate size data from holograms. The former effort is summarized in the report from Professor D.W. Netzer. Feature identification and counting was speeded up through the reprogramming of our algorithms into C language. Speed improvements continue to be achieved as the code is optimized. Additionally, less fragmentation of the programs is required. Memory limitations imposed by DOS in the Fortran programs limited some processing to partial images. These memory limitations were removed by the dynamic memory allocation techniques that C allows. Additionally the processing had to be done with sequential Fortran programs due to limited memory. Now all operations are done in one program on full screen images under menu control.

PUBLICATIONS: J. Powers, "Automatic Particle Sizing from Rocket Motor Holograms", Technical Report NPS-EC-91-003, Naval Postgraduate School, Monterey, California, 1990.

THESIS DIRECTED: "Particle Sizing in Rocket Motor Holograms Using a C Language Program", Valerie Hochgraver, LT, USN, MSEE, September 1989.

A VISIBILITY DEPENDENT DEPTH OF FOCUS FOR INCOHERENT PERIODIC SOURCES

Ron J. Pieper, Associate Professor of Electrical and Computer Engineering
Sponsor: Research Initiation Program
Funding: Naval Postgraduate School

OBJECTIVE: Characterize the depth-of-focus for sources which are both incoherent and periodic.

SUMMARY: The often cited criterion for the depth-of-focus is expressed solely in terms of the f/# of the imaging system and the wavelength of light. Perceived image quality will generally depend on not only these parameters but also the spectral content of the object. Recent investigations on this subject have shown that the deterioration of the depth-of-focus with spatial frequency can be developed using the image visibility as an estimator of image quality. An extension of this work to cover general periodic profiles has been proposed. The analysis developed would be applicable to the standard bar type patterns often employed to characterize the resolution capabilities of infrared imaging systems.

PUBLICATIONS: R.J. Pieper, K. Raj. T.-C. Poon, "A Visibility Dependent Depth of Focus for Incoherent Sinusoidal Sources", Applied Optics, submitted.

CONFERENCE PRESENTATION: K. Raj .-C. Poon, R.J. Pieper, "A Visibility Dependent Depth of Focus for Incoherent Sources", Optical Society of America, National Meeting, Boston, MA, October 1990.

ACOUSTO-OPTIC CHANNELIZER STUDY

John P. Powers, Professor of Electrical and Computer Engineering
Sponsor: Space and Naval Warfare Systems Command
Funding: Naval Postgraduate School

OBJECTIVE: The objective of this work is to use acousto-optic principles to divide the spectrum of a wide-band spread-spectrum signal into sub-channels. All sub channels can be, in principle, coherently summed to reconstruct the original signal. Effects due the fiber optic pickup array and imbalances in the subchannel response degrade the reconstructed signal. Our goal was to experimentally demonstrate the channelization and reconstruction of a wideband signal and to simulate the system on a computer for parametric study.

SUMMARY: We have successfully transmitted and recovered a wideband BPSK signal through our bragg cell system. The optical interferometer system was aligned and a signal generator was constructed and tested. (The main problem in the signal simulator turned out to be synchronization of the rf generators used in the simulator.) The system has been successfully simulated using the MATLAB computer program on a 386-type computer. Because of the high rf frequencies involved, signal samples had to be closely located in time and a large data sample was required. An extended version of MATLAB that allows operation beyond the 650K memory limits of DOS was required, along with an 8-megabyte-memory computer.

PUBLICATIONS: J.P. Power, CPT J.P. Harvey and LT D. Marinsalta, Acoustic Channelizer Study, To be published in Proceedings of the 1990 IEEE Ultrasonics Symposium, IEEE Press, New York.

CONFERENCE PRESENTATIONS: J.P. Powers, CPT J.P. Harvey and LT D. Marinsalta, Acoustic Channelizer Study, IEEE Ultrasonics Symposium, Honolulu, December 1990.

SECTOR-SCANNING SONAR ACOUSTIC IMAGING

John P. Powers, Professor of Electrical and Computer Engineering
Dr. Rajendar Bahl, NRC Research Associate
(Indian Institute of Technology)
Sponsor: National Research Council
Funding: Naval Postgraduate School

OBJECTIVE: The objective of this work was to model on a microcomputer the underwater acoustic images produced by a sector-scanning sonar. The shape of the target and the source-target geometry are variable and controllable by the operator. Backscatter effects from the sea floor and backscattering from the medium are also included in the model. Geometric distortions are corrected allowing an ortholinear representation of the image. Efforts were also begun on the classification of targets based on their acoustic image and, particularly, on their acoustic shadow.

SUMMARY: We have successfully constructed an image model that produces an acoustic image representation on a video screen using an PCVisionplus image processing board hosted on a 386-based microcomputer. Objects are simulated by stacks of wire-frame components that simulate various geometric shapes such as cylinders, rectangles, and spheres. More complicated geometries are simulated by assemblies of these basic geometric shapes. The user provide geometrical information and the programs assemble the objects and produce the acoustic images. These images can be observed in their raw form or can be corrected for geometric distortion. Preliminary efforts on classifying objects by their acoustic shadow showed promise of success. Work is continuing on this aspect of our research.

PUBLICATIONS: R. Bahl and J. Powers, Computer Model of a High-Resolution Imaging Sonar, Technical Report NPS-62-90-011, Naval Postgraduate School, Monterey, California, 1990.

R. Bahl and J. Powers "HIRSM: Computer Model of a High Resolution Imaging Sonar", submitted to IEEE Journal of Oceanic Engineering.

UNDERWATER FIBER OPTIC COMMUNICATIONS

John P. Powers, Professor of Electrical and Computer Engineering
Sponsor: Space and Naval Warfare Systems Command
Funding: Naval Postgraduate School

OBJECTIVE: To study the use of fiber optic cables for transmitting the data. This report is on the fiber optic telemetry portion of this project.

SUMMARY: Design efforts continued on a multi-channel fiber optic data link from undersea experiments to shore. Three approaches were investigated. The first is an analog link using FM optical carrier modulation to allow multiple analog channels to be frequency division multiplexed and transmitted over the fiber. A set of active filters separate and detect the channels. (Active filters using commercial components have been designed and test up to 10 MHz operating frequencies, for the first time.) The second approach uses a high-speed A/D converter to digitize the data. A micro-processor controls the digitization, time-domain multiplexing, and frame synchronization. The clock encoded data stream is received and demodulated at the receiving end. The third approach studied the use of code division multiplexing to all several channels of information to be transmitted simultaneously.

THESES DIRECTED: "Implementation of a Code Division Multiple Access Transmitter Receiver Scheme Utilizing a Fiber Optic Medium", Scott Sundt, LT, USN, MSEE, December 1989.

"RF Frequency-Division Multiplexing on a Fiber Optics Communications Link", Ilias Dimopoulos, LT, Hellenic Navy, MSEE, December 1989.

"Design of a Stabilized, dc-powered Analog Laser Diode Driver", John Bradunas, MAJ, USMC, MSEE, September 1990.

CORRECT PACKET CAPTURE IN MOBILE DATA COMMUNICATIONS WITH CONVOLUTIONAL CODING

R. Clark Robertson, Associate Professor of Electrical and Computer Engineering
Sponsor: Research Initiation Program
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project was to examine the effect of the capture phenomenon on local/mobile packet radio systems and to determine if the pseudo-Bayesian algorithm can be used to stabilize these systems at maximum channel throughput in the local/mobile operating environment.

SUMMARY: An analysis of the performance of a local/mobile radio communications system utilizing the slotted Aloha multiple random access protocol was performed. The probability of correct packet capture was evaluated for a local/mobile packet radio system using ideal coherent binary phase-shift-keying (BPSK) modulation. Both the near/far effect and the effect of Rayleigh fading on the probability of correct packet capture were taken into account, but the effect of thermal noise was neglected since the interference due to competing packets is dominant in practical systems. The probability of correct packet reception was evaluated for a system using spatial diversity. In addition, the effect on system performance of either convolution coding with hard decision Viterbi decoding or binary linear block coding with hard decision decoding was evaluated. The pseudo-Bayesian algorithm that has been developed to stabilize a packet system based on the slotted Aloha protocol at maximum channel throughout was found to be adaptable to the local/ mobile operating environment. For the slotted Aloha system considered, it is possible to obtain channel throughputs as high as 0.66 provided a spatial diversity of around ten can be implemented.

PUBLICATIONS: R. Clark Robertson and Tri T. Ha, "A Model for Local/Mobile Radio Communications with Correct Packet Capture," IEEE Transactions on Communications, forthcoming.

CONFERENCE PRESENTATION: R. Clark Robertson and Tri T. Ha, "A Model for Local/Mobile Radio Communications with Correct Packet Capture," 1990 IEEE Military Communications Conference, Monterey, CA, September 30 - October 3, 1990.

MAPPING HARD REAL-TIME APPLICATIONS ON LOOSELY COUPLED MULTIPROCESSORS

Shridhar B. Shukla, Assistant Professor of Electrical and Computer Engineering
Sponsor: Research Initiation Program
Funding: Naval Postgraduate School

OBJECTIVE: The objective of this two-year project is development of a framework for mapping hard real-time applications on loosely coupled mutliprocessors to guarantee performance. The emphasis is on task allocation to minimize contention-based communication cost and on contention-free message routing.

SUMMARY: Current multiprocessor mapping strategies for task allocation and message routing are unsuitable for hard real-time applications because they are independent of each other, and therefore, make system-level performance guarantees difficult to achieve. In the first year of developing an integrated mapping strategy, a task allocation algorithm that minimizes the number of hot-spots in the network has been developed. A routing technique to generate and execute a distributed message transmission schedule that uses time bounds on individual messages has been developed. Simulation experiments on various 64 node multicomputer topologies have shown that the contention-based allocation algorithm significantly improves performance and the explicitly scheduled communication guarantees throughput and eliminates flow-control overhead.

OTHER: After the initial phase of algorithm and program development, the results have been compiled and the following manuscripts have been submitted for publication.

1. Shridhar B. Shukla, D.P. Agrawal, "Scheduling Communication in Multicomputers for Real-time Task-level Pipelining", Journal of Parallel and Distributed Computing, submitted in Nov. 90 for publication in the special issue on massively parallel computation.

2. Shridhar B. Shukla, D.P. Agrawal, "Scheduling Pipelined Communication in Distributed Memory Multiprocesors for Real-time Applications", submitted in Nov. 90 for presentation at the 18th International Symposium in Computer Architecture, May 1991.

3. Shridhar B. Shukla, D.P. Agrawal, "Task Allocation in Distributed Memory Multiprocessors for Periodic Real-time Applications", submitted in Jan. 91 for presentation at the 20th International Conference in Parallel Processing, August 1991.

The software developed for this project so far consists of approximately 6000 lines of C code.

HIGH-RESOLUTION SPECTRAL ESTIMATION AND DIRECTION FINDING PROBLEMS

Charles W. Therrien, Professor of Electric and Computer Engineering
Murali Tummala, Associate Professor of Electric and Computer Engineering
Sponsor: Naval Ocean Systems Center, San Diego, CA
Funding: Naval Postgraduate School

OBJECTIVE: The main goal of this work was to develop high-resolution spectral estimation algorithms based on block matrix methods to process signals received at an array of sensors.

SUMMARY: The work involved development of block algorithms based on both Lanczos method and least squares techniques. These algorithms are applicable where we need to estimate only a few of the extreme eigenvalues or seek the spectrum corresponding to the minimum least squares error criterion. Both approaches are iterative in nature meaning they start with an approximate solution and continuously update it until satisfactory accuracy is achieved. Particular applications of interest to us are high resolution spectral analysis and estimation of the direction-of-arrival of point sources in low signal-to-noise ratio environments. The block Lanczos algorithm falls under a class of problems called subspace methods. We have used the spectral product technique, previously used in the single vector case, to enhance the spectral estimation performance at low signal-to-noise ratios down to about -5 dB. The perturbation analysis of Lanczos class of algorithms is currently in progress which is required to evaluate the effects of data error measurements, covariance estimation errors, and the numerical error in the algorithm. The least squares algorithm is centered around the multidimensional data formulation. The algorithm developed considers quarter-plane, nonsymmetric half-plane, and combined quadrant parameter array supports. The combined quadrant method has produced encouraging results at SNRs down to 0 dB and required only one iteration. The algorithm was tested on several two target cases with the simulated data being measured at a linear array yielding a data set of size 8 times 8 and mask size of 3 times 3.

PUBLICATION: R. Wester, M. Tummala, C.W. Therrien, "Multidimensional Autoregressive Spectral Estimation Using Iterative Methods", Proc. Twenty-Fourth Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, November 1990.

THESIS DIRECTED: R. Wester, "Two-Dimensional Autoregressive Spectral Estimation Using Iterative Methods", Master Thesis, June 1990.

CHAFF & OFF-BOARD DECOYS

H. Titus, Professor of Electrical and Computer Engineering
Sponsor: NAVSEA, Code 06W312

OBJECTIVE: The goal of this project was to develop a simulation on the use of NULKA and chaff in ship defense, and to study their effectiveness.

SUMMARY: For some years we have studied ship defense against the ASCM using chaff. This primarily entailed simulating the missile-ship encounter with various chaff placements, wind conditions and strategies. Variations of these programs are being used by friendly nations (Israel and Brazil). The US Navy's chaff systems are most effective in confusing the enemy's search and acquisition systems. Because of the fixed amount launchers, they are of marginal effectivenss in the terminal track phase of a missile attack. The development of the NULKA is an attempt to address this problem. We developed a simulation to investigate the use of the NULKA. LCDR Mike Sagen did a very good job. Mr. Ray Lee is continuing on with this simulation extending it to include several ships and other players. The optimal jamming technique and trajectory for the NULKA is quite critical. A version of this work is being submitted to the Tri-Service EW Symposium. NULKA has suffered large cost overruns and time slippages. The project has been trimmed and the development time has been extended. I still feel strongly that it is an important adjunct to our ship defense.

TORPEDO TRACKING

H. Titus, Professor of Electrical and Computer Engineering
Sponsor: NUWES, Keyport Washington

OBJECTIVE: Our task was to develop a Kalaman filter torpedo tracking program which incorporated the acoustic range data and the torpedo's INS data as well.

SUMMARY: For over a dozen years, we have had thesis students and faculty involved in various torpedo tracking problems as requested by the research arm of the NUWES facility. This past year we investigated the Kalaman filter fusing and smoothing of the range acoustic data with an internal INS data. Lt Alfaro has done a very good job and they are incorporating his work. The problem was made interesting due to the fact that the INS had very high drift rates, making a problem in aligning accelerometer outputs to the range coordinate system. The observation rates were nonsynchronous, and the acoustic data had dropouts, and discontinuities as the torpedo would pass from one acoustic array to another.

MISSILE SIMULATION

H. Titus, Professor of Electrical and Computer Engineering
Department of Electrical and Computer Engineering
Sponsor: US Army Missile & Space Intelligence Center

OBJECTIVE: The purpose of this effort was to support the Crossbow Committee and several of their intelligence teams. We studied and simulated several Soviet missiles and attempted to develop techniques to counter them.

SUMMARY: We have studied and simulated in considerable detail, the Soviet SA-6, SA-11, and now the follow on system, SA-17x. The SA-6 was used effectively in the 73 War by Egypt. It is a major system in Iraq. The follow on, the SA-11 is operational in the Soviet Union. The SA-17x is in R&D test. Our task is to know everything possible about the guidance and control of these systems. We have frequent briefings by CIA, NSA, DIA, MSIC and others. The simulations have been used to study the missile systems and how to counter them. The purpose of this group is to design and develop several of these systems to be used at appropriate Air Force and Navy facilities.

UNDERWATER ACOUSTIC PROPAGATION AND SCATTERING IN A RANDOM OCEAN - A LINEAR SYSTEMS THEORY APPROACH

Lawrence J. Ziomek, Associate Professor of Electrical and Computer Engineering
Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: Continuation of the development of both a mathematical and a numerical ocean acoustic pulse-propagation model based on the principles of linear, time-variant, space-variant, random filter theory and the physics of wave propagation in random media.

SUMMARY: A full-wave, pulse propagation model for three dimensional wave propagation in a Pekeris waveguide based on linear systems theory is under continued development and generalization. The randomly rough ocean surface and bottom are accounted for via coherent (average) reflection coefficients. Frequency dependent attenuation in all three fluid media is included. Transmit and receive planar arrays with beam steering can be simulated and, as a result, vertical arrays and a single, omnidirectional point source are automatically included. A built in signal generator can simulate arbitrary amplitude and angle modulated transmitted pulses. Outputs from this model include plots of the magnitude and phase of the ocean surface and bottom reflection coefficients and the complex frequency spectrum of the acoustic field across the receive array. Also, plots of the time-domain pulse(s) at the receive array are provided. Ray trace plots, travel time calculations (especially at focal points) along individual ray paths using cubic splines to fit measured (i.e., experimentally obtained) depth-dependent sound-speed data has been accomplished. Computer programming of a recursive algorithm to draw ray trace plots for a sound-speed profile that is a function of all three spatial coordinates has begun.

PUBLICATIONS: L.J. Ziomek, "Comments on the Relationships Between Linear Systems Theory and the Free-Space Solution of the Free-Space Solution of the Inhomogeneous Linear Wave Equation", Journal of the Acoustical Society of America, Vol. 88, 2027-2030 (1990).

CONFERENCE PRESENTATIONS: L.J. Ziomek, "LSVOCN: A Pulse Propagation Model for a Linear, Space-Variant Ocean", 119th Meeting of the Acoustical Society of America, May 21-25, 1990, Penn State University, University Park, PA, Journal of the Acoustical Society of America, Supplement 1, Vol. 87, pp. S130-S131.

L.J. Ziomek, "Linear Systems Theory and its Relationship to Ocean Acoustics", 120th Meeting of the Acoustical Society of America, November 26-30, 1990, San Diego, CA, Journal of the Acoustical Society of America, Supplement 1, Vol. 88, p. S37.

THESIS DIRECTED: C. kee-Lim, MAJ., Republic of Singapore Navy, "Acoustic Ray Tracing", Master of Science in Electrical Engineering, September 1990.

OTHER: L.J. Ziomek and R.P. Breckenridge, "Estimation of the Spherical Coordinates of Broadband Targets via Adaptive Beamforming and Nonlinear Least Squares", in progress.

DEPARTMENT OF MATHEMATICS

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, weather prediction, fluid flow, orbital mechanics 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 appears in the form of student theses, technical reports, conference presentations, and refereed journal articles.

SCIENTIFIC COMPUTATION

The area of scientific computation includes both numerical (serial and parallel) 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 Neta, Gragg and Lustman to develop algorithms for the INTEL hypercube to solve systems of ordinary differential equations in parallel. Such systems appear in many areas of application, such as orbital mechanics and weather prediction.

Professor Gragg has also developed numerous MATLAB programs for linear programming problems.

Professor Danielson and several students have obtained analytical solutions to the equations of motion of a satellite orbiting an oblate planet. The complexity of the algebraic manipulations was eased by the use of MACSYMA on the Vax computer (ECE department). Another PC software program (MATHEMATICA) was employed by Professor Canright in his research. His studies were in the area of fluid dynamics.

Professors Neta, Schoenstadt and Lustman are working with Professor R.T. Williams of Meteorology on the development of finite element schemes for weather prediction. This research includes the development of algorithms to use parallel computers. The Mathematics Department uses an INTEL iPSC/2 hypercube with 8 processors.

Professors Gragg and Thornton are working on parallelizing algorithms for fast evaluation of eigenvalues and singular value decompositions. On scientific, non-parallel computation, Professor Franke continues his work on scattered data approximation especially with application to meteorological data.

Professors Canright and Scandrett are working with Professor Baker of Physics on the application of the T-matrix method to low frequency active array performance prediction.

Professor Leader is investigating chaotic iterations from the view point of nonlinear dynamics. Results obtained are also related to iterative methods for computing eigenvalues.

Professor Frenzen is working on error bounds for asymptotic expansions of several special functions. These results can be used for accurate numerical calculations. He is also studying the prediction of breaking time for nonlinear hyperbolic partial differential equations, which arise in high speed flow and shock problems.

Professor Fischer is working on discrete analogues of orthogonal polynomials, which have applications in coding theory.

SIMULATION and MODELING

Professors Jayachandran and Franke are working on quality assessment of meteorological data. The primary goal is identification of erroneous data and its possible correction. Some algorithms for detection of errors have been proposed and are under investigation using actual data from NOARL. In the case of systematic error, algorithms for correction of the data will be developed.

Professors Barr and Weir have worked on combat models for the U.S. Army TRADOC Analysis Center. Other modeling problems being investigated by Professor Barr include a model for predicting recruiting success of Army Reserve units.

Professors Danielson and Frenzen are working on the development of a mathematical model for buckling of stiffened plates which are important components of ships and submarines. The methods developed will improve the construction of these vessels.

DISCRETE MATHEMATICS/COMMUNICATION

Professor Fredricksen has been working on development of a stream cipher coding/cryptography system analogous to the block coding system of classical design. He also is developing an algorithm to answer a communication need for broadcast channels. His protocol enables messages to be transmitted over broadcast channels and directed to specific users without explicit reference to those users being made. Professor Forre has been working on a stream cipher from a nonlinear dynamics point of view.

Professor Query is applying graph theory to communication networks for channel assignments. She is also developing an algorithm which will decompose a large network into smaller subnetworks. This will facilitate making frequency assignment in polynomial time.

APPLICATION OF THE T-MATRIX METHOD TO LOW-FREQUENCY ACTIVE ARRAY PERFORMANCE PREDICTION

S.R. Baker, Assistant Professor of Physics
D.R. Canright, Assistant Professor of Mathematics
C.L. Scandrett, Assistant Professor of Mathematics
(Co-Principal Investigators)
Sponsor: Anti-Submarine Warfare Group
Funding: Naval Postgraduate School

OBJECTIVE: Produce a computationally efficient, accurate model of low-frequency active sonar array performance.

SUMMARY: Our approach is to split the problem into two: a finite-element model for the sonar transducers, and an analytic model of the acoustic field (including multiple acoustic interactions by the T-Matrix Method). Professors Canright and Scandrett have jointly developed a general computer program that implements the analytic acoustic model for arbitrary array geometry, characterizing the interactions as an impedance matrix. This code has been applied to an array of three elastic spherical shell transducers. Work on the finite-element transducer model, and coupling the two models, is still underway.

PUBLICATIONS: C.L. Scandrett and D.R. Canright, "Acoustic Interactions in Arrays of Spherical Elastic Shell," Journal of the Acoustical Society of America, accepted for publication, September 1990.

CONFERENCE PRESENTATIONS: None.

THESIS DIRECTED: K.A. McLean, LT, USN, "Transformation of a Finite-Element Model of a Piezoelectric Spherical Shell Transducer from a Nodal to a Spherical Harmonic Function Representation," Master Thesis, June 1990.

ALIVENESS

D.R. Barr, Adjunct Professor of Mathematics
Sponsor: None
Funding: None

OBJECTIVE: The purpose of this project is to develop statistical methods of estimating expected casualty rates in combat. The goal is to develop and validate estimators with properties superior to the casualty rate estimators currently in use in the U.S. Army analysis community.

SUMMARY: An extension of the "sum of pk's" estimator, first proposed by M. Bryson, has been investigated. This uses the concept of the "aliveness" of a combat unit. A unit has aliveness 1.0 at the beginning of a battle, but as a result of engagements by hostile fire, may have aliveness degraded to values below 1.0. Aliveness values greater than 1.0 are also possible. The expected number of casualties is computed as the total reduction of aliveness of all combat units on each side of a conflict. It has been shown that this is a generalization of the sum of pk's estimator, and it has been shown the estimator has good properties relative to alternative estimators.

PUBLICATIONS: D. R. Barr and M. Bryson, "Correcting Casualty Estimates," accepted for publication in Interfaces, 1991.

EVALUATION OF EFFECTS OF INCORPORATING HUMAN FACTORS INTO COMBAT MODELS

D.R. Barr, Adjunct Professor of Mathematics
M. Weir, Professor of Mathematics
Sponsor: TRADOC Analysis Command - Monterey
Funding: TRADOC Analysis Command - Monterey

OBJECTIVE: The goal of this project is to develop methods of comparing combat results from Army combat models and other data sources such as field tests and the National Training Center. Initially, methods for comparing data from runs of the Janus model with and without a fratricide enhancement will be developed. The long term goal is to develop and evaluate methods for making comparisons from a broad range of sources.

SUMMARY: Work during the period July to December was very low-level: The major portion of work on the project is scheduled to take place during the Winter Quarter of AY 91. To date, an approach to the problem has been developed, and several thesis students have started their thesis research in related components of this problem. The approach involves fitting analytical models of appropriate form to data from each model or source, and to compare the combat results in terms of analytical attributes of the fitted models. We are investigating Lanchester-like models as well as high level measures such as exchange elasticity.

PUBLICATIONS: Technical Report will be prepared in AY 91.

CONFERENCE PRESENTATIONS: Paper will be delivered at the Military Operations Research Society meetings, summer of 1991.

THESIS DIRECTED: Craig Buzan, "Operational Implications of 3X8 Artillery Battalions," MS in Operations Research, Sept. 1990.

ESTIMATION OF UNIT SUCCESS/MIX MODEL FOR USAR

D.R. Barr, Adjunct Professor of Mathematics
Sponsor: U.S. Army Recruiting Command
Funding: U.S. Army Recruiting Command

OBJECTIVE: The goal of this project is to develop models for predicting the recruiting success of Army Reserve units, as functions of demographic factors, location characteristics and unit characteristics.

SUMMARY: A set of statistical models has been developed for predicting the fill rates of Army Reserve units. It has been determined that fill rates are effected by unit and location characteristics and, in the case of units within urban areas, by competition from other reserve and national guard units. Analysis of covariance has been used to models for predicting unit fill rates, based on fifteen measurable factors and covariables. Validation of the estimated models will be undertaken during AY 91.

PUBLICATIONS: D. Barr and G. Thomas, "Optimal Classification Selection in Logistic Regression," journal article in preparation.

D. Barr, "Statistical Models for Predicting Reserve Unit Recruiting Success," NPS Technical Report in preparation.

CONFERENCE PRESENTATIONS: D. Barr and G. Thomas, "Goodness-of-Fit Classification Threshold Selection for Discrete Choice Models," to be presented at the 1991 Meetings of the Decision Sciences Institute, March 1991.

DEVELOPMENT AND VERIFICATION OF MATHEMATICAL FORMULAS FOR THE ORBITS OF EARTH SATELLITES

D.A. Danielson, Associate Professor of Mathematics
Sponsor: Space Systems Academic Group
Funding: Naval Postgraduate School

OBJECTIVE: Develop mathematical formulas for the orbits of artificial satellites.

SUMMARY: An analytical solution was found to the equations of motion of a satellite orbiting on an oblate planet. The formulas accounted for the perturbational effects on satellite orbits caused by a planet's oblateness. Our theory was compared with a numerical solution of the differential equations and with actual satellite data. Solution was found to be significantly more accurate than the two body formulations.

PUBLICATIONS: D.A. Danielson, C.P. Sagovac, J.R. Snider, "Satellite Motion Around an Oblate Planet: A Perturbation Solution for all Orbital Parameters, Part II - Orbits for all Inclinations," AIAA/AHA Astrodynamics Conference, pp. 35-43, August 22, 1990.

D.A. Danielson, D.P. Kihl, D.H. Hodges, "Tripping of Thin-Walled Plating Stiffeners in Axial Compression", Thin-Walled Structures, Vol. 10, pp. 121-142, 1990.

D.A. Danielson, S.L. Garrett, "Fiber-Optic Ellipsoidal Flextensional Hydrophones," Journal of Lightwave Technology, Vol. 7, No. 12, pp. 1995-2002, December 1989.

D.A. Brown, S.L. Garrett, D.A. Danielson, "Fiber-Optic Oblate Flextensional Hydrophone," Proceedings of the SPIE, Vol. 1169, Fiber Optic and Laser Sensors VII, pp. 240-248, 1989.

D.A. Danielson, J.R. Snider, "Satellite Motion Around an Oblate Earth: A Perturbation Solution for all Orbital Parameters, Part I - Equatorial and Polar Orbits," Astrodynamics 1989, Vol. 71, Part II, Advances in the Astronautical Sciences, pp. 1217-1227, 1990.

CONFERENCE PRESENTATIONS: D.A. Danielson, C.P. Sagovac, S.D. Krambeck," Satellite Motion Around an Oblate Planet: A Perturbation Solution for all Orbital Parameters," AIAA/AAS Astrodynamic Conference, Portland, Oregon, August 20, 1990.

TRIPPING OF THIN-WALLED PLATING STIFFENERS UNDER AXIAL COMPRESSION

D.A. Danielson, Associate Professor of Mathematics
Sponsor: David Taylor Research Center
Funding: David Taylor Research Center

OBJECTIVE: Develop mathematical formulas for the buckling of stiffened plates on essential structural component of ships and submarines.

SUMMARY: The subject of this work is the buckling behavior of a rectangular plate, with a thin-walled stiffener attached to the middle of one side, subjected to a combination of axial compression and lateral pressure. The plate was modeled by the von Kerman plate equations and the beam by a nonlinear beam theory recently derived. An analytical solution was obtained to the beam buckling equations. Simple formulas express the buckling loads corresponding to each of four possible mode shapes in terms of geometrical and material parameters.

PUBLICATIONS: D.A. Danielson, D.P. Kihl, D.H. Hodges, "Gripping of Thin-Walled Plating Stiffeners in Axial Compression," Thin-Walled Structures, Vol. 10, pp. 121-142, 1990.

D.A. Danielson, C.L. Frenzen, N. Vasuderan, "Buckling of Stiffened Plates under Axial Compression and Lateral Pressure," submitted to Thin-Walled Structures.

A HIGHER ORDER NONLINEAR SHELL THEORY

D.A. Danielson, Associate Professor of Mathematics
Sponsor: Naval Postgraduate School

OBJECTIVE: Provide theoretical foundation for higher order shell theory, useful for predicting mechanical behavior of composite plates and shells.

SUMMARY: The kinematics developed recently for beams are used to derived equations for plates undergoing large deflection and rotation but with small strain. The theory is based upon the decomposition of the rotation into a large global rotation of the reference tread, a small rotation due to transverse shear, and an additional small local rotation.

PUBLICATION: D.H. Hodges, A.R. Atilgan, D.A. Danielson, "On the Intrinsic Equations of Plate Theory", submitted to the Journal of Applied Mechanics.

CONFERENCE PRESENTATION: Accepted for presentation at the Second Pan American Congress of Applied Mechanics to be held in Chile on January 2-5, 1991.

SPECIAL FUNCTIONS AND ORTHOGONAL POLYNOMIALS

Ismor Fischer, Adjunct Professor of Mathematics
Sponsor: Naval Postgradute School
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this research was to write up a Ph.D. thesis ("Discrete Orthogonal Polynomials") results for eventual publication in a refereed journal, as well as conduct further investigation into allied problems.

SUMMARY: Dissertation results were written up for journal publication. ("Discrete Orthogonal Polynomial Expansions of Averaged Functions" to be submitted to Journal of Applied Analysis). Moreover, investigation into these problems led to interest in several new ones in related mathematical areas. Several results have been obtained, and research is ongoing. A peripheral result was written up for journal submittance. In addition, a former MA2121 student expressed interest in this mathematical specialization and is currently working on selected background material for a Master's thesis under my supervision.

KEYSTREAM GENERATORS

R. Forre, Adjunct Professor of Mathematics
Sponsor: Naval Postgraduate School
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project was to investigate the possibility of using a strange attractor (nonlinear dynamics) or a pseudo random keystream generator as a stream cipher.

SUMMARY: A two-dimensional quadratic mapping f investigated by Henon in 1976 was used to construct pseudo random binary sequences with good cryptographic properties: linear complexity and jump complexity profiles similar to those of truly random sequences, high sensitivity to initial conditions, per-bit entropy close to one, n-cycle distribution uniform for small numbers w.

PUBLICATIONS: "The Henon Attrctor as a Keystream Generator", submitted to EUROCRYPT '91 conference, Brighton, England.

INTERPOLATION OF SCATTERED METEOROLOGICAL DATA

Richard Franke, Professor of Mathematics
Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this research was to investigate the influence of missing observations and misspecification of parameters in statistical interpolation schemes used in objective analysis.

SUMMARY: Expected errors were computed under various configurations of observations points and assumptions about the error statistics. The results were analyzed in order to identify important parameters in the process as well as those that have only a small influence on the accuracy of the scheme.

PUBLICATION: Richard Franke, Sensitivity of the error in multivariate statistical interpolation to parameter values, NPS-53-90-006, March 1990. (Accepted for publication in Monthly Weather Review in slightly revised form, to appear in 1991.)

Richard Franke, Approximation of scattered data for meteorological applications, in Multivariate Approximation and Interpolation, W. Haussman and K. Jetter (eds), Birkhauser-Verlag, 1990, 107-120.

Richard Franke and Gregory M. Nielson, Scattered data interpolation and applications: A tutorial and survey, in Geometric Modelling: Methods and Their Applications, H. Hagen and D. Roller (eds), Springer-Verlag, 1990,107-120.

OTHER: The investigator was invited to present a tutorial on scattered data interpolation (joint with Greg Nielson, Arizona State University) at Bingen, Germany, May 1990.

QUALITY ASSESSMENT OF METEOROLOGICAL DATA

Richard Franke, Professor of Mathematics
Toke Jayachandran, Professor of Mathematics
Sponsor: Naval Oceanographic and Atmospheric Research Laboratory
Funding: Naval Oceanographic and Atmospheric Research Laboratory

OBJECTIVE: The goal of this research is to investigate ways of identifying erroneous meteorological observations and correcting those with systematic error.

SUMMARY: A study of current practice at NWP facilities was carried out in collaboration with NOARL personnel. A scheme for identifying erroneous observations has been formulated and tested in a limited way. A second scheme for adaptive correction of observations with systematic errors is undergoing testing with real data. Preliminary results look promising.

OTHER: The investigators attended the summer workshop on Mesoscale Data Assimilation at the National Center for Atmospheric Research. The work is being carried out in close cooperation with NOARL personnel. This is an ongoing project.

ERROR BOUNDS OF THE ASYMPTOTIC EXPANSION OF THE RATIO OF TWO GAMMA FUNCTIONS WITH COMPLEX ARGUMENT

C.L. Frenzen, Associate Professor of Mathematics
Sponsor: Naval Postgraduate School

OBJECTIVE: The goal of this project was to obtain error bounds for the asymptotic expansion of the ratio of two gamma functions with complex argument.

SUMMARY: Error bounds are obtained for an asymptotic expansion of the ratio of two gamma functions $\frac{\Gamma(z+a)}{\Gamma(z+b)}$ when a and b are complex constants and $|z|$ is large. These bounds reduce to earlier bounds for the real case when a, b and z are real. Properties of completely monotonic functions are used to provide error bounds in the complex case, as in the earlier real case.

PUBLICATION: C.L. Frenzen, "Error Bounds for the Asymptotic Expansion of the Ratio of Two Gamma Functions with Complex Argument", submitted to SIAM Journal on Mathematical Analysis.

TRIPPING OF THIN-WALLED PLATING STIFFENERS UNDER AXIAL COMPRESSION

C.L. Frenzen, Associate Professor of Mathematics
Sponsor: Naval Postgraduate School

OBJECTIVE: To develop mathematical formulas for the buckling of stiffened plates, an essential structural component of ships and submarines.

SUMMARY: The subject of this work is the buckling behavior of a rectangular plate with a thin-walled stiffener attached to the middle of one side, subjected to a combination of axial compression and vertical pressure. The plate was modeled by the Van Karman plate equations and the beam by a non-linear beam theory recently derived. An analytical solution was obtained to the beam buckling equations. Simple formulas express the buckling loads corresponding to each of four possible mode shapes in terms of geometrical and material parameters.

PUBLICATIONS: D.A. Danielson, C.L. Frenzen, N. Vasudevan, "Buckling of Stiffened Plates under Axial Compression and Lateral Pressure," submitted to Thin-Walled Structures.

SCIENTIFIC COMPUTATION GROUP

W.B. Gragg, Professor of Mathematics
Sponsor: William A. Van Winkle, NUSC
Funding: Naval Postgraduate School

OBJECTIVE: The purpose of this project was to initiate an activity in Scientific Computing at NPS. Our original intent was to provide a consulting service to help thesis students and faculty who are not conversant with techniques of modern computation.

SUMMARY: We initiated a series of colloquia in Scientific Computation within the Mathematics Department. Six speakers gave presentations on state-of-the-art algorithms for large scale Scientific Computing problems. Particularly impressive were D.C. Sorensen's treatment of large eigenvalue problems and Roland Freund's new codes for large nonsymmetric systems of linear equations. All these modern techniques use parallel computation. They are the result from "big computing". On the other hand we feel that PCs are currently fast enough to solve most run-of-the-mill computing problems and that Matlab will be the high-level language of the future. We have become proficient with these tools. A large number of Matlab codes were written, among which are linear programming problem solvers, ODE solvers and codes for high precision arithmetic on PCs. With our ODE solver we integrated a Toda flow with 1000 ODEs over a long time interval to full machine precision. This code was also used, in consultation, to quickly solve a problem which had proved difficult for its formulator. The fast interactive nature of this type of computing is a powerful tool for problem solving. We hope that the skills needed for using it wisely can be learned with the help of our codes.

OTHER: Matlab programs are available from the investigator.

ALGEBRAIC GRAPH THEORY

A.W. Higgins, Adjunct Professor of Mathematics
Sponsor: National Science Foundation

OBJECTIVE: This project is funded at the University of Dayton, OH. It is part of the NSF's Research Experiences for Undergraduates (REU) Program. Only fifteen REU programs were funded in mathematics in the summer of 1990. The eight week-long residential program is designed to show undergraduates what research in mathematics is with a view to encouraging them to pursue graduate studies and careers in mathematics. The programs were initiated as part of a solution to the problem of declining numbers of U.S. citizens earning advanced degrees in mathematics and sciences. This grant is for two years, specifically for the summers of 1990 and 1991. Eight students are provided with an opportunity to participate in a program of research guided by two P.I.s in algebraic graph theory. We teach the students the rudiments of the subject, and then encourage them to choose their own research problems, guide them in their research and help them prepare the results of their research for presentation as a 15 minute paper at the national summer Joint Meetings of the American Mathematical Society and the Mathematical Association of America. The students earn academic credit and a $2000 stipend.

SUMMARY: The program's research was in algebraic graph theory and encompassed such topics as chromatic and achromatic number of graphs, counting Eulerian circuits in a graph, line graphs and properties preserved by the line graph operation, matroids, regular graphs and their relationship to distance-degree regular graphs and pancyclic graphs. I conducted one summer of this program prior to my year as an adjunct professor at NPS, and will return to Dayton to conduct the second summer of this program. This program is quite independent of my appointment at NPS and has no bearing on NPS, its students or DoD except, perhaps, in a long-term sense of playing a part in keeping open the pipeline of interested students who will pursue graduate studies in mathematics, thus benefiting those parts of the government and defense industry that depend on qualified and trained mathematicians.

ANALYSIS OF A CHAOTIC ITERATION IN RN

Jeffery J. Leader, Assistant Professor of Mathematics
Sponsor: Naval Postgraduate School Research Council
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project is to investigate a chaotic iteration from the viewpoint of the current research in nonlinear dynamics, and to write up and submit already completed research of the author in this area.

SUMMARY: A new approach to the problems of boundedness and asymptotics of the iteration in question led to greatly simplified proofs of known results and extensions to previously intractable cases. Additionally, an interesting connection to the power method for numerical eigenvalue problems was made that should be of interest to those working in scientific computation.

PUBLICATION: Jeffery J. Leader, "Limit Orbits of a Power Iteration for Dominant Eigenvalue Problems," Applied Mathematics Letters, forthcoming.

Jeffery J. Leader, "A Weakly Chaotic Iteration in Rn," Applied Mathematics Letters, forthcoming.

OTHER: Three other papers have been submitted and are in the review process. Three NPS technical reports (one directed at students) have been submitted. An additional paper is almost completed.

SELECTED TOPICS IN TOPOLOGICAL FIXED POINT THEORY

Aaron Schusteff, Adjunct Professor of Mathematics
Sponsor: Department of Mathematics
Funding: Naval Postgraduate School

OBJECTIVE: To continue investigating various questions related to the doctoral dissertation written by the principal investigator in the area of topological fixed point theory.

SUMMARY: Research was conducted on criteria and techniques for obtaining product formulas for Nielsen and Reidemeister numbers of fiber-preserving self-maps of nonorientable fiber spaces. Investigations were also made into the problem of constructing fiber maps with given behavior on base space and fibers, and on the problem of extending the characterization the fixed point sets of homotopy classes of self-maps of the circle to more general 1-complexes. Submission for publication of articles concerning these continuing research projects in refereed journals is planned for the coming year. Work was also done in preparing the principal investigators dissertation itself for journal publication.

CONFERENCE PRESENTATIONS: A. Schusteff, "Product Formulas for Relative Reidemeister Numbers of Fiber Map Pairs", Topology Hawaii Conference, University of Hawaii, August 15, 1990.

REAL TIME PATH PLANNING OF NONREPETITIVE TASKS FOR A ROBOT ARM

J.R. Thornton, Professor of Mathematics
Sponsor: Naval Postgraduate School
Funded: Naval Postgraduate School

OBJECTIVE: The goal of this project is to develop structures and techniques which provide for the rapid planning of nonrepetitive tasks for robots and fixed shoulder robot arms.

SUMMARY: The general approach taken is to first partition the set of possible paths into homotopy equivalence classes and to identify a set of classes for searching. Secondly, candidate classes are searched for particular trajectories for the robot to follow. In this second phase the robot is modeled as a Product Automaton, which is the cartesian product of algebraic automata. Lower bounds on the costs of member paths may be associated with each equivalence class prior to the start of the second phase. These bounds allow us to limit the extent of the search. For the identification of homotopy classes, have found two forms for the representation of path classes when the underlying topological space is the plane minus obstacles. Both depend on the drawing of a reference frame which may be drawn once and and for all for a given collection of obstacles (in contrast to a competing approach). One representational form names homotopy classes in terms of characters drawn from the reference frame, while the other represents homotopy classes in terms of a particular collection of generators of the fundamental group of the topological space. For the searching phase, have investigated some properties of Product Automata and published two papers on the subject.

PUBLICATIONS: **Appeared 1990** - R.E. Haymond and J.R. Thornton, "Event Detection by Inner Product Methods in Discrete-Continuous Hybrid Simulation of a Robot Arm, Proceedings of the Twentieth Annual Pittsburgh Conference on Modeling and Simulation, University of Pittsburgh School of Engineering, May 1989.

Accepted 1990 - J.R. Thornton and R.E. Haymond, "Discrete-Continuous Hybrid Simulations with Product Automata, "Proceedings of the Twenty First Annual Pittsburgh Conference on Modeling and Simulation, University of Pittsburgh School of Engineering, May 1990.

R.E. Haymond and J.R. Thornton, "Product Automation Simulation Structure," Proceedings of the Twenty First Annual Pittsburgh Conference on Modeling and Simulation , University of Pittsburgh School of Engineering, May 1990.

CONFERENCE PRESENTATIONS: Publications above were presented at the conferences indicated. Organized the 1990 session of papers on Product Automata.

OTHER: A paper on classification of robot paths into homotopy equivalence classes is now in progress. I am now directing two thesis students who are implementing these methods of path classification in computer code.

DEVELOPMENT OF A FINITE ELEMENT PREDICTION MODEL

R.T. Williams, Professor of Meteorology
A.L. Schoenstadt, Professor of Mathematics
B. Neta, Associate Professor of Mathematics

OBJECTIVE: To develop and test finite element atmospheric prediction models on parallel and other computers. This is a continuing project.

SUMMARY: We have started to use the Intel IPSC2 hypercube for several problems related to weather forecasting. The algorithm developed by Katti and Neta has been programmed on the hypercube available in the Mathematics Department. Lustman, Neta and Katti (1990) used this algorithm to solve a linear system of ordinary differential equations (like those obtained from semi discretization of the shallow water equations). Encouraged by these results which showed the benefit of parallel computation, we have initiated several related ideas, the first being the solution of a rank two modified tridiagonal system of equations (i.e., the coefficient matrix is almost tridiagonal and includes a nonzero element at top right and bottom left corners). Such a system arises in the semi-Lagrangian semi-implicit scheme for the shallow water equations as formulated by Monk. An algorithm for a domain decomposition with reasonably accurate values on these interfaces was developed by Neta and Okamoto (1990). We explored the use of semi-Lagrangian methods in a situation where the spatial scale of the flow collapses to zero during the time integration (Kuo and Williams, 1990). It was shown that despite the variable manner in which the gradient of the wind field approaches infinity in the neighborhood of the shock, the semi-Lagrangian method gave accurate results even with larger time steps (Courant number greater than two or four) than are possible with Eularian methods. The solutions which form the linearized shallow water model were compared to the first order solutions (Hyde, 1984) as a function of the bottom slope (Staniforth, Williams and Neta, 1990). It was found that the phase speed dependence on the bottom slope is much more complicated than can be described by the first order theory.

PUBLICATIONS:

H.-C. Kuo and R. T. Williams, "Semi-Lagrangian Solutions to the Inviscid Burger's Equation," Monthly Weather Review, 118, pp. 1278-1288, June 1990.

B. Neta, P. Nelson and C. P. Katti, "Convergence of Inner/outer Source Iterations with Finite Terminations of the Inner Iteration," Journal of Integral Equations and Applications, 2, pp 147-174, 1990.

B. Neta, J. M. Navon and J. Yu, "Analysis of the Turkel-Zwas Scheme for the Two Dimensional Shallow Water Equations", (to be published in International Journal of Numerical Methods in Fluids).

B. Neta and N. Okamoto, "On Domain Decomposition Methods for Solving Partial Differential Equations," Naval Postgraduate School Technical Report 53-90-004, March 1990, pp. 9.

B. Neta, I. M. Navon and J. Yu, "Analysis of the Turkel-Zwas Scheme for the Two Dimensional Shallow Water Equation in Spherical Coordinates," Florida State University Supercomputer Computation Research Institute Technical Report, FSU-SCRI-90-91, May 1990, pp. 17.

DEPARTMENT OF MECHANICAL ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

The primary thrust of 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 material optimization; underwater shock and vibration damping; control of dynamic systems; fundamentals of fluid mechanics, hydrodynamics, and heat transfer including applications to electronic cooling, welding, boiling and condensation, and applied thermodynamics; and materials science applied to metals and metal matrix composites.

In addition to the research activities of the 18 tenure track faculty, the department has from 8 to 10 adjunct and visiting faculty including the ONT Chair in Submarine Technology, held this year by Professor T. Geers from the University of Colorado. Distinguished visitors this year include Dr. R. Shoureshi, Purdue University.

Results of research are published in the student theses, NPS technical reports, and in papers both presented at, and appearing in, national conference proceedings, and published in the scientific quarterly journals.

SOLIDS MECHANICS, SHOCK AND VIBRATION

Professor Young Shin continued his work in the area of machinery diagnostics, underwater shock and vibration damping sponsored by DTRC, NAVSEA, DARPA, and the DNA as well as the NPS Direct Research Fund. Projects funded by DNA are concerned with the dynamic response and failure mechanisms of composite structures to underwater explosion. The research includes both analytical and experimental studies of UNDEX behavior of S-2 glass/polyester and aluminum panels. Funded by DTRC, he continued to develop effective means for vibration control of primary structures using constrained layer treatments, tuned dampers, and waveguide absorbers with direct application to the advanced submarine technology. In addition, funded by DARPA and NAVSEA, he began projects in machinery noise monitoring and diagnostics and the condition monitoring of torpedo ejection pumps (TEP's). The approach taken for TEP's is to investigate the use of the Wigner-Ville Distribution for time dependent spectral analysis, as the device is basically a transient machine. Neural networks are considered for use in identification of machinery failure diagnostics. Professor P. Shin continued his work on design of laminated plate with stiffener ribs with a view towards optimum design for buckling strength. New to the group was Professor Y. Kwon who has begun a project to develop a nonlinear analysis to investigate crack tip fields in metal matrix composites. Professor D. Salinas is developing a 3-D finite element model of electronic packages including chip, leads and solder joints to predict the thermal stress fields.

DYNAMICS SYSTEMS AND CONTROL

In this area, Professor Healey continued working with the project on Autonomous Underwater Vehicles. Contributing work was done by Professor F. Papoulias, and Professors Kwak, Lee, McGhee, from Computer Science, and Professor Cristi from the ECE Department. During this year, the design of the NPS AUV 2 vehicle progressed to the point where a conceptual design was finalized and the vehicle was launched on June 15, 1990 in the NPS swimming pool. Robust autopilot design using Sliding Mode Control theory has demonstrated that advanced autopilots will control highly non-linear vehicles with uncertain hydrodynamic parameters very effectively. Experimental verification of these results including the system identification of the unknown hydrodynamic parameters is ongoing. Additionally, the first pool mission using closed loop steering to obtain sonar recognition of the pool boundaries was accomplished. Professor L. Chang has continued his work on the control of flexible structures, again using Sliding Mode Control methods, and has developed an extension of the methodology that will more appropriately handle flexible bodies with largely unknown payload mass. Professor M. Driels has initiated research into the design and development of dexterous end effectors for use in direct drive robotic hands and has obtained a six degree bilateral force feedback manipulator to investigate how the human haptic system could be used to identify an object through remote telemanipulation. Professor Papoulias also investigated the stability of towed surface vessels using bifurcation theory demonstrating that a problem of multiple bifurcating equilibria could be identified. Feasibility of control was studied.

FLUID MECHANICS, THERMODYNAMICS AND HEAT TRANSFER

One of the most active groups in the department, this area covers convective cooling of electronic components; fluid and thermal aspects of the welding process; field modeling of the spread of fire and smoke in confined spaces; cryogenic heat pipes for motor cooling, and boiling heat transfer with refrigerants; gas turbine flow modeling; film cooling for turbine blades; heat transfer in boundary layers with embedded vortices; and research in time dependent hydrodynamic flows, vortex/free surface interactions, parachute collapse, and flow forces on cylinders in complex oscillatory flow fields. Professor Joshi continued his activity in electronics cooling with extensive flow visualization and numerical simulation studies, and both analytical and experimental work in thermal modeling of fusion welding processes. Measurements of the surface temperatures using thermocouples were used to determine the electronics cooling project which also includes Professor B. Neta (Mathematics Department) to develop further numerical schemes for three dimensional conduction problems. Professor Kelleher also worked on the further development of a simulation program to model the thermal and fluid processes for the FIRE 1 research chamber of NRL. The effects of surface radiation and combustion processes are now being included. Professor Marto has begun to investigate the use of cryogenic heat pipes for thermal diodes and magnetic refrigerators. A literature search has been started. He also continued his activity in refrigeration boiling heat transfer to see if a predictive model could be developed for nucleate pool boiling and by continuing experiments on tube bundles using finned tubes of various kinds for heat transfer enhancement. More than 70 different finned tubes have been tested. Professors Ligrani and Subramanian worked under the external sponsorship of Wright Patterson AFB and NASA Lewis research Center to continue the program in the understanding of heat transfer in the transitional boundary layer with embedded vortices. The experiments conducted simulate the flow around gas turbine engine blades and the effect of cooling flows injected from cooling holes. Work this year included experimental studies of the influence of harmonically fluctuating components in the main flow stream. Professor Sarpkaya continued his work on the understanding of time dependent fluid mechanics. His DARPA work deals with investigations into the migration of vortices shed from submarine planes at angles of attack and their interaction with the free surface. His work on separation points for flows around cylinders (smooth and rough) funded by NSF continued with emphasis on multi-frequency harmonic flows. He has performed numerous experiments and analyses towards the evaluation of the behavior of free surface scars generated by rising vortices in terms of Froude numbers, Atwood numbers, and the Vaisala-Brunt frequencies, and continues with the work on numerical analysis of separated flow about bluff bodies.

MATERIALS SCIENCE

The materials science group has grown by the recent hiring of Professors Fox and Dutta. Professor Dutta has initiated an active research program in metal matrix composites (MMC's), including an investigation into the thermal-mechanical processing for cast Al-SiC composites to alleviate some of the problems found with current casting technology. He is also studying experimentally and by finite element modeling, the aging processes, the effects of load transfer and residual stress on the composite yield strength of MMC's. In addition, he is also studying the corrosion behavior and corrosion fatigue behavior of Graphite/Aluminum composites under sponsorship by NWSC, Crane, IN. Professor Fox, under sponsorship by US Department of Energy and others, has begun an active research program in several areas of interest to the Navy, including the delamination of ceramic/metal interfaces as thin coating films separate from their ceramic substrates. His basic research in accurate structure factor determination using electron diffraction means continues well and he has begun to investigate the crystallographic and chemical characterization of microstructures in high-strength low alloy steels and their weldments and microstructures arising from heat treatments on Al-Li alloys. Professor McNelley continued his activity in the superplastic forming of Aluminum alloys and this year has developed a qualitative model for the occurrence of continuous recrystallization during processing of the materials. Professor Perkins continues his work in the characterization and understanding of the behavior of high damping alloys which has lead this year to the discovery of a flickering phenomenon in TEM images of certain aged alloys that is thought to be related to their enhanced damping properties.

SLIDING CONTROL ON A SINGLE-FLEXIBLE-LINK ARM

L.W. Chang, Assistant Professor of Mechanical Engineering
Sponsor: Naval Research Laboratory
Funding: Naval Postgraduate School

OBJECTIVE: This was to continue the study of flexible-body control and its applications. The objective of this research was to investigate the performance of sliding controls on a single-flexible-link arm.

SUMMARY: The nonlinear dynamics of the electrohydraulic actuator was included with the flexible arm in a state-space model, and the control was designed based on the state-space model. New developed Versatile Sliding Control and Straight Sliding Control were applied to the manipulator system and the performance was investigated.

PUBLICATIONS: L.W. Chang, "A MIMO Sliding Control with a First-Order Plus Integral Sliding Condition," Automatica: The Journal of IFAC (the International Federation of Automatic Control), Accepted for publication, Nov. 1990.

L.W. Chang, "Sliding Control Techniques in Robust Control Systems," invited contribution in International Academic Press series on Advances in Control and Dynamic Systems, Volume 52, forthcoming.

CONFERENCE PRESENTATIONS: L.W. Chang and K.S. Park, "A Vertical-Plane Motion Control of an Electrohydraulically-Actuated Single-Flexible-Link Arm." Proceedings of the 1990 American Control Conference, Vol. 2, San Diego, CA, pp. 1208-1213, May 23-25, 1990.

L.W. Chang and M. Kirkland, "Implementation of a Vertical-Plane Motion Control of an Electrohydraulically-Actuated Single-Flexible-Link Arm." Proceedings of the 1990 American Control Conference, Vol. 2, San Diego, CA, pp. 1214-1219, May 23-25, 1990.

L.W. Chang, "A MIMO Sliding Control with a Second-Order Sliding Condition," 90-WA/DSC-5, ASME Winter Annual Meeting, Dallas, TX, November 25-30, 1990.

THESIS DIRECTED: C.C. Feng, LT, Taiwan Navy, "Sliding Control Design and Implementation on a Single-Link Flexible Arm," Engineer Degree Thesis, December 1990.

OTHER: L.W. Chang, "A MIMO Sliding Control with a Second-Order Sliding Condition," ASME Journal of Dynamic Systems, Measurement, and Control, under review.

L.W. Chang, "A Sliding Control with a First Order Sliding Condition Using Matrix Norms for Multiple-Input-Multiple-Output Systems," IEEE Transactions on Automatic Control, under review.

L.W. Chang, "A Robust Motion Control of Actuators in Disk Files," ASME Journal of Dynamic Systems, Measurements, and Control, under review.

L.W. Chang, "New Sliding Controls in State-Space Forms," in preparation.

L.W. Chang and C.C. Feng, "Robust Motion Control Design and Implementation for an Electrohydraulically-Actuated Single-Flexible-Link Arm," in preparation.

ADAPTIVE CONTROL OF DIRECT DRIVE ROBOTIC HAND WITH BILATERAL TACTILE SENSING

Morris Driels, Professor of Mechanical Engineering
Sponsor: Naval Ocean Systems Center
Funding: Naval Postgraduate School

OBJECTIVE: The goals of this project were to: (1) develop the mechanical component design of a multi-jointed, multi-finger direct drive dexterous hand; (2) investigate adaptive force control strategies for the operation of the hand and; (3) determine preliminary models regarding how such a hand may be used in a haptic exploratory system to identify remote objects using teleoperation.

SUMMARY: This work proceeded on two related fronts. The first task was to design the basic actuation system of a single finger joint of a multi-degree of freedom dexterous end effector. This involved the design of the actuation system, the selection of suitable joint measurement components, and their incorporation into an operational servo-system of sufficiently small size. This was accomplished using a commercially available motor and gearbox, but a custom analog joint angle sensor was designed and built. A prototype joint was built and tested, and preliminary work on the force-adaptive controller was begun. This task is currently being pursued in FY91.

The second research thrust is directed towards the determination of how the human haptic system (touch system) might use such a dexterous end effort in conjunction with a remote telemanipulator system in order to identify object probed by the slave arm. This work used data obtained by the PI while working as an ONR Fellow at NOSC, and reviewed current physiological models of the haptic system in order to explain the data. New hypotheses were proposed and the results written up in a conference paper, and a journal paper to be published in 1991. With the funding provided in 1990, a telemanipulator has been purchased and will allow further basic research into the area to be conducted, again with the sponsorship of NOSC.

PUBLICATIONS: "Haptic Recognition Through Remote Teleoperation", (with Spain), Proc. 2nd International Conference on Human Aspects of Advanced Manufacturing and Hybrid Automation, Honolulu, Hawaii August 12, 1990.

"Perception of Two Dimensional Shapes Using Haptic Feedback", International Journal of Industrial Ergonomics, 1991.

THESES DIRECTED: M. Wiegand, LCDR, USN, "Kinetic Calibration of Telemanipulator Linkages" MS Thesis 1991.

Y. Turkegenci, MAJ. Turkish Army, "Complaint Control of a Robotic Finger Joint" MS Thesis 1991.

EFFECT OF REINFORCEMENTS ON THE MATRIX MICROSTRUCTURE OF DISCONTINUOUS METAL MATRIX COMPOSITES

I. Dutta, Assistant Professor of Mechanic Engineering

Sponsor: NPS Research Council, FY89

OBJECTIVE: To investigate the cause of accelerated aging in metal matrix composites and to determine the effect of matrix microstructure on the properties of MMCs from a mechanistic standpoint. In FY89-90, the work was based on 6061 A1-matrix MMCs. In FY91, 2014 A1-matrix MMCs will be studied.

SUMMARY: The effect of reinforcements on the early stages of precipitation in composite matrices has been studied. Resistivity measurements and differential scanning calorimetry have been utilized to measure the thermodynamic and kinetic parameters influencing aging in the monolithic matrix alloy and the composite matrix. The importance of this project to the Navy and the scientific community lies in the fact that without a proper understanding of the aging behavior of MMCs, heat treatments to obtain the optimum combination of mechanical properties in these materials cannot be designed. Currently, trial and error techniques are being used to heat treat the MMCs to the peak aged condition. The knowledge gained from this work will facilitate the prediction of heat treatments and obviate the need for trial and error.

PUBLICATIONS: I. Dutta and S.M. Allen, "A Calorimetric Study of Precipitation in Commercial Aluminum Alloy 6061", Journal of Materials Science Letters, accepted, August 1990.

I. Dutta, S.M. Allen and J.L. Hafley, "Effect of Alumina Particulate Addition on Precipitation in 6061 Aluminum-Matrix Composites", submitted to Metallurgical Transactions A, March 1991.

CONFERENCE PRESENTATIONS: I. Dutta, S.M. Allen and J.L. Hafley, "Effect of Reinforcement on the Early Stages of Precipitation in Cast 6061A1-A1 0 Particulate Composites", presented in the 118th Annual Meeting of TMS-AIME, Anaheim, California, February 1990.

THESES DIRECTED: S.M. Allen, "Effect of Alumina Particle Addition on the Aging Kinetics of 6061 Aluminum Matrix Composites", M.S. thesis, June 1990.

C. Harper, "Effect of Alumina Particle Addition on the Aging Kinetics of 2014 Aluminum Matrix Composites", M.S. thesis, in progress (expected September 1990).

EFFECT OF THERMAL RESIDUAL STRESSES ON THE MECHANICAL PROPERTIES OF DISCONTINUOUS METAL MATRIX COMPOSITES

I. Dutta, Assistant Professor of Mechanical Engineering

Sponsor: NPS Research Council, FY90

OBJECTIVES: (1) To find the effects of residual stresses on composite properties; and (2) to characterize the corrosion behavior of continuous fiber composites in aqueous environments. The first part of the project is still in progress.

SUMMARY: In this project, the effect of thermal residual stresses on composite flow stress is being studied via Finite Element Modeling. Metal Matrix Composites are being considered for use in various components for naval sea and air systems and a fundamental understanding of the role of thermal residual stresses (which are always present in MMCs) in determining composite properties is essential for proper design and selection of materials. The results obtained indicate that residual stresses reduce the contribution of load transfer to composite strengthening. The effects of fiber volume fraction, fiber aspect ratio and reinforcement distribution on the composite properties have also been studied. The effect of residual stresses have been found to be significantly different in tensile and compressive loading. Continuing effort is underway to better understand the role of thermal stresses on localized flow and load transfer in composites.

PUBLICATIONS: I. Dutta, "The Nature and the Effect of Thermal Residual Stresses in Discontinuous Fiber Reinforced Metal Matrix Composites", Composites Science and Technology, 41, (1991), p. 193.

CONFERENCE PRESENTATION: I. Dutta, "Residual Stresses and their Effect on Composite Strength", presented in the 1989 Fall Meeting of TMS-AIME, Indianapolis, Indiana, October 1989.

THESES DIRECTED: J. Sims, "Effect of Thermal Residual Stresses on the Uniaxial Tensile Properties of Discontinuous Fiber Composites, M.S. Thesis, September 1990.

D.M. Seigenthaler, "Effect of Thermal Residual Stresses on the Stress-Strain Behavior of Metal-Matrix Composites, M.S. thesis, September 1991.

CORROSION AND FATIGUE BEHAVIOR OF GRAPHITE-ALUMINUM COMPOSITES

I. Dutta, Assistant Professor of Mechanical Engineering
Sponsors: Naval Weapons Support Center, Crane (REIMBURSABLE FY90)
NPS Research Council (Research Initiation Program, FY90)

OBJECTIVE: To characterize the corrosion behavior of fiber composites in aqueous marine environments.

SUMMARY: NWSC, Crane is currently considering the possibility of using Gr-A1 composites as electronic module frame materials, which are subjected to various marine environments. This project consists of two parts. The study an in depth investigation of the corrosion behavior of Gr/A1 MMCs in aqueous environments with special emphasis on the effects of pH, sulphite ion contamination from stack gases and heat treatment of the corrosion behavior of Gr-A1 composites on aqueous salt solutions. In addition, the principal mechanism of corrosion of Gr/A1 composites has been identified.

PUBLICATIONS: I. Dutta, L.R. Elkin and J.D. King, "Corrosion Behavior of a P130x Graphite Fiber Reinforced 6063 Aluminum Composite Laminate in Aqueous Environments", accepted, Journal of Electrochemical Society, (April 1991).

CONFERENCE PRESENTATIONS: I. Dutta. L.R. Elkin and J.D. King, "Corrosion Behavior of P130x-6063 A1 Composite Laminates in Aqueous Environments", 119th Annual Meeting of TMS-AIME, New Orleans, Louisiana, February 1991.

THESES DIRECTED: J.D. King, "Characterization to the Corrosion Behavior of a P130x Graphite-6063 Aluminum Metal Matrix Composite", M.S. Thesis, December 1989.

L.R. Elkin, "Corrosion Mechanisms and Behavior of Gr-A1 Composites in Aqueous Environments", M.S. Thesis, September 1990.

CHARACTERIZATION OF ALUMINUM NITRIDE SUBSTRATES AND COPPER-ALUMINUM NITRIDE METALLIZATIONS FOR ELECTRONIC PACKAGING APPLICATION

I. Dutta, Assistant Professor of Mechanical Engineering
Sponsor: Naval Weapons Support Center, Crane (Reimbursable FY91)

OBJECTIVE: To correlate the process-microstructure-property relationships of aluminum nitride substrates, and characterize Cu-A1N interfaces in metallized substrates.

SUMMARY: The sintering kinetics in liquid phase sintered aluminum nitride bulk pieces are being investigated to optimize processing parameters with respect to resultant microstructural changes. Thermal conductivity, which is a very important property of good substrate materials for electronic packaging, is being measured to investigate the effect of process variables on substrate properties. At a later stage, copper-A1N metallizations will also be studied in detail.

PUBLICATIONS: None yet.

THESIS DIRECTED: J. Cooper, "Correlation of Processing and Properties of A1N Substrate Materials for Electronic Packaging", M.S. Thesis, in progress [expected December 1991].

THERMAL AND MECHANICAL FATIGUE BEHAVIOR OF GRAPHITE FIBER REINFORCED ALUMINUM COMPOSITES

I. Dutta, Assistant Professor of Mechanical Engineering

Sponsors: Naval Weapons Support Center, Crane (Reimbursable, FY90)
NPS Research Council & NWSC, Crane (Direct Funds, FY91)

OBJECTIVE: To characterize the thermal and mechanical fatigue behaviors of continuous graphite fiber reinforced aluminum composites.

SUMMARY: Initial work done on FY90 reimbursable funds showed that the composite shows significantly different response to both thermal and mechanical fatigue with respect to the unreinforced matrix material. Crack initiation and crack propagation studies are currently being conducted to identify the fatigue damage mechanisms of the composite with special emphasis on the residual stress state and the nature of the fiber-matrix interfaces.

PUBLICATIONS: S. Mitra, I. Dutta and R.C. Hansen, "Thermal Cycling Studies of Cross-Plied P100 Graphite Fiber Reinforced 6061 A1 Composite Laminates", accepted, Journal of Material Science, (february 1990).

I. Dutta, S. Mitra and R.C. Hansen, "Flexural Fatigue Behavior of a Cast P100 Graphite Fiber Reinforced 6061 Aluminum Composite Laminate", Scripta Metall., accepted (April 1991).

CONFERENCE PRESENTATIONS: S. Mitra, I. Dutta and R.C. Hansen, "Thermal Cycling Behavior of a P100 Graphite-6061 Aluminum Composite Laminates", 119th Annual Meeting of TMS-AIME, New Orleans, Louisiana, February 1991.

THESES DIRECTED: R.C. Hansen, "Thermal and Mechanical Fatigue of P100 Gr-6061A1 Composite Laminates", M.S. Thesis, September 1990 [co-adviser: Prof. S. Mitra].

C.R. Baker, "Fatigue of Graphite-Aluminum Composites", M.S. thesis, in progress [co-adviser: Prof S. Mitra].

THE PHASES AND MICROSTRUCTURES RESULTING FROM VARIOUS HEAT TREATMENTS ON AI-LI AEROSPACE ALLOYS

A.G. Fox, Associate Professor of Mechanical Engineering,
Materials Science Group,
Department of Mechanical Engineering
Sponsor: NPS Research Council and Department of Energy

OBJECTIVE: To fully understand the relationships between heat treament, microstructure and mechanical properties for A1-Li base alloys so that their range of applications in the aerospace industry can be extended.

SUMMARY: The relationship between thermo-mechanical processing, microstructure and physical and mechanical properties is important for any alloy system. Despite the many proposed uses of low density, high stiffness A1-Li alloys, particularly in aerospace applications, many have not been realized because the necessary properties have not been achieved. One of the major reasons for this is because the fundamental properties of these alloys is not properly understood. This work, initiated by Professors Fox, Thomas and Radmilovic when Professor Fox was at the Department of Energy, aims to clarify the basic physical properties of A1-Li base alloys so that more potential uses of these can be realized. During 1990 three Masters Theses were completed together with appropriate publications.

PUBLICATIONS: A.G. Fox, S. C. Fuller, C. E. Whitman and V. Radmilovic, "A Powder X-Ray Diffraction Study of A Solution Treated and Ice-Brine-Quenched A1-14.25 at .% Li Alloy" accepted for publication in Journal of Materials Research.

CONFERENCE PRESENTATIONS: A.G. Fox and V. Radmilovic, "X-Ray Diffraction Studies of As-Quenched A1-Li Alloys" presented at The Metallurgical Society Annual Meeting, New Orleans, LA., February 1991.

THESES DIRECTED: C. Whitman, LT., USN, "Nucleation of Precipitates in an AI-2.5 wt.% Li Alloy - An X-ray Diffraction Study". Masters Thesis March 1990.

S.C. Fuller, Captain, USMC, "An Investigation of the As-Quenched and Early Aging Characteristics of an AI - 4.1 wt.% Alloy by X-Ray Diffraction". Masters Thesis June 1990.

T.K. Wang, Major, Taiwan Army. " A Powder X-Ray Diffraction Study of the A1-Li Alloy Navalite". Masters Thesis, January 1991.

THE CRYSTALLOGRAPHIC AND CHEMICAL CHARACTERIZATION OF MICROSTRUCTURES AND NON-METALLIC INCLUSIONS IN HIGH-STRENGTH, LOW-ALLOY (HSLA) STEELS AND THEIR WELDMENTS

A.G. Fox, Associate Professor of Mechanical Engineering,
Material Science Group,
Department of Mechanical Engineering
Sponsors: For FY89 NPS Research Council, For FY90 NPS Research Council, and David Taylor Research Center (USN), Bethesda, 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 preheat 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 these for ship and submarine construction. This project aims to support these objectives with fundamental physical metallurgy studies at NPS. This project is now proceeding extremely well with three Masters Theses completed and two publications in preparation.

PUBLICATIONS: J.T. Haddock, A.G. Fox and J.K. Batham, "A New Magnesium-Based Reagent for the Ladle Treatment of Steel. Part I, Theory and Laboratory Evaluation", submitted to Metallurgical Transactions B.

I. Hussain, J.T. Haddock, A.G. Fox and J.K. Batham, "A New Magnesium Based Reagent for the Ladle Treatment of Steel. Part II Steelworks Evaluations", submitted to Metallurgical Transactions B.

THESES DIRECTED: V.R. Mattes, Lieutenant, U.S. Navy, "Microstructure and Mechanical Properties of HSLA-100 Steel", Mechanical Engineers Thesis, December 1990.

D.J. Ellis, Lieutenant, U.S. Navy, "The Effect of Titanium Inclusions on HY-80 GMA Weld Deposits", Masters Thesis, December 1990.

ACCURATE STRUCTURE FACTOR MEASUREMENT BY ELECTRON DIFFRACTION

A.G. Fox, Associate Professor of Mechanical Engineering,
Materials Science Group,
Department of Mechanical Engineering
Sponsors: Department of Energy, Science and Engineering Research Council (U.K.)
and the Naval Postgraduate School

OBJECTIVE: To accurately measure the low angle structure factors of selected materials by electron diffraction 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 Be, Al, Cr, Fe, Cu, Zn and ßNiAl", Acta Metallurgica in press (1991).

CONFERENCE PRESENTATIONS: A.G. Fox and M.A. Tabbernor, "The Bonding Charge Densities of ßNiAl" presented at the Materials Research Society Spring Meeting, San Francisco, CA. April 1990.

A.G. Fox and M.A. Tabbernor, "Elemental Atomic Scattering Factors and Charge Densities of Some Metallic Elements" an invited talk presented at the International Union on Crystallography 90 Meeting, Bordeaux, France, June 1990.

J.M. Zuo, J.C.H. Spence, A.G. Fox and M.A. Tabbernor, "Accurate Structure Factor Determination by Convergent Beam Electron Diffraction" presented at the International Union on Crystallography 90 Meeting, Bordeaux, France, June 1990.

A.G. Fox, M.A. Tabbernor and R.M. Fisher, "Understanding Crystal Bonding - The Contribution of Electron Diffraction" presented at the 12th International Conference on Electron Microscopy, Seattle, WA., August 1990.

THESIS DIRECTED: M.A. Tabbernor, Graduate Student at Wolverhampton Polytechnic U.K. "Bonding Charge Densities of Some Metallic Elements and the Alloy ßNiAl" Doctoral Thesis completed; defense conducted July 1990 and degree of PhD awarded.

PLANNING, NAVIGATION, DYNAMICS AND CONTROL OF AUTONOMOUS UNDERWATER VEHICLES

Anthony J. Healey, Professor and Chairman of Mechanical Engineering
Robert B. McGhee, Associate Professor and Chairman of Computer Science
Yuh-jeng Lee, Assistant Professor of Computer Science
Sehung Kwak, Adjunct Research Professor of Computer Science
R. Cristi, Associate Professor of Electrical and Computer Engineering
F.A. Papoulias, Assistant Professor of Mechanical Engineering
Glenn Reid, Adjunct Professor, NSTEP Assignment from NSWC (White Oak)
Sponsor: Naval Surface Weapons Center, White Oak Laboratories, Code U-25

OBJECTIVE: This research project is a long term continuing program to investigate and improve basic technologies related to the real time control, artificial intelligence, and computer architectures needed for the support of Autonomous Underwater Vehicles.

SUMMARY: The objective to be met is to demonstrate fully autonomous behavior in a controlled environment. Progress for this reporting period has included a major effort in the development of Sliding Mode Controllers for both steering and depth changing control of vehicles of the type to be used for future AUV operations. An extensive computer graphics simulation using an IRIS workstation together with an AI based mission planning software package has been improved. Theoretical studies in the design of adaptive autopilots have produced encouraging results. A second generation testbed vehicle has been built 385 lbs. in weight having 4 sonar channels, a suite of gyros and accelerometers and 2 on-board computers (an MS-DOS machine for data gathering and mission level control and a GESPAC Motorola 68030 based machine for real-time control). A highly maneuverable design has been generated, and was launched by RADM R. West on June 15, 1990 in the NPS Swimming Pool. Tests are underway for the propulsion system, and closed loop control performance. A novel thruster design is being perfected. Further information is available from the Principal Investigator.

PUBLICATIONS:

Cristi, R., Healey, A.J., Papoulias, F.A., "Adaptive Sliding Mode Control of Autonomous Underwater Vehicles in the Dive Plane" IEEE Journal of Oceanic Engineering, Vol 15, No. 16, 6 July 1990, pp. 152-161.

Healey, A.J., Papoulias, F.A. Lienard, D., "Multivariable Sliding Mode Control for Autonomous Diving and Steering of Unmanned Underwater Vehicles" Proceedings of the International Conference on Modeling and Control of Marine Craft, University of Exeter, April 18-20, 1990.

Papoulias, F.A., Healey, A.J. "Path Tracking of Surface Ships Using Multivariable Sliding Mode Control" Proceedings of the 9th Ship Control Systems Symposium, Washington, D.C., September 10-14, 1990.

Cristi, R., Healey, A.J., Papoulias, F.A., "Dynamic Output Feedback by Robust Observer and Variable Structure Control" Proceedings of the American Control Conference, San Diego, June 1990.

Cristi, R., Feuer, A., Healey, A.J., Papoulias, F.A., "Variable Structure Control of Dynamic Systems with Input Output Observations" Accepted in Trans ASME Journal of Dynamic Systems Measurement and Control, to appear 1991.

Healey, A.J., "Model Based Maneuvering Controls for Autonomous Underwater Vehicles". Accepted for Trans ASME Journal of Dynamic Systems, Measurement and Control to appear in 1991.

Healey, A.J., McGhee, R.B., Cristi, R., Papoulias, F.A., Kwak, S.H. Kanayama, Y. Lee, Y.," Mission Planning, Execution and Data Analysis for the NPS AUV II Autonomous Underwater Vehicle" NSF Workshop on Mobile Undersea Robotics, held at Monterey Bay Aquarium Research Institute, Monterey, CA., October 23-26, 1990.

Zyda, M.J., McGhee, R.B., Kwak, S.H., Nordman, D.B., Rogers, R.C., Marco, D. "Three Dimensional Visualization of Mission Planning and Control for the NPS Autonomous Underwater Vehicle", IEEE Journal of Oceanic Engineering, July 1990.

Kwak, S.H., Ong, S.M., McGhee, R.B., "A Mission Planning System for an Autonomous Underwater Vehicle" Proceedings of AUV 90 Washington, D.C., June 5-6, 1990, also in IEEE Journal of Oceanic Engineering, July 1990, Vol. 15, No. 3, pp. 217-220.

Bihari, T.E., McGhee, R.B., Luqi, Lee, Y.,

"Applying a Computer Aided Prototyping System to the Software of an Autonomous Underwater Vehicle" Proceedings of the DARPA Workshop on Software Tools for Distributed Intelligent Control Systems, Pacifica, CA., July 17-19, 1990.

THESES DIRECTED: Saunders, T., "Performance of Small Thrusters and Propulsion Systems" M.S. Degree Thesis, March 1990.

Riling, W.D., "A Microprocessor Based Controller for an Autonomous Underwater Vehicle" MS Degree Thesis March 1990.

Ong, S.M., "A Mission Planning Expert System with Three Dimensional Path Optimization for the NPS II Autonomous Underwater Vehicle" MS Degree Thesis, June 1990.

Cloutier, M.J., "Guidance and Control System for an Autonomous Vehicle" M.S. Degree Thesis, June 1990.

Lienard, D.E., "Autopilot Design for Autonomous Underwater Vehicles Based on Sliding Mode Control" M.E. Degree Thesis, June 1990.

Chism, S.R., "Robust Path Tracking of Autonomous Underwater Vehicles Using Sliding Modes" M.E. Thesis, December 1990.

Hawkinson, T.B., "Multiple Input Sliding Mode Control for Autonomous Diving and Steering of Underwater Vehicles" M.E. Thesis, December 1990.

COMPUTATIONS AND EXPERIMENTS ON HEAT TRANSFER AND FLUID DYNAMICS OF FUSION WELDING

Yogendra Joshi, Associate Professor of Mechanical Engineering
Sponsor: David Taylor Research Center, Annapolis, MD

OBJECTIVE: A continuing investigation of applications of heat transfer and fluid flow in the automation of fusion welding processes.

SUMMARY: Heat transfer and fluid flow patterns during fusion welding are known to be modified by various anomalies during the process. These need to be detected and corrected systematically in an automated arrangement. This study aims to characterize these defects through measurements and models of surface temperatures and weld-pool geometry. During the reporting period an experimental setup was constructed for the determination of welding efficiencies. Measurements of surface temperatures using thermocouples were made to detect the presence of sub-surface impurities. The laser vision system was installed and tested.

PUBLICATIONS: R.L. Ule, Y. Joshi and E.B. Sedy," A New technique for Three-Dimensional Transient Heat Transfer Computations of Autogenous Arc Welding," Metallurgical Transactions B, December 1990.

THESIS DIRECTED: E.B. Sedy, LT, USN, "Validation of a computer model for autogenous arc welding," Mechanical Engineer Thesis by E.B. Sedy, March 1990.

HEAT TRANSFER AND FLUID FLOW IN FUSION WELDING

Yogendra Joshi, Associate Professor of Mechanical Engineering
Sponsor: National Science Foundation, Washington, D.C.

OBJECTIVE: As part of a continuing initiative study of the heat transfer and fluid flow associated with fusion welding processes.

SUMMARY: The research reported here was started during FY88. It involves computational modeling and accompanying experimental investigations of heat transfer and fluid flow processes during fusion welding. During the past year, a three-dimensional computational model of heat transfer in fusion welding was developed. In high welding current applications, fluid flow within the fusion zone may significantly alter the weld-pool shape and cooling rates compared to a pure diffusion situation. A two-dimensional model was developed to study these effects. The model uses an enthalpy formulation of the energy equation and solves the governing equations in the primitive variables form. Results of this model will be compared with the conduction model and the laser vision system measurements.

OTHER: The computational results to date are currently in preparation for publication.

CONVECTIVE COOLING OF ELECTRONIC EQUIPMENT: EXPERIMENTS AND COMPUTATIONS

Yogendra Joshi, Associate Professor of Mechanical Engineering
Matthew D. Kelleher, Professor of Mechanical Engineering
Beny Neta, Associate Professor of Mathematics
Sponsor: Naval Weapons Support Center, Crane, Indiana

OBJECTIVE: As part of a multi-year effort, investigation of convective flow and heat transfer characteristics of simulated and actual electronic components.

SUMMARY: This effort was initiated in FY88. During the present reporting period, the combined conduction and convection processes associated with liquid cooling of electronic devices were examined experimentally and computationally. Experimental natural convection studies of flush heat sources in liquid filled vertical channels and enclosures continued. Additional experiments were initiated to study boiling from simulated electronic components in dielectric liquids. Two-dimensional computations were carried out to model prior natural convection experimental studies on isolated components. A three-dimensional code was developed for the analysis of steady heat transfer and fluid flow problems in rectangular systems. The general purpose code ELLPACK was used to model three-dimensional heat conduction in rectangular systems.

PUBLICATIONS: Y. Joshi and D.L. Knight, "Natural Convection From a Column of Flush Heat Sources in a Vertical Channel in Water," Journal of Electronic Packaging, Transactions of ASME, pp. 367-374, 1990.

Y. Joshi and R.A. Paje, "Natural Convection Cooling of a Ceramic Substrate Mounted Leadless Chip Carrier in Dielectric Liquids," International Communications in Heat and Mass Transfer, forthcoming.

S.B. Sathe and Y. Joshi, "Natural Convection Arising From a Heat Generating Substrate-Mounted Protrusion in a Liquid-Filled Two-Dimensional Enclosure," International Journal of Heat and Mass Transfer, forthcoming.

CONFERENCE PRESENTATION: S.B. Sathe and Y. Joshi, "Natural Convection Liquid Cooling of a Substrate-Mounted Protrusion in a Square Enclosure: Effects of Thermophysical Properties, Geometric Dimensions and Boundary Conditions," ASME Winter Annual Meeting, Dallas, Texas, November 25-30, 1990.

THESES DIRECTED: L.O. Haukenes, LT, USN, "A computational and experimental study of flush heat sources in liquids," Mechanical Engineer Thesis June 1990.

L.J. Carling IV, LT, USN, "Effects of flow pulsations on heat transfer from a discrete heat source in a liquid filled parallel plate channel," Master of Science Thesis by L.J. Carling December 1990.

OTHER: The following manuscript is currently under preparation: Y. Joshi, M.D. Kelleher, E. Torres and M. Powell, "Natural Convection From an Array of Protruding Heat Sources in an Enclosure Filled With Dielectric Liquid".

FIELD MODELING OF FIRE AND SMOKE SPREAD IN CONFINED SPACES

Matthew D. Kelleher, Professor Mechanical Engineering
K.T. Yang, Viola D. Hank, Professor of Engineering,
University of Notre Dame, Notre Dame, Indiana
Sponsor: Naval Research Laboratory

OBJECTIVE: Develop a finite difference numerical model for the realistic determination of the time dependent fire and smoke spread in confined spaces. This is to be used to simulate various fire scenarios in submarines and surface ships for fire safety and design considerations.

SUMMARY: A finite difference model to simulate the spread of fire and smoke in the FIRE-I research chamber at the Naval Research Laboratory has been developed. The present version of the model uses a system of general orthogonal coordinates so that the specification of the geometry is not a major constraint. The model is also capable of including the presence of solid objects or obstruction, such as machinery components, within the enclosure. The effects of surface radiation as well as volumetric gaseous radiation have also been included. The model can also accommodate the presence of forced ventilation within the space so that the presence of fans or ventilation ducts can be included. Algorithms are being developed to incorporate combustion processes in the model. Graphics post-processing capabilities are also being developed the enhance the presentation of the results.

PUBLICATIONS: M.D. Kelleher, J. Raycraft, H.Q. Yang, and K.T. Yang, "Fire Spread in a Three-Dimensional Pressure Vessel with Radiation Exchange and Wall Heat Losses", accepted for publication in the International Journal of Mathematical and Computer Modeling.

CONFERENCE PRESENTATION: M.D. Kelleher, R. Houck and K.T. Yang, "Numerical Field Model Simulation of Full Scale Fires in a Closed Vessel with Internal Forced Circulation", Eurotherm Fire Modeling Conference, Harwell Laboratory, Didcot, UK, June 4-7, 1990.

FRACTURE ANALYSIS IN METAL-MATRIX COMPOSITES

Y.W. Kwon, Assistant Professor of Mechanical Engineering
Sponsor: Research Administration Office
Funding: Naval Postgraduate School (RIP)

OBJECTIVE: The goal of this project was to develop a nonlinear analysis model for fiber-reinforced composites and to investigate the crack tip fields of metal-matrix composites at the micromechanical level.

SUMMARY: Previous analysis models for continuous fiber reinforced composites were examined and a new model was developed to bridge the gap between the micromechanical analysis model and the macromechanical analysis model. Some initial numerical study using the finite element method shows that the new analysis model was proven to be quite powerful for material nonlinear analyses of metal-matrix composites, which had elastic deformation of fiber and elastoplastic (or elastoviscoplastic) deformation of matrix.

PUBLICATION: Y.W. Kwon, "Elasto-Viscoplastic Analysis of Fiber-Reinforced Composites", Engineering Computations, Accepted for publication.

Y.W. Kwon, "Simplified Finite Element Analysis of Double Cantilever Beams", Computers and Structures, Vol. 34, No. 1, pp. 145-149, 1990.

Y.W. Kwon and K.Y. Byun, "Development of a New Finite Element Formulation for the Elasto-Plastic Analysis of Fiber Reinforced Composites, Computer and Structures, Vol. 35, No. 5, pp. 563-570, 1990.

Y.W. Kwon and E.F. Kelemntich, and K.I. Ko, "An Efficient and Accurate Model for the Structural Analysis of Threaded Tubular Connections", SPE Production Engineering, pp. 261-264, 1990.

Y.W. Kwon, "Finite Element Analysis of Dynamic Instability of Layered Composite Plates Using a High-Order Bending Theory", Computers and Structures, Accepted for publication.

Y.W. Kwon et al., "CANFEA - Finite Element Analysis Program for Metal Containers", Report for Anheuser Busch/Metal Container Corporation, 1990.

CONFERENCE PRESENTATIONS: Y.W. Kwon and K.Y. Byun, "Development of Micromechanics Finite Element for Analysis of Composites with Local Damage", Composite Material Technology 1990, pp. 107-112, New Orleans, Louisiana, January 1990.

Y.W. Kwon and K.Y. Byun, "A Micro-Macro Analysis Model for Fiber-Reinforced Composite Structures," Eleventh U.S. National Congress of Applied Mechanics, Tucson, Arizona, May 1990.

Y.W. Kwon and K. Weiseman, "Study of Flexural Stiffness in Delaminated Composite Plates," Accepted for Publication and Presentation at ASME Energy Technology Conference and Exhibition, Houston, Texas, January 1991.

Y.W. Kwon, "Reliability Analysis of Composite Plates for Eigenvalue Problems", Accepted for Publication and Presentation at ASME Energy Technology Conference and Exhibition, Houston, Texas, January 1991.

Y.W. Kwon, "Elastoviscoplastic Analysis Plate Bending of Composites", Accepted for Publication and Presentation at ASME Pressure Vessels and Piping Conference, San Diego, California, June 1991.

Y.W. Kwon, "Material Nonlinear Analysis of Composites", Accepted for Publication and Presentation at 13th Canadian Congress of Applied Mechanics, June 1991.

Y.W. Kwon and R. Dutton, "Boundary Element Shape Function for Bimaterial Interface Cracks", Accepted for Publication and Presentation at 13th Canadian Congress of Applied Mechanics, June 1991.

D. Salinas, Y.W. Kwon, and B.S. Ritter, "A Study of Linearization Techniques in Nonlinear FEM", Submitted for Publication and Presentation at Eight Int. Conference on Mathematical and Computer Modeling.

OTHER: Six papers have been submitted for publication to a refereed journals.

EFFECTS OF UNSTEADINESS ON LAMINAR-TURBULENT TRANSITION IN STRAIGHT CHANNEL FLOW

P.M. Ligrani, Associate Professor of Mechanical Engineering
Department of Mechanical Engineering
Sponsor: Office of Naval Research, Arlington, VA.,
Naval Postgraduate School, Monterey, CA
Funding: Naval Postgraduate School

OBJECTIVE: To investigate the influences of imposed, bulk flow unsteadiness on transition in a straight channel with large aspect ratio. Of particular interest are the interactions between the imposed unsteadiness and transition flow phenomena and, during these interactions, whether certain frequencies and amplitudes of unsteadiness stabilize or de-stabilize transition events.

SUMMARY: Results from this study elucidate fundamental mechanisms operative during the laminar/turbulent transition process as it is affected by imposed bulk flow unsteadiness. Information is obtained on: (1) parameters governing the unsteady flow, (2) events occurring during the onset and development of transition, (3) interactions between the imposed bulk flow unsteadiness and transition phenomena, and (4) how heat transfer in the transitioning flow is affected by the imposed bulk flow unsteadiness. Results for Reynolds numbers from 1400 to 1800 and Strouhal numbers Str from 0.004 to 0.050 show different subcritical transition events including two and three-dimensional Tollmien-Schlichting waves, vortex-array type motions evidenced by smoke swirls (normal/span planes) and ribbon-like patterns (stream/span planes), turbulent spots, and fully turbulent flow. With high inlet disturbance levels, longitudinal fluctuating intensities near the edge of the Stokes layer are reduced by imposed unsteadiness at 1 Hz for $2000 < Re < 2400$ or $0.032 > Str > 0.028$. At 2 Hz, this occurs for $2200 < Re < 2400$ or $0.059 > Str > 0.054$. Within the range of Str so far considered (and with high inlet disturbance levels), transition events appear at lower Reynolds number and persist over a wider range of Reynolds number compared to flows with no unsteadiness.

PUBLICATIONS: P.M. Ligrani, C.S. Subramanian, T.M. Coumes, F.J. Greco, H. Koth, J.M. Longest, "Study of the Imposition of Bulk Flow Unsteadiness on Plane Channel Flow at Low Strouhal Numbers," Experimental Thermal and Fluid Science, 1991.

P.M. Ligrani, G.E. Schwartz, P.E. Skogerboe, and A. Ortiz, "Constant Heat Flux Surfaces for Measurement of Nusselt Numbers and Stanton Numbers," submitted to the Journal of Physics E-Scientific Instruments, 1990.

P.M. Ligrani, C.S. Subramanian, D.S. Morrow, B.J. Smith and H. Koth, "Effects of Low Amplitude Imposed Unsteadiness at Low Strouhal Numbers on Transition from Laminar to Turbulent Flow in a Straight Channel," in preparation for Physics of Fluids, 1991.

CONFERENCE PRESENTATIONS: T.M. Coumes, F.J. Greco, P.M. Ligrani and C.S. Subramanian, "Effects of Bulk Flow Unsteadiness on Laminar/Turbulent Transition in a Straight Channel," Paper HA5, American Physical Society, Division of Fluid Dynamics, Forty-Second Annual Meeting, NASA-Ames, Moffett Field, CA November 19-21, 1989.

C.S. Subramanian, P.M. Ligrani and H.E. Koth, "Experimental Observation of the Center Mode of Instability During Laminar/Turbulent Transition in Plane Poiseuille Flow," Paper CK4, American Physical Society, Division of Fluid Dynamics, Forty-Third Annual Meeting, Cornell University, Ithaca, N.Y., November 18-20, 1990.

THESES DIRECTED: J.M. Longest (LT USN), "Flow Visualization Studies in (1) a Curved Rectangular Channel with 40 to 1 Aspect ratio and (2) a Straight Channel with Bulk Flow Unsteadiness," M.S. Thesis, June 1989.

F.J. Greco (LCDR USN), "Effects of 2 Hz Imposed Bulk Flow Unsteadiness on Laminar/Turbulent Transition in a Straight Channel," M.S. Thesis, December 1989.

T.M. Coumes (LCDR USN), "Effects of 1 Hz Imposed Bulk Flow Unsteadiness on Laminar/Turbulent Transition in a Straight Channel," M.S. Thesis, December 1989.

H.E. Koth (LT USN), "Effects of Imposed Bulk Flow Oscillations at 1,2,3 and 4 Hz on Transition in a Straight Channel with 40 to 1 Aspect Ratio," M.S. Thesis, June 1990.

D.S. Morrow (LT USN), "Effects of High

Amplitude Imposed Oscillations on Laminar/Turbulent Transition in a Straight Channel at Imposed Frequencies Less Than 2 Hertz," M.S. Thesis, March 1991.

B.J. Smith, (LT USN), "Effects of High Amplitude Imposed Oscillations on Laminar/Turbulent Transition in a Straight Channel at Imposed Frequencies Greater Than 2 Hertz," M.S. Thesis, March 1991.

TURBULENCE STRUCTURAL CHARACTERISTICS OF FILM COOLING JETS WITHOUT INTERACTIONS WITH EMBEDDED LONGITUDINAL VORTICES IN TURBULENT BOUNDARY LAYERS

P.M. Ligrani, Associate Professor of Mechanical Engineering
C.S. Subramanian, Adjunct Research Professor of Mechanical Engineering
Sponsor: Office of Naval Research, Arlington, VA.,
Naval Postgraduate School, Monterey, CA
Funding: Naval Postgraduate School

OBJECTIVE: To survey and study the Reynolds stress tenor components and turbulent transport triple products resulting from the presence of film cooling injection in turbulent boundary layers both with and without interactions with embedded longitudinal vortices.

SUMMARY: The vortex is produced in a zero-pressure gradient turbulent boundary layer using a half delta wing on the wind tunnel floor at a location 63 injection hole diameters upstream of the injection site. The single, circular wall jet is inclined at 30 degrees to the horizontal. Vortex circulation is 0.085 m2/s 41.9 diameters downstream of injection holes. With the jet opposing the vortex downwash and the blowing ratio increasing from 0 to 4.8, maximum streamwise vorticity decreases from 750 to 150 s-1, while circulation decreases from 0.148 to 0.05 m2/s. For a 1.5 blowing ratio, the six Reynolds stress components and associated triple products are altered significantly in the embedded vortex because of the presence of the wall jet. Because of the jet, the longitudinal and spanwise normal Reynold stress components are increased in the vortex upwash. Changes due to the jet are similar in the vortex core and downwash region. Reynolds shear stress components indicate regions of negative production near the vortex core which are more intense with a blowing ratio of 1.5 than with zero injection. This situation also gives stress gradients which are severely distorted by the jet beneath the vortex core.

PUBLICATIONS: P.M. Ligrani and G.E. Schwartz, "Control of Embedded Longitudinal Vortices Using a Wall Jet," International Journal of Heat and Fluid Flow, vol. 11, No. 4, December 1990.

C.S. Subramanian, P.M. Ligrani, J.G. Green, W.D. Doner and P. Kaisuwan, "Development and Structure of a Film-cooling Jet in a Turbulent Boundary Layer with Heat Transfer," Transport Phenomena and Dynamics of Rotating Machinery, 1991.

C.S. Subramanian, P.M. Ligrani and M.F. Tuzzolo, "Surface Heat Transfer and Flow Properties of Vortex Arrays Induced Artificially and From Centrifugal Instabilities," submitted to International Journal of Heat and Fluid Flow, 1991.

C.S. Subramanian, P.M. Ligrani, J.G. Green and W.D. Doner, "Turbulence Structure of Embedded Vortex/Wall Jet Injection in a Turbulent Boundary Layer," in preparation for Journal of Fluid Mechanics, 1991.

CONFERENCE PRESENTATIONS: C.S. Subramanian, P.M. Ligrani and J.G. Green, "Interactions Between a Turbulent Embedded Vortex and a Turbulent Wall Jet," Paper T-6, Open Forum, Seventh Symposium on Turbulent Shear Flows, Stanford University, Stanford, CA., August 21-23, 1989.

C.S. Subramanian, P.M. Ligrani and J.G. Green, "Interaction Between a Longitudinal Embedded Vortex and a Wall Jet in a Turbulent Boundary Layer," Paper FC5, American Physical Society, Division of Fluid Dynamics, Forty-Second Annual Meeting, NASA-Ames, Moffett Field, CA., November 19-21, 1989.

C.S. Subramanian, P.M. Ligrani, J.G. Green, and W.D. Doner, "Development and Structure of a Film-Cooling Jet in a Turbulent Boundary Layer with Heat Transfer," Third International Symposium on Transport Phenomena and Dynamics of Rotating Machinery (ISROMAC-3), Honolulu, HI., April 1-4, 1990.

THESES DIRECTED: G.E. Schwartz (LCDR USN), "Control of Embedded Vortices Using Wall Jets," M.S. Thesis, September 1988.

J.G. Green (LT USN), "Turbulence Structure Resulting from Interactions Between an Embedded Vortex and Wall Jet," M.S. Thesis, June 1989.

W.D. Doner (LT USN), "Further Studies of Turbulence Structure Resulting from Interactions Between Embedded Vortices and Wall Jets at High Blowing Ratios," M.S. Thesis, December 1989.

EFFECTS OF EMBEDDED LONGITUDINAL VORTICES ON BOUNDARY L /ERS FILM-COOLED USING COMPOUND ANGLE INJECTION HOLES

P.M. Ligrani, Associate Professor of Mechanical Engineering

Sponsor: Aero-Propulsion Laboratory, Wright-Patterson Air Force Base, Ohio

OBJECTIVE: To investigate the effects of film injection from holes with compound angle orientations, as compared to injection from holes with simple angle orientations. Also investigated are the effects of embedded longitudinal vortices on heat transfer and injectant distributions downstream of single and double rows of holes with compound angle configurations. Injection from compound angle holes is used for end-wall and blade surfaces in the first stage of gas turbine engines in state-of-the-art high-temperature engines.

SUMMARY: Film cooling is currently used as a heat sink and as a thermal barrier to protect gas turbine surfaces from exposure to hot gases. The present study investigates the effects of film injection from holes with compound angle orientations, as compared to injection from holes with simple angle orientations. The comparisons are made based on measured surveys of injectant distributions and all three components of mean velocity. Also measured are surface distributions of heat transfer coefficients, as well as the adiabatic film cooling effectiveness determined using the technique of linear superposition.

Intense secondary flows, such as embedded longitudinal vortices, disturb the injectant as well as the protection nominally provided by the injectant. In the present study, investigated are the effects of single embedded longitudinal vortices on heat transfer and injectant in a turbulent boundary layer downstream of one and two rows of film-cooling holes with compound angle orientations. Attention is focussed on the changes which result as vortex size, vortex position with respect to injection holes, and vortex circulation magnitudes are varied. Mean temperature results are to be obtained which show how injectant is distorted and redistributed by vortices, along with heat transfer measurements and mean velocity surveys. To quantify the influences of the vortices on the injectant and local heat transfer, the parameter defined as the ratio of vortex circulation to vortex core diameter times mean injection velocity is used. Except for special circumstances, the vortices reduce the protection provided by the film injection.

PUBLICATIONS: P.M. Ligrani and S.W. Mitchell, "Effects of Embedded, Longitudinal Vortices on Heat Transfer and Injectant Distributions Downstream of a Double Row of Film Cooling Holes with Compound Angles," in preparation for ASME Transactions Journal of Turbomachinery, 1991.

P.M. Ligrani, S. Ciriello, and D.T. Bishop, "Heat Transfer, Adiabatic Effectiveness and Injectant Distributions Downstream of Single Row and Two Staggered Rows of Film-Cooling Holes," ASME Transactions Journal of Turbomachinery, 1991.

CONFERENCE PRESENTATIONS: P.M. Ligrani and S.W. Mitchell, "Effects of Embedded, Longitudinal Vortices on Heat Transfer and Injectant Distributions Downstream of a Double Row of Film Cooling Holes with Compound Angles," ASME Winter Annual Meeting, Atlanta, Georgia, November 1991.

THESIS DIRECTED: S.W. Mitchell (LT USN), "The Effects of Embedded Vortices on Heat Transfer in a Turbulent Boundary Layer with Film Cooling from Holes with Compound Angles," M.S. Thesis, September 1990.

D.T. Bishop (LT USN), "Heat Transfer, Adiabatic Effectiveness and Injectant Distributions Downstream of Single and Double Rows of Film-Cooling Holes with Compound Angles," M.S. Thesis, September 1990.

C. Ciriello (LT USN), "Study of the Adiabatic Film Cooling Effectiveness Downstream of One Row and Two Rows of Radially Oriented and Compound Angle Film-Cooling Holes," M.S. Thesis, March 1991.

STUDY OF THE EFFECTS OF CENTRIFUGAL INSTABILITIES ON TRANSITION FROM LAMINAR TO TURBULENT FLOW IN CURVED CHANNELS FOR DEAN NUMBERS FROM 160 TO FULLY TURBULENT CONDITIONS

P.M. Ligrani, Associate Professor of Mechanical Engineering
Sponsor: Propulsion Directorate, U.S. Army Aviation Research and Technology Activity-AVSCOM, NASA-Lewis Research Center, Cleveland, Ohio

OBJECTIVE: To study of the effects of centrifugal instabilities on transition from laminar to turbulent flow in curved channels for Dean numbers from 160 to fully turbulent conditions. Of particular interest is the development of Dean vortices and their influences on heat transfer and the later stages of transition.

SUMMARY: The structure and development of flow in a curved rectangular channel with 40 to 1 aspect ratio is to be studied. Results are to be obtained for Dean numbers ranging from 160 to values where fully turbulent flow is present. Of interest are the effects of centrifugal instabilities on: (1) convective heat transfer processes, and (2) the later stages of transition from laminar to turbulent flow. The experimental data are also intended to be used for comparison with and development of computational and simulation models of curved channel flows. In order to understand flow characteristics, high-speed movies and still photographs are to be made of the flow when it is visualized using smoke. Spatially resolved fluctuations of wall skin friction are to be measured using array of wall mounted hot-film probes. Measurements are also to be made of wall heat transfer, mean velocity components, mean vorticity components, and spectra of voltage signals from ordinary-sized as well as subminiature sized hot-wire probes.

PUBLICATIONS: W.H. Finlay, P.M. Ligrani and S.B. Bland, "Features of Wavy Vortices in a Curved Channel from Experimental and Numerical Studies," submitted to Physics of Fluids, 1990.

P.M. Ligrani and J.E Longest, "Appearance, Disappearance and Spanwise Wavenumber Selection of Dean Vortex Pairs in a Curved Rectangular Channel," submitted to Physics of Fluids, 1991.

P.M. Ligrani, G.E. Schwartz, P.E. Skogerboe, and A. Ortiz, "Constant Heat Flux Surfaces for Measurement of Nusselt Numbers and Stanton Numbers," submitted to Journal of Physics E-Scientific Instruments, 1990.

P.M. Ligrani, W.A. Fields, L.R. Baun, and M.R. Kendall, "Development and Structure of Dean Vortices in a Curved Rectangular Channel with 40 to 1 Aspect Ratio," in preparation for Physics of Fluids, 1991.

C.S. Subramanian, P.M. Ligrani and M.F. Tuzzolo, "Surface Heat Transfer and Flow Properties of Vortex Arrays Induced Artificially and From Centrifugal Instabilities, submitted to International Journal of Heat and Fluid Flow, 1991.

CONFERENCE PRESENTATIONS: P.M. Ligrani, L.R. Baun, J.M. Longest and C.S. Subramanian, "Development and Structure of Dean Vortices in a Curved Channel with 40:1 Aspect Ratio," Paper HA4, American Physical Society, Division of Fluid Dynamics, Forty-Second Annual Meeting, NASA-Ames, Moffett Field, CA., November 19-21, 1989.

P.M. Ligrani, L.R. Baun, J.M. Longest, and W.A. Fields, "Development and Structure of Dean Vortices in a Curved Rectangular Channel with 40 to 1 Aspect Ratio for Dean Numbers Less Than 200," EUROMECH 261, First Symposium on Goertler Vortex Flows, University of Nantex, France, June 10-12, 1990.

P.M. Ligrani and J.E. Longest, "Appearance, Disappearance and Spanwise Wavenumber Selection of Dean Vortex Vortex Pairs in a Curved Rectangular Channel," Paper CK1, American Physical Society, Division of Fluid Dynamics, Forty-Third Annual Meeting, Cornell University, Ithica, N.Y., November 18-20, 1990.

P.M. Ligrani, "Experimental Investigation of Splitting, Merging and Spanwise Wavenumber Selection of Dean Vortex Pairs in a Curved Rectangular Channel," 7th Taylor-Couette Workshop: Ordered and Turbulent Patterns in Taylor-Couette Flow, NATO Advanced Research Workshop, Ohio State University, Columbus, OH, May 22-24, 1991.

THESES DIRECTED: R.E. Hughes (LT USN), "Development, Qualification and Measurements in Two Curved Channels with 40 to 1 Aspect Ratio," M.S. Thesis, September 1989.

P.E. Skogerboe (LT USN), " Local and Spatially Averaged Heat Transfer Distributions in a Curved Channel with 40 to 1 Aspect Ratio for Dean Numbers from 50 to 200," M.S. Thesis, March

1990.

W.A. Fields (LT USN), "Study of the Effects of Centrifugal Instabilities on Flow in a 40 to 1 Aspect Ratio Rectangular Curved Channel for Dean Numbers from 35 to Fully Turbulent Conditions, M.E. Thesis, December 1990.

M.R. Kendall (LT USN), "Effects of Centrifugal Instabilities on Fluid and Heat Transfer Phenomena in Curved Rectangular Channels with 40 to 1 Aspect Ratios for Dean Numbers from 200 to 450," M.E. Thesis, June 1991.

A PREDICTIVE METHOD TO DESCRIBE THE BOILING BEHAVIOR OF REFRIGERANT/OIL MIXTURES

P.J. Marto, Distinguished Professor of Mechanical Engineering
J.R. Lloyd, Adjunct Professor of Mechanical Engineering
Sponsor: David Taylor Research Center
Funding: NAVSEA

OBJECTIVE: The goal of this project is to study the possibility of developing a theoretical model to predict nucleate pool boiling behavior of refrigerant/oil mixtures from various boiling surfaces.

SUMMARY: An exhaustive literature search was performed together with an assessment of existing models of binary mixture boiling for their appropriateness to use with new alternative refrigerants such as R-124 and oils such as Zerol 300. Three expressions were found that could be considered for use, but they all require empirical data for every new refrigerant/oil combination. An expression currently under development for mixtures was found to be promising in that it only depends on the thermophysical properties of the liquids and their mixtures. No empirical constants are necessary. The mass diffusion coefficient of the oil in the refrigerant was determined to be the key property to be measured. Experiments are proposed to obtain this key property and then to test the capability of this expression to predict experimental boiling data.

PUBLICATIONS: "A Predictive Method to Describe the Boiling Behavior of Refrigerant/Oil Mixtures", J.R. Lloyd and P.J. Marto, NPS Report No. NPS 69-9007, December 1990.

ENHANCED BOILING AND CONDENSATION OF REFRIGERANTS

P.J. Marto, Distinguished Professor of Mechanical Engineering
S.B. Memory, Adjunct Research Professor of Mechanical Engineering
Sponsor: David Taylor Research Center
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project is to assist the Navy by verifying design information on advanced refrigerant evaporators and condensers and determining if the best possible heat transfer rates are being achieved.

SUMMARY: Nucleate pool boiling heat transfer coefficients were obtained in a small tube bundle using smooth tubes, finned tubes and HIGH FLUX enhanced tubes using R-114/Oil mixtures. Results showed that for pure refrigerant and refrigerant/oil mixtures, the HIGH FLUX tubes gave superior performance except at oil concentrations greater than 10 percent and heat fluxes greater than 30 KW/m , where the HIGH FLUX performance became markedly reduced due to a tendency for oil to collect in the pores of this enhanced surface.

Under normal operating conditions, the HIGH FLUX surface is the preferred surface to use. Remaining tests examined the TURBO-B surface for comparison and considered local boiling coefficients within the bundle.

THESIS DIRECTED: H. Eraydin, LTJG, Turkish Navy, "Nucleate Pool Boiling of R-114/Oil Mixtures from a Bundle of High Flux and Turbo-B Tubes", Masters Thesis, December 1990.

A CRYOGENIC-TEMPERATURE APPLICATION OF HEAT-PIPE THERMAL DIODES AND MAGNETIC REFRIGERATORS

P.J. Marto, Distinguished Professor of Mechanical Engineering
S.B. Memory, Adjunct Research Professor of Mechanical Engineering
Sponsor: David Taylor Research Center
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project is to assist DTRC in determining if cryogenic heat pipe thermal diodes can be utilized in a magnetic refrigerator containing no moving parts.

SUMMARY: Research publications involving heat pipe thermal diodes operating between 4-25K were examined. A theoretical model to study the transient analysis of a hydrogen heat pipe switch that was formulated at Los Alamos National Laboratory, was evaluated for its technical appropriateness and utilization in this concept. The thermal diode must have a rapid transient response in order to be effective, and offers certain advantages over other methods. The use of heat pipes to cool electrical machines was also reviewed. The following book titled "Heat Pipes in Electrical Machine" by V.M. Petrov, et al was translated from Russian into English for future use.

ULTRA-FINE GRAINED SUPERPLASTIC ALUMINUM ALLOYS: THERMOMECHANICAL PROCESSING AND MICROSTRUCTURAL DEVELOPMENT

T.R. McNelley, Professor of Materials
Department of Mechanical Engineering
Sponsor: Naval Air Systems Command
Funding: Naval Postgraduate School

OBJECTIVE: To conduct basic research into the development of refined microstructures in Al-based alloys by means of thermomechanical processing, with particular emphasis on the enhancement of the low-temperatures superplastic response of the materials.

SUMMARY: A qualitative model for the occurrence of continuous recrystallization in a progressive manner through a series of deformation and annealing cycles in warm rolling has been proposed. The model is capable of predicting the dependence of the resultant superplastic response on warm rolling parameters such as reduction per pass and reheating interval. Further investigation of grain boundary character has revealed that warm rolling under conditions allowing sufficient time for recovery results in retention of a strong Cu-texture component, the evolution of high angle boundaries in a fine-grained microstructure and the absence of low-index coincident site boundaries. Such structures support extensive superplasticity in Al-Mg alloys. In contrast, suppression of recovery results in a Brass-texture component, low angle boundaries and retention of twin-related, low-index coincident site boundaries. This latter structure is not superplastic. These methods are applicable to other Al-based alloys and enhancement of low temperature superplastic response has been demonstrated in several such alloys.

PUBLICATIONS: "Continuous Recrystallization During Thermomechanical Processing of a Superplastic Al-10Mg-0.1Zr Alloy", S.J. Hales, T.R. McNelley and R. Crooks, in Recrystallization '90, Proceedings of the International Conference on Recrystallization in Metallic Materials, T. Chandra, ed., The Metallurgical Society of AIME, Warrendale, PA, 1990, pp. 231-236.

"The Roles of Zr and Mn in Processing and Superplasticity of Al-Mg Alloys", T.R. McNelley and S.J. Hales, in Superplasticity in Aerospace II, T.R. McNelley and H.C. Heikkenen, eds., The Metallurgical Society of AIME, Warrendale, PA, 1990, pp. 207-222.

"Processing, Microstructural Refinement and Superplasticity of NAVALITE", E.W. Lee and T.R. McNelley, in Superplasticity in Aerospace II, T.R. McNelley and H.C. Heikkenen, eds., The Metallurgical Society of AIME, Warrendale, PA, 1990, pp 223-234.

"Recrystallization and Superplasticity at 300°C in an Aluminum Magnesium Alloy", S.J. Hales, T.R. McNelley and H.J. McQueen, Metallurgical Transaction, Vol. 22A, 1991, pp. 1037-1048.

CONFERENCE PRESENTATIONS: "Continuous Recrystallization During Thermomechanical Processing of a Superplastic Al-10Mg-0.1Zr Alloy", S.J. Hales, T.R. McNelley and R. Crooks, in Recrystallization in Metallic Materials, held at Wollongong, NSW, Australia, January 22-25, 1990.

"The Roles of Zr and Mn in Processing and Superplasticity of Al-Mg Alloys", T.R. McNelley and S.J. Hales, in Superplasticity in Aerospace II, the second Symposium in conjunction with the 119th Annual Meeting of TMS-AIME, held at Anaheim, CA, February 19-21, 1990.

"Processing, Microstructural Refinement and Superplasticity of NAVALITE", E.W. Lee and T.R. McNelley, in Superplasticity in Aerospace II, the second Symposium in conjunction with the 119th Annual Meeting of TMS-AIME, held at Anaheim, CA, February 19-22, 1990.

THESIS DIRECTED: "Processing Studies of Aluminum-Magnesium and Aluminum-Lithium-Copper Alloys", F.J. Harsacky, MSME, March 1990.

ELEVATED TEMPERATURE DEFORMATION IN Al-Li ALLOYS

T.R. McNelley, Professor of Materials
Department of Mechanical Engineering
Sponsor: Naval Air Systems Command
Funded: Naval Postgraduate School

OBJECTIVE: To determine the influence of Li additions to Al, in the range up to two wt. pct. and at temperatures above 0.5T , where T is the absolute melting temperature, on the stress and temperature dependence of creep in binary Al-Li alloys.

SUMMARY: Material representing three Lithium concentrations, 0.5 wt. pct., 1.0 wt. pct. and 2.0 pct., have been obtained from the Naval Surface Weapons Center, White Oak, MD. These materials were cast under inert gas to assure minimum contamination levels. Billets from each casting have been homogenized and hot rolled to a thickness of 2.0 mm and test samples have been prepared. Creep tests have been accomplished on the 2.0 Li alloy. All tests have been conducted under stressed conditions and some samples have been thermally cycled (to obtain activation energy data directly) while others have been tested to failure under constant temperature conditions. The stress dependence of creep is the same as that of pure Al as reflected in the stress exponent n ($=d \log \epsilon / d \log \sigma$) which was determined to have a value of $\approx$ 5. Evidence for subgrain formation was seen. The activation energy for creep also was the same as that of Al at temperatures above 500 °C. However, at lower temperatures the activation energy became progressively higher than that of the pure metal. This was associated with ordering of Li in the Al lattice which independent research has shown to begin on cooling below T $\approx$ 470°C.

THESES DIRECTED: "The Elevated Temperature Creep Behavior of a Binary Al-Li Alloy Containing 2.0 Weight Percent Lithium", K.H. Ellison, MS in Metallurgical Engineering, Department of Metallurgical Engineering, Colorado School of Mines, Golden, CO, May 1990. This program was conducted at NPS and jointly supervised with Professor D.K. Matlock of CSM.

"The Influence of Temperature and Composition on the Activation Energy for Creep in Binary Aluminum Lithium Alloys", R. Seaton, MSME, December 1990.

THERMOMECHANICAL PROCESSING OF METAL MATRIX COMPOSITES

T.R. McNelley, Professor Materials and Mechanical Engineering
Department of Mechanical Engineering

OBJECTIVE: To investigate the feasibility of improving the mechanical properties of Al-based, cast metal matrix composites using either Al_2O_3 or SiC particulate additions.

SUMMARY: A cast and extruded 6061 Al - Al_2O_3 material was obtained from a commercial vendor. Metallographic examination has determined that the extruded material exhibits an inhomogeneous distribution of the Al 0 addition as well as the as-cast material, in spite of the large strains associated with extrusion. Processing by warm rolling with controlled reheating between passes results in homogenization of the particle distribution and the attainment of a completely recrystallized microstructure as a result of particle-stimulated nucleation during reheating in the rolling process. Mechanical testing reveals that the processing results in substantially increased ductility although the yield and ultimate strengths are not significantly affected.

PUBLICATIONS: "Effect of Hot Working on the Microstructure and Properties of a Cast 5083 Al-SiC Metal Matrix Composite", I. Dutta, C.F. Tiedemann and T.R. McNelley, Scripta Metallurgica, Vol. 24, 1990, pp. 1233-1238.
"Microstructural Refinement by Thermomechanical Treatment of a Cast and Extruded 6061 Al - Al_2O_3 Composite", P.N. Kalu and T.R. McNelley, Scripta Metallurgica, Vol 25, 1991, pp. 853-858.

THESIS DIRECTED: "Thermomechanical Processing and Ambient Temperature Mechanical Properties of a 6061 Aluminum 10 Volume Percent Alumina Metal Matrix Composite", T.A. Schaefer, MSME, March, 1990.

"The Influence of Thermomechanical Processing Parameters on the Elevated Temperature Mechanical Behavior of 6061 Aluminum - Alumina Metal Matrix Composite Materials", M.D. Magill, MSES, December, 1990.

"Computer Simulation of Random and Non-Random Second-Phase Distributions in Two-Phase Materials", M.E. Pas, MSES, December, 1990.

"Processing, Microstructure and Elevated Temperature Mechanical Properties of a 6061 *Aluminum* - Alumina Metal Matrix Composite", P.D. Macri, MSME, December, 1990.0

DYNAMICS AND CONTROL OF TETHERED MARINE VEHICLES

F.A. Papoulias, Assistant Professor of Mechanical Engineering
Sponsor: NPS Research Council
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project was to investigate the dynamics and the mechanism of loss of stability of towed surface ships and submersibles and to explore means for active control.

SUMMARY: Nonlinear motion analyses of towing systems, underwater and surface vehicles, were conducted. Bifurcation theory was utilized to study global stability questions and bifurcations to solution branching and periodic solutions. Such periodic solutions were shown to occur during subcritical or supercritical Hopf bifurcations. Singularity theory was used to study bifurcations of steady state equilibria and it demonstrated that the problem of multiple bifurcating equilibria could be identified with individual paths on the cusp surface of catastrophe theory. The feasibility for active control of lateral motions and motion stabilization was also demonstrated.

PUBLICATIONS: F.A. Papoulias, (1990). Analysis of straight line motion of towed ships. Journal of Ship Research, In press. F.A. Papoulias, (1990). Stability and bifurcations of towed underwater vehicles in the dive plane. Journal of Ship Research, in press.

THESIS DIRECTED: J.B. Newell, "Automatic Control of Straight Line Motion of Towed Ships", Master of Science in Mechanical Engineering, March 1990.

HIGH DAMPING ALLOYS: PROPERTIES, MECHANISMS AND APPLICATIONS

Jeff Perkins, Professor of Mechanical Engineering
Sponsor: David Taylor Center, Annapolis, MD

OBJECTIVE: The purpose of this research has been to characterize the damping performance and to delineate the damping mechanisms in a variety of "quiet metals". Three main classes of quiet metals have been investigated. These include shape memory alloys such as those from them Ti-Ni, Cu-Zn-Al and Cu-Al-Ni alloy systems, ferromagnetic alloys from the Fe-Cr-Mo and Fe-Cr-A1 systems, and antiferromagnetic Cu-Mn-based alloys. The general approach of the research has been through an experimental program with emphasis on microstructural analysis and quantitative characterization of damping properties.

Progress in the past years may be separated into several areas, including (1) mechanisms of damping in Cu-Mn-based alloys; (2) heat treatment and microstructural effects on damping in cu-A1-Ni shae memory alloys; (3) comparison of the strain-dependence of damping in different classes of high-damping alloys, and between different alloys and heat treatments in a given class; (4) correlation of the damping properties of martensitic alloys with the transformation kinetics and microstructure; (5) development of a high-damping database: (6) refinement of testing techniques.

Microscopic studies of aged Cu-Mn-based alloys in the past two years have provided results which are both exciting, unusual and important. Recent work examined a unique phenomenon of "flickering" contrast in TEM images of certain aged alloys. This effect is apparently due to the fluctuation of the orientation of very small regions of crystal, and is probably directly related to the internal friction mechanism 9.

In a wide variety of alloys we are now able to delineate with some precision a cyclic strain amplitude which constitutes a threshold for the activation of high damping. It is also possible in most cases to delineate a saturation of damping above a given value of strain. Different classes of alloys, and in some cases, different alloys within a given class, display inherently different types of strain-dependence. This can be related to the particular details of the internal friction mechanisms.

Alloys from the Ti-Ni, Cu-Zn-A1, and Cu-A1-Ni systems have been studied in terms of the correlation, if any, between damping and the temperature range of transformation to martensite. Differential scanning calorimetry has been used to monitor the transformation kinetics. A considerable amount of transmission electron microscopy has also been done. The effect of heat treatment and cold work on the transformation has also formed part of this area of investigation. The results have shown that there is a clear correlation between damping and the martensitic state, as well as the atomistic substructure of the martensite crystal structure and its boundaries. A general principle for the achievement of high damping in this class of alloys is that a great many mobile boundaries must be present, and that these must present a balance between too little internal friction and too much.

High damping alloys continue to be a relatively untapped resource for possible U.S. Navy ships applications. If practical use is to be made of this unusual class of engineering materials, a great deal of further knowledge and experience must be acquired. Such knowledge and experience would serve to clarify the factors which influence damping in high damping alloys, as well as indicate the means to control damping properties, and begin to establish design guidelines.

THERMOELASTIC STRESSES IN ELECTRONIC PACKAGES

David Salinas, Associate Professor of Mechanical Engineering
Sponsor: Naval Weapons Support Center

OBJECTIVE: To develop a three dimensional model of an electronic package including the chip, leads, solder joints and substrates, and to determine the stresses in electronic packages resulting from thermal cycling.

SUMMARY: Chip packages are comprised of chips with connecting leads via solder to substrates. Each of these components are of different materials, each with its own material properties. As a result of the different thermal properties of the materials, such as coefficients of expansion and specific heats, thermal stresses will develop during the fabrication of the assembled package. Additional thermal stresses result from the cyclic on-off operation of the unit which is immersed in a surrounding environment which changes in temperature during operation. The problem is further complicated by the fact that the chip and substrate materials are not isotopic. Thesis topics have been proposed for student assistance in this research project.

OTHER: This research activity has just been initiated as of 1 October 1990. During the October to December 1990 period, a visit to the Naval Weapons Support Center to consult with the sponsors about the project. Work has been initiated on the formulation of the problem.

PUBLICATIONS: D. Salinas, and P.J. Marto, "Analysis of an Internally-Finned Rotating Heat Pipe," accepted for publication (6/90) in the Numerical Heat Transfer journal.

CONFERENCE PRESENTATIONS: D. Salinas, and E.E. Cooper, "Gas turbine Engine Test Cell Modeling," ASME Paper 90-GT-244, presented at the Gas Turbine and Aeroengine Congress and Exposition, June 11-14, 1990, Brussels, Belgium.

D. Salinas, Y.W. Kwon, and B.S. Ritter, "A Study of Linearization Techniques in Nonlinear FEM," accepted for presentation at the Eight International Conference on Mathematical and Computer Modelling, 1-4 April, 1991 at University of Maryland, College Park, Maryland.

SEPARATION POINTS ON A CYLINDER IN SINUSOIDALLY-OSCILLATING FLOW

T. Sarpkaya, Distinguished Professor of Mechanical Engineering
Sponsor: National Sciences Foundation
Funding: National Sciences Foundation

OBJECTIVE: The purpose of this investigation is to determine the excursion of the separation points on a smooth circular cylinder in a sinusoidally oscillating flow. The unsteady flow used in this investigation is a special case of a more general harmonic flow composed of many frequencies. The latter is the subject of another investigation.

SUMMARY: Experiments have been carried out in a U-shaped water tunnel at various Reynolds numbers and Keulegan-Carpenter numbers, using a wave of constant frequency. In addition, flow visualization experiments have been performed in a large basin. The motion of the separation points on smooth and sand-roughened circular cylinders has been determined as a function of a normalized time and relative roughness for various Keulegan Carpenter numbers and Reynolds numbers. The results will serve several purposes: (1) they will be compared with those obtained numerically through the use of the vortex element methods to guide and complement the analysis; (2) they will enhance our basic understanding of separation through the use of a relatively idealized time-dependent flow about bluff bodies; and (3) they will help to devise methods to delay the occurrence of separation. It must be emphasized that very little is known about the motion of separation points in unsteady flows. A parallel investigation will extend the results obtained with the mono-harmonic flow to the more general case of multi-frequency harmonic oscillations about smooth and rough cylinders.

PUBLICATIONS: T. Sarpkaya, "Wave Forces on Cylindrical Piles," The Sea, Vol. 9: Ocean Engineering Sciences (Eds. B. Le Mehaute & D.M. Haynes), John Wiley & Sons, N.Y., 1990, pp. 169-195.

T. Sarpkaya, "On the Effect of Roughness on Cylinders," Journal of Offshore Mechanics and Arctic Engineering, Trans, ASME, Vol, 112, Nov. 1990, pp. 334-340.

CONFERENCE PRESENTATION: T. Sarpkaya, "Brief Reviews of Some Time-Dependent Flows," Proceedings of the International Symposium on Nonsteady Fluid Dynamics, Fluids Engineering Division of ASME, Vol. 92, June 1990, pp. 3-14.

THESIS DIRECTED: M. Ozel, LT, Turkish Navy, "Separation Points on a Cylinder in Sinusoidally Oscillating Flow," MSME Thesis, December 1990.

EFFECT ON BOW PLANES ON VORTICAL FLOW ABOUT SSN-21

T. Sarpkaya, Distinguised Professor of Mechanical Engineering
Sponsor: Defense Advanced Research Projects Agency (DARPA)
Funding: DARPA

OBJECTIVE: The understanding of the stability of flow along the body, the interaction of streamwise vortices with the existing boundary layer, identification, priorization, and theoretical and experimental investigation of sources and mechanisms of hydrodynamic noise and drag on an SSN-21 type submerged body.

SUMMARY: Extensive measurements were made through the use of SSN-21 model in a towing tank to determine its wake characteristics. These were related to the dimensionless parameters such as the Reynolds number, Froude number, Brunt-Vaisala frequency, the angle of attack of the body and the bow planes, and the parameters characterizing the body shape. The investigation delineated the range of the angle of attack of the bow planes for which the vortex migration is limited to certain depths. Furthermore, experiments with oscillating bodies have been performed to understand the physics of transition due to vortex interaction with the existing boundary layer.

CONFERENCE PRESENTATION: T. Sarpkaya, "Discussion of the Numerical Prediction of the Hydrodynamic Characteristics of Submerged Bodies, "DARPA-ONT Meeting (SECRET) on "Future Prospects in Submarine Technology," November 6-9, 1989.

THESIS DIRECTED: M.P. Cady, LT, USN, "Instability of Flow Oscillating Along a Cylinder," MSME Thesis, December 1990.

NUMERICAL ANALYSIS OF SEPARATED FLOW ABOUT BLUFF BODIES

T. Sarpkaya, Distinguished Professor of Mechanical Engineering
Sponsor: National Science Foundation
Funding: National Science Foundation

OBJECTIVE: Basic numerical and experimental research towards the understanding of the effect of unsteadiness on the characteristics of the resulting time-dependent flow.

SUMMARY: A two-step, three-level, finite-difference, predictor-corrector scheme (based on the second-order Adams-Bashforth method) and a Fast Poisson Solver based on FFT methods are used to carry out the numerical experiments. A von Neumann linear stability analysis was performed and the mesh sizes and time steps were chosen to provide a conditionally stable solution. The physical experiments were carried out in an accelerating-flow tunnel. The special case of impulsively-started-flow analysis has yielded results which agree closely with existing results from both calculations and experiments. The methodology will be extended to oscillating flow about a cylinder to determine the excursion of the separation points.

PUBLICATIONS: T. Sarpkaya, S.M. Mostafa and P.D. Munz, "Numerical Simulation of Unsteady Flow about Cambered Plates," Journal of Aircraft, Vol. 27, No. 1, Jan 1990, pp. 51-59.

CONFERENCE PRESENTATIONS: T. Sarpkaya, "Non-Impulsively Started Steady Flow about a Circular Cylinder," AIAA Paper No. 90-0578, Jan. 1990 (pending publication in the AIAA Journal).

T. Sarpkaya and P. Lindsey, "Unsteady Flow about Porous Cambered Shells," AIAA Paper No. 90-0314, Jan. 1990 (pending publication in the Journal of Aircraft).

THESIS DIRECTED: K.A. Fredrickson, LT, USN, "Numerical Study of Non-Impulsively Started Flow Around a Circular Cylinder," MSME Thesis, June 1990.

OTHER: The investigator is preparing a book entitled "Vortex-Element Methods" for publication. Completion is expected in October 1991.

INTERACTION OF A VORTEX PAIR WITH A FREE SURFACE

T. Sarpkaya, Distinguished Professor of Mechanical Engineering
Sponsor: Chief of Naval Research (ONR)
Funding: Naval Postgraduate School

OBJECTIVE: Basic research towards the understanding of the fundamental mechanisms and physical processes underlying two and three-dimensional vortex/free-surface interactions in homogeneous, stratified, and sheared media, taking into account ambient turbulence, viscous effects, and various large-scale instabilities (sinusoidal instability and vortex breakdown) for ship and submarine related hydrodynamics in a real ocean environment.

SUMMARY: Numerous numerical experiments have been carried out in a large towing tank with various lifting surfaces and submerged bodies in homogeneous and density-stratified medium. In addition, experiments with two-dimensional vortex pairs have been conducted in a large water basin using both stratified and homogeneous medium. The characteristics of the resulting surface scars have been evaluated in terms of the governing parameters through the use of a Motion Analysis System and a Sun computer. Extensive numerical analysis has been performed and a computer code has been developed to predict numerically the characteristics of the surface disturbances. Experiments and analysis are continuing towards the evaluation of the behavior of the scars in terms of the prevailing Froude numbers, Atwood numbers and the Vaisala-Brunt frequencies.

PUBLICATIONS: T. Sarpkaya and P.B. R. Suthon, "Scarred and Striated Signature of a Vortex Pair on the Free Surface," Proceedings of the 18th Symposium on Naval Hydrodynamics, National Academy Press, Vol 1, 1990, pp. 53-60.

T. Sarpkaya and P.B. R. Suthon, "Interaction of a vortex couple with a free surface," (pending publication in Experiments in Fluids, April 1991).

THESIS DIRECTED: P.B. R. Suthon, LT, USN, "Interaction of a Vortex Pair with a Free Surface: Measurements and Computations," MSME and Engineer Degree Thesis, June 1990.

DYNAMIC RESPONSE AND FAILURE OF COMPOSITE AND METAL PANELS TO UNDERWATER SHOCKLOADS

Young S. Shin, Professor of Mechanical Engineering

Sponsor: Defense Nuclear Agency

OBJECTIVE: To advance our understanding on shock induced dynamic behavior and failure mechanism of composite structures through the analytical studies and the underwater explosion testings.

SUMMARY: Recent rapid progress in composite material technologies made it possible to apply the material in underwater structures. The principal damage mechanism of an underwater explosion of a nuclear weapon is the strong shock wave. The survivability of a structure depends on the shock resistance of the structure and the shock reduction effect of the structure to protect the internal equipments. However, the response of composite structures under shock loads and failure mechanism are not well understood yet. The underwater explosion testings were performed using both metal and composite panels to investigate the dynamics response and failure mechanism. Among the many possible failure modes such as fiber breakage, shear rupture, matrix failure, delamination, buckling, etc., the test results showed that the principal failure mechanism of composite panels appear to be localized matrix failure in compression due to the high circumferential stresses. Both analytical and experimental studies are being continued to advance our understanding on shock induced dynamic behavior and failure mechanism of both composite and metal (compressible) models. It includes coupling Underwater Shock Analysis (USA) code to nonlinear inelastic dynamic analysis code, such as DYNA enhancing composite capabilities. A series of underwater explosion testings will be performed to verify the computational method and numerical analysis results. The results of this research efforts are being contributed for the better use of composite materials to submarine applications such as sonar dome, external flaring, and to the surface ship components exposed directly to shocks such as mine sweeper.

PUBLICATIONS: Jones, R.A. and Shin, Y.S., "The Response and Failure Mechanisms of Circular Metal and Composite Plates Subjected to Underwater Shock Loading, Proceedings of 61st Shock and Vibration Symposium, Vol. III, pp. 163-178, Pasadena, CA, October 16-18, 1990.

CONFERENCE PRESENTATION: Jones, R.A. and Shin, Y.S., "The Response and Failure Mechanisms of Circular Metal and Composite Plates Subjected to Underwater Shock Loading, Presented at 61st Shock and Vibration Bulletin, Pasadena, CA, October 16-18, 1990.

THESIS DIRECTED: J.A. Jones, LCDR, USN, "Experimental Studies on Dynamic Responses of Circular Composite Panel to Underwater Shock", Engineer's thesis in Mechanical Engineering, March, 1990.

SUBMARINE-INSTALLED MACHINERY CONDITION MONITORING AND DIAGNOSTICS

Young S. Shin, Professor of Mechanical Engineering
Sponsor: Naval Sea Systems Command

OBJECTIVE: To develop the machinery condition monitoring techniques and diagnostic methods for the turbine-driven torpedo pump ejection system.

SUMMARY: The basic and applied research has been conducted to develop machinery-condition monitoring techniques and diagnostic methods for the turbine-driven torpedo pump ejection system (TPES). This research effort includes both analytical and experimental studies of transient and steady-state machinery noise and vibration signature analysis. It requires to develop time-frequency domain spectra to characterize the transient signatures. Pseudo Wigner-Ville Distribution (PWVD) has been developed and the computer code was written. The testing was performed using land-based TEP at NUSC, Newport, RI and the transient signatures of torpedo pump ejection system were processed using PWVD code developed in NPS. The future analysis will also include such parameters as pressure and temperature. A successful monitoring scheme will lead into the diagnostics method and subsequently recommendation for design modification will be made to prolong the design life of the pump. Currently, we are expanding the capabilities of Pseudo Wigner-Ville Distribution and are also conducting the sensitivity studies. The results of this research are extremely useful to prevent any catastrophic failure of TEP system and will save US Navy the time and cost of unnecessary periodic maintenance.

CONFERENCE PRESENTATION: Rossano, G.W., Hamilton, J.F., and Shin, Y.S., "The Pseudo Wigner-Ville Distribution as a Method for Machinery Condition Monitoring of Transient Phenomena," Presented at the 2nd International Machinery Monitoring & Diagnostics Conference, Los Angeles, CA, October 22-25, 1990.

THESIS DIRECTED: Rossano, G.W., Hamilton, J.F., and Shin, Y.S., "The Pseudo Wigner-Ville Distribution as a Method for Machinery Condition Monitoring of Transient Phenomena," Master's thesis in Mechanical Engineering, June 1990.

VIBRATION DAMPING - DESIGN, ANALYSIS AND TESTING

Young S. Shin, Professor of Mechanical Engineering
Sponsors: Direct Funding and David Taylor Research Center

OBJECTIVE: To develop the highly damped passive vibration control devices or treatment to the primary structures and to apply for critical naval components for ship silencing.

SUMMARY: This research work is for continuation of on-going research in vibration damping. The control of vibration of a mechanical system is usually accomplished by both active and passive devices or treatment to the structures. In this continuing project, the passive device and treatment to the system have been a concern to control the vibration in the form of energy dissipation, isolation and absorbing devices. The application of concept of combining the constrained viscoelastic layers, tuned dampers, and waveguide absorbers to naval components are explored to effectively introduce the significant damping into the system. The results of on-going research have given significant contributions to improve the design of the critical naval components from the standpoint of ship silencing. It gave the direct impact on the design concept and philosophy of the critical component of submarine.

PUBLICATIONS: Shin, Y.S. and Maurer, G.J., "Vibration Response of Constrained Viscoelastically Damped Plates: Analysis and Experiments," Journal of Finite Elements in Analysis and Design, Vol. 7, 1991, pp. 291-297.

Hettema, C. D., Shin, Y.S. and Kim, K.S., "Analysis of Circular Viscoelastic Waveguide Absorber," ASME Journal of Vibration and Acoustics, Accepted for publication.

Shin, Y.S. Iverson, J.C. and Kim, K.S., "Experimental Studies on Damping Characteristics of Bolted Joints for Plates and Shells," ASME Journal of Pressure Vessel Technology, Accepted for publication.

Shin, Y.S., Milster, P.F. and Knouse, S.T., "Parametric Studies on the Measurement of Damping Quantities," Journal of Nuclear Engineering and Design, Accepted for publication.

Bateman, J., Kim, K.S., and Shin, y.S. Constrained Viscoelastic Layer Damping of Thick Aluminum Plates: Design, Analysis and Testing," NPS Technical Report, NPS 69-90-05, May 1990.

THESIS DIRECTED: "Constrained Viscoelastic Layer Damping of Thick Aluminum Plates: Design, Analysis and Testing," by LT M.J. Bateman, USN, Engineer's degree in Mechanical Engineering, March 1990. (Advisor)

"A Method of Machinery Condition Monitoring of Transient Phenomena Using the Pseudo Wigner-Ville Distribution," by LT G. Rossano, USN, Master's thesis in Mechanical Engineering, June 1990. (Advisor)

"A Pseudo Wigner-Ville Distribution and its Application to Torpedo Pump Ejection System Characterization," by LCDR J. Carahorrano, USN, Master's thesis (classified) in Mechanical Engineering, December 1990. (Advisor)

"Passive Vibration Control of Thick Aluminum Plates Using Constrained Viscoelastic Layered Damping," by CPT H.C. Ping, Taiwan Army, Master's thesis in Mechanical Engineering, December 1990. (Advisor)

DESIGN OPTIMIZATION OF BLADE STIFFENED LAMINATED PLATES FOR MAXIMUM BUCKLING LOAD

P.Y. Shin, Assistant Professor of Solid Mechanics,
Department of Mechanical Engineering
Sponsor: Research Administration Office
Funding: Naval Postgraduate School

OBJECTIVE: Composite Materials are ideal for structural applications where high strength-to-weight ratios are required. The objectives of the research are to devise an adequate procedure for the optimal design when there exist a number of eigenvalue constraints and to apply the design procedure for design of blade-stiffened laminated composite plates.

SUMMARY: A finite element computer code for composite plates buckling analysis is written in FORTRAN. The classical laminate theory is used to obtain flexural stiffness matrix and enplane stiffness matrix. The buckling analysis is performed in two steps. For the first case, the blade stiffener is treated as a beam and included in the formulation of the global stiffness matrix in the finite element formulation. For the second case, the blade stiffener is treated as a plate subject to a plane compressive load that has three sides simply supported and the fourth side free. Then, the local buckling of the plate is considered separately from the main finite element analysis. The above computer program is used to find the optimal design using a nested approach in optimization which yields a system of nonlinear equations. These equations are then solved using the Homotype method. The procedure is applied successfully to find the optimal design of stiffened laminated plates. As the total weight of the plate is increased, the number of simultaneous buckling modes of corresponding optimal design is also increased. So, for low weights the optimal design starts with unimodal design and for higher weight the optimal design becomes bimodal, trimodal, and finally it becomes tetramodal. It was also found that in some range of the total weight the unstiffened plate has greater buckling load than the stiffened plate.

PUBLICATIONS: P.Y. Shin, "Optimal Design of Stiffened Laminated Plates Using a Homotype Method," Paper presented at the 32nd AIAA/ASME/ASCE/AHS Structures Structural Dynamics and Materials (SDM) Conference, Baltimore, MD, April 8-10, 1991.

P.Y. Shin and m.R. Achenbach, "Design Optimization of Blade Stiffened Laminated Composite Plates," to be presented at the ASME Winter Annual Meeting, Atlanta, GA, December 1-6, 1991.

THESIS DIRECTED: "Design Optimization of Blade Stiffened Laminated Composite Plates for Maximum Buckling Load," Mark R. Achenbach, M.S., December, 1990.

DEPARTMENT OF METEOROLOGY

DEPARTMENT OF METEOROLOGY

The research program in the Department of Meteorology continues in several areas: (1) numerical air/ocean modeling and prediction; (2) dynamics of fronts and flow over and around mountains; (3) analysis and dynamics of tropical weather systems; (4) analysis and dynamics of mid-latitude weather systems; (5) atmospheric boundary layers over the sea and ice; (6) regional weather studies and; (7) remote sensing. A number of related investigations have been pursued by various faculty members under each of these headings.

NUMERICAL MODELING AND PREDICTION

R. T. Williams is developing and testing numerical procedures for global and regional weather prediction. He is investigating various finite element and semi-Lagrangian formulations with respect to treatment of small-scale flow fields. He is also applying the techniques to the prediction of cyclogenesis. R. T. Williams, C.-P. Chang and M. S. Peng are investigating the "Mei-Yu" front over eastern Asia with a dynamical front model.

Numerical-observational studies of rapid maritime cyclogenesis events are being pursued by C. H. Wash, W. A. Nuss, P. M. Pauley, R. L. Elsberry, and P. A. Hirschberg. Diagnostic studies of analyses and predictions by the naval Operational Regional Atmospheric Prediction System (NORAPS) are used to evaluate physical processes that occur during rapid cyclogenesis observed in the ONR ERICA field program. P. Harr and R. L. Elsberry are examining a large set of global model predictions to identify error tendencies in the forecasts of maritime cyclone intensities and positions. A decision theoretic approach is being used to examine the utility of model error tendencies to the operational forecaster. On a similar topic, P. M. Pauley is examining the sensitivity of the National Meteorological Center's Nested Grid Model (NGM) forecasts of rapid cyclogenesis to various physical processes.

J. W. Glendening is employing a finite-element model for the atmospheric boundary layer using second-order closure to predict turbulence production and transport, to analyze boundary layer structure and its temporal and spatial variation in the Arctic marginal ice zone. In addition, he is employing large-eddy closure techniques to study boundary layer development in the strongly baroclinic zone above and down wind of Arctic leads.

T. R. Holt is examining the effects of mesoscale marine atmospheric boundary layer processes on coastal cyclogenesis. Diagnostic studies of numerical simulations from the NRL mesoscale model are conducted to investigate the importance/interaction of the low level-baroclinic zone, latent heat release and upper level forcing. In addition, numerical studies to consider latent heat release associated with convective precipitation are examined through the use of an observing system simulation experiment (OSSE) using assimilated SSM/I rainfall rate.

W. A. Nuss is investigating the role of boundary layer processes in frontogenesis and cyclogenesis over the ocean using the NCAR/Penn State mesoscale model. Diagnostic studies of the model predictions were used to evaluate the alteration of baroclinic processes by surface forcing. Observational studies of these processes are also being performed using aircraft data taken during ERICA.

Other modeling efforts include: (1) a marine atmospheric boundary layer model for predicting (6-12 hours) properties that affect radar and optical propagation within the boundary layer, and those factors (radiation and boundary fluxes) that affect the upper part of the ocean, directed by K. L. Davidson and; (2) a numerical investigation of the dynamics and prediction of synoptic-scale variability in the coastal ocean off California observed in the ONR CTZ field program, led by R. L. Haney.

DYNAMIC OF FRONTS AND FLOW OVER AND AROUND MOUNTAINS

R. T. Williams and M. S. Peng are studying the conditions that determine whether or not the air will flow over or around a long mountain range. Also, R. T. Williams and M. S. Peng are studying the interaction of fronts with topography, and R. L. Haney is investigating the effects of topography and baroclinity in the coastal ocean circulation.

ANALYSIS AND DYNAMICS OF TROPICAL WEATHER SYSTEMS

C.-P. Chang, R. T. Williams, J.-M. Chen and M. S. Peng continue to investigate various aspects of the dynamics of tropical synoptic and planetary motions, and tropical mid-latitude interactions. The diagnostic analysis of oceanic tropical weather systems using the Navy Operational Global Atmospheric Prediction System (NOGAPS) is being pursued by C.-P. Chang and J.-M. Chen.

A multi-year basic research program to understand the dynamics of tropical cyclone motion has begun. R. L. Elsberry serves as the Technical Director of the overall research initiative for the Office of Naval Research. P. Harr and R. L. Elsberry are examining the relationship between tropical cyclone track characteristics and large scale tropical circulation anomalies. R. T. Williams and M. S. Peng are developing analytical and numerical models of tropical cyclone motion. R. L. Elsberry and associates continue applied research efforts to improve tropical cyclone prediction via statistical evaluations and expert systems.

During 1991, the G. J. Haltiner Research Chair in the Meteorology Department is being occupied by Dr. Hugh E. Willoughby of NOAA's National Hurricane Research Laboratory in Miami, Florida. Dr. Willoughby is investigating tropical cyclone motion with a hierarchy of semispectral numerical models that simulate the effects of initial asymmetries, environmental currents, convective mass sources and sinks, and gradients of environmental vorticity. These models offer new insight into the physics of vortex motion and show promise of forecasting application.

C.-P. Chang and T. C. Yeh are studying the effects of big island terrain on typhoon motions in the Western Pacific near Taiwan and the Philippines.

ANALYSIS AND DYNAMICS OF TROPICAL WEATHER SYSTEMS

Observational studies of rapid maritime cyclogenesis events are being pursued by W. A. Nuss, C. H. Wash and P. M. Pauley. Operational and special experimental data taken during the ERICA field program are used to diagnose the structure and physical professes that contribute to the rapid development of oceanic cyclones. W. A. Nuss is also studying the development of several cyclones along the coast of Japan to characterize boundary layer processes in ocean cyclogenesis.

ATMOSPHERIC BOUNDARY LAYERS OVER THE SEA AND ICE IN THE COASTAL ZONE

Observation based research on properties of the atmospheric boundary layer and on several interdisciplinary subjects is continuing with analysis/interpretation of existing data sets and plans for near-future experiments. These are being conducted by K. L. Davidson, J. Glendening and P. Guest. Past collaborative experiments were conducted from ships, near shore towers, aircraft, and buoys.

Analyses are now being performed on atmospheric surface and mixed layer data collected in the Eastern Arctic region, near Svalbard, from September 1988 to May 1989. Measurements were made from ships, ice camps, and aircraft (NOAA P-3). The period extended through the Arctic night and into the period of total sunlight, and a wide range of boundary conditions were observed. Experiments are planned for 1991 and 1992 on atmospheric forcing associated with the formation of leads within interior ice regimes. These will occur in the Western Arctic, north of the Alaskan Peninsula.

Analyses are being performed on shipboard obtained marine boundary layer data sets obtained off the Netherlands coast, near a SST front in the west North Atlantic, off the California coast, and off the Florida Keys. Objectives of the individual projects are : (1) to evaluate and formulate models that relate changes in the depth and structure of the atmospheric boundary layer to surface fluxes and sky conditions, (2) to evaluate and formulate models for equilibrium marine aerosol distributions, (3) to establish synoptic-scale descriptions of the magnitude and height variations of optical turbulence, and (4) to evaluate synoptic-scale forcing on the boundary layer processes and evolutions in the marginal ice zone, and (5) to improve the specifications of momentum and maritime flux at the air-sea interface and determine its influence on the overlying atmosphere.

Variations of wind and temperature within and above the boundary-layer in the marginal ice zone are being investigated by J. Glendening. A finite-element boundary-layer model generates a "coastal front"

near an ice edge, which gives wind jets, sloping inversion heights, and multiple inversion layers formed by the induced vertical motion. The jets positions were found to be a significant non-linear feature, which has lead to further analytic interpretations.

J. Glendening is investigating the influence of Arctic leads (breaks in the polar ice) on the polar climate using large-eddy simulation, a "state-of-the-art" boundary-layer model technique. Wintertime heat fluxes through the leads are often several orders of magnitude larger than those through the surrounding ice, so leads are important for both Arctic meteorology and global climate. The purpose is to (1) better understand the transfer of heat into the atmosphere, (2) aid the design of the upcoming LEADEX (NRL/NOAA) experiment, and (3) help large-scale atmospheric modelers parameterize the effect of the small-scale heat transfers.

REGIONAL WEATHER STUDIES

Forecaster's Handbooks for the Southern African Continent and Atlantic/Indian Ocean Transit (1985) and for Central America and Adjacent Waters (1989) were published by F. R. Williams and R. J. Renard. Following a data gathering trip to military and foreign installations in the western Pacific during 1990, a forecaster handbook for the Philippine Islands and surrounding waters is being prepared by F. R. Williams. In addition to presentation of relevant air/ocean climatologies, as well as coastal oceanographic effects by G. H. Jung (Professor Emeritus of the Oceanography Department), the handbook will present case studies depicting the performance of Navy Operational Global Atmospheric Prediction Systems (NOGAPS) analyses and prognoses for different seasons over the Philippines.

REMOTE SENSING

P. A. Durkee is examining the relationship between satellite-detected visible and infrared radiance and extinction by aerosols. The effects of aerosols on cloud brightness and subsequent radiative effects are also being studied. In addition, P. A. Durkee is participating in the Stratospheric Aerosol and Gas Experiment (SAGE III). C. H. Wash is exploring methods of using multi-channel satellite data to objectively classify clouds and precipitation. Wash and Durkee are also working on improved methods to earth locate satellite data.

K. L. Davidson is involved in experimental verification on mechanisms responsible for scatterometer and synthetic aperture radar (SAR) images of the ocean surfaces. Analyses were completed on surface stress data from a tower off the coast of California near San Diego and were collected in conjunction with aircraft and tower radar measurements. In another experiment off the Norwegian west coast surface wind stress measurements were made during moderate to high winds from a buoy as well as a ship. The ship also had a three wavelength (L-, C- and X-band) scatterometer onboard and, distributed over the region, was a quite extensive wave and current measurement system. This was a high wind and high sea-state experiment.

TROPICAL AND MONSOON STUDIES

C.-P. Chang, Professor of Meteorology
R.T. Williams, Professor of Meteorology
M.S. Peng, Adjunct Research Professor
J.M. Chen, Adjunct Research Professor

OBJECTIVE: Develop and test better numerical techniques for use in Navy weather forecasting models. This is a continuing project.

SUMMARY: The interaction between planetary-scale motions and synoptic scale motions is very important for longer period variations in the atmosphere and for climate change. We have analyzed the energy interactions between these scales of motion in terms of vertical modes (McAtee and Williams, 1990). For the first or barotropic vertical mode the energy flows from the synoptic scales to planetary scales, while for the second and third modes the energy flows from the planetary to the synoptic scales of motion. It is known that the synoptic scales of motion have the same type of interaction with the zonal mean flow. The passage of a front over a long ridge was studied with a two-dimensional numerical model (Williams, Peng and Zankofsky, 1990). The basic current was stratified with no vertical shear. Frontogenesis was forced by a horizontal deformation field that moved with the basic flow. The fronts weakened as they moved up the slope, and they strengthened as they moved down the lee slope. These solutions were compared with the semi-geostrophic solutions that were obtained by Zehnder and Bannon. For steeper mountains our solutions departed much more from the semi-geostrophic solutions. Frontal solutions with no forcing were compared with the advection of a scalar field, following the semi-geostrophic theory of Blumen and Gross. The agreement was good for the larger scale mountain, but it was poorer for the steep mountains over which the flow was less semi-geostrophic.

PUBLICATIONS: J. L. Hayes, R. T. Williams and M. A. Rennick, "Lee Cyclogenesis, Part II: Numerical Studies," under revision for Journal of the Atmospheric Sciences.

R. T. Williams, M. S. Peng and D. A. Zankofsky, "Effects of Topography on Fronts," submitted to Journal of the Atmospheric Sciences.

CONFERENCE PRESENTATIONS: M. S. Peng and R. T. Williams, "Interaction of Fronts with Topography," Conference on Weather Analysis and Forecasting, Taipei, Taiwan (ROC), 2-5 May 1990.

D. Knight and R. T. Williams, "Baroclinic Flow over Mesoscale Mountains," Fifth American Meteorological Society Conference on Mountain Meteorology, Boulder, CO, 25-29 June 1990.

AIR SEA INTERACTION AND REMOTE SENSING

K.L. Davidson, Professor of Meteorology
P.J. Boyle, Meteorologist
C. Skupniewicz, Meteorologist
Sponsor: Office of Naval Research (1121RS)
Funding: Naval Postgraduate School

OBJECTIVE: Current objectives in these continuing studies are to complete coordinated (with other groups) analyses and interpretations of atmospheric surface wind stress and boundary layer data obtained in the Frontal Air Sea INteraction EXperiment (FASINEX), in the Humidity EXchange MAin Experiment (HEXMAX), and in the NORwegian Continental Shelf EXperiment (NORCSEX).

SUMMARY: FASINEX results relate to the influence of a SST front on the surface wind stress and on mixed layer properties (Freihe et al., 1991 and Stage et al., 1991) and to the variability of atmospheric forcing of the Ocean (Davidson et al., 1991). HEXMAX results pertain to shipboard (R/V Frederick Russell) measured influence of and location, relative to proximity to a coastal located tower (MPN-with 15 meters water depth), and storm fronts on the surface wind stress. Examinations of ship values when it was near MPN to those when it was at a location, with 18 meter water depths, 60 to 65 KM west southwest of MPN revealed no significant differences between the two locations. NORCSEX buoy and shipboard wind stress results show that the regime is typical of other open ocean regions (Davidson and Skupniewicz, 1991) and that good correlation occurs between wind stress and radar backscatter changes (Johannessen et al, 1991 and Davidson, Onstott et al, 1991).

PUBLICATIONS: Davidson, K. L. and C. E. Skupniewicz, "Wind Stress Estimates from a Small Buoy," Proceedings, Ninth Symposium of Turbulence and Diffusion, Roskilde, Denmark, April 30 - 5 May 1990, 21-24, May 1990.

Davidson, K. L. and P. J. Boyle, "Overwater results on the Dimensionless TKE Dissipation Rate," Proceedings, Ninth Symposium on Turbulence and Diffusion, Roskilde, Denmark, April 30-5 May 1990, 51-53, May 1990.

Davidson, K. L. and C. E. Skupniewicz, "Wind-stress Surface Truth Measurements for NORCSEX, "IEEE Transactions on Geoscience and Remote Sensing, A5773 (in press), January 1991.

Freihe, C., W. J. Shaw, D. Rogers, K. L. Davidson, W. Large, G. Crescenti, S. Stage, "Air-Sea Fluxes and Surface layer Turbulence Around a Sea Surface Temperature Front," Journal of Geophysical Research, (special FASINEX issue) (in press), 1991.

Guest, P. S., and K. L. Davidson, "Meteorological Triggers for Deep Convection in the Greenland Sea," Elsevier Oceanography Series, papers from Second International Conference on Deep Convection and Deep Water Formation, Naval Postgraduate School, Monterey, CA, 26-30 March 1990 (accepted).

Skupniewicz, C. E. and K. L. Davidson, "Hot Film Measurements from a Small Buoy: Surface Wind Stress Estimates Using the Inertial Dissipation Method," Journal of Atmospheric and Oceanic Technology (accepted), 1991.

Johannessen, J. A., R. A. Shuchman, O. M. Johannessen, and K. L. Davidson, "SAR Imaging Capabilities of Upper Ocean Circulation Features and Wind Fronts," Journal of Geophysical Research (accepted), 1991.

Davidson, K. L., P. J. Boyle, C. Gautier, H. Hanson, and S. Khalsa, "Medium to Large Scale Atmospheric Variability during FASINEX," Journal of Geophysical Research (Special FASINEX issue) (accepted), 1991.

Davidson, K. L., R. G. Onstott, J. A. Johannessen, P. J. Boyle, R. A Shuchman, O. Skagseth and C. E. Skupniewicz, "Wind Stress and Radar Scatter Observations of Ocean Surface Properties from a Ship in NORCSEX-88," Journal of Geophysical Research (under revision), 1991.

Stage, S., W. J. Shaw, G. Crescenti, K. L. Davidson, K. Katsaros, G. Greenhut, S. Khalsa and M-K Wai, "Response of the Atmosphere to Oceanic Fronts, "Journal of Geophysical Research, (special FASINEX issue), (submitted), 1991.

Davidson, K. L., "Atmospheric Boundary Layer Properties and Forecasting in Gulf and Coastal Regions," Journal of Applied Meteorology, (Special issue from conference on Air-Sea Interaction and

Air Mass Modification, Galveston TX, 7-9 Jan 1991 (submitted for conference review), 1991.

Davidson, K. L., J. Edson, C. W. Fairall, P. Mestayer and S. E. Larsen, 1991c: "Comparisons of Ship and Tower Inertial-Dissipation Estimates of the Surface Wind Stress," Journal of Geophysical Research, (in preparation).

Davidson, K. L., J. DeCosmos, G. DeLeeuw, J. Edson, K. Katsaros, and P. Taylor, "The Response of the PBL to Frontal /Storm Front Passages," Journal of Geophysical Research, (in preparation).

Smith, S. D., R. Anderson, W. Oost, C. Kraan, J. DeCosmo, K. Katsaros, K. L. Davidson ,"Sea Surface Wind Stress and Drag Coefficients: The HEXOS Results," Journal of Geophysical Research, (in preparation).

CONFERENCE PRESENTATIONS: Kenneth L. Davidson and P. J. Boyle, "Overwater Results on the Dimensionless TKE Dissipation Rate, Ninth AMS Symposium on Turbulence and Diffusion, Roskilde, Denmark, 30 April-5 May 1990.

Kenneth L. Davidson and C. Skupniewicz, "Wind Stress Estimates from a Small Buoy," Ninth AMS Symposium on Turbulence and Diffusion, Roskilde, Denmark, 30 April-5 May 1990.

Kenneth L. Davidson, "Overview of Meteorology Issues: SAR Meso-scale," Hi-resolution ARI Workshop II, Johns Hopkins University, Applied Physics Laboratory, Laurel, MD, 5-6 September 1990.

METEOROLOGICAL STUDIES OF ARCTIC REGIONS

K.L. Davidson, Professor of Meteorology
P.S. Guest, Meteorologist
P. Frederickson, Physical Scientist
Sponsor: Office of Naval Research (ONR-1125AR),
Naval Oceanographic and Atmospheric Research Laboratory

OBJECTIVE: Objectives of continuing Arctic Meteorology Studies are to obtain descriptions of arctic atmospheric boundary layer structure from analyses/interpretations of meteorological data collected in two Marginal Ice Zone EXperiments (MIZEX-84 and -87) and in the Coordinated Eastern ARctic EXperiment (CEAREX- 88 & 89).

SUMMARY: Analyses and interpretations of vector wind and wind stress data collected in MIZEX-84 and -87 yielded results relating surface roughness to ice types (Guest and Davidson, 1991) and the surface wind to the geostrophic wind (Overland and Davidson, 1991). Examination of data with respect to synoptic and mesoscale atmospheric features existing during CEAREX are continuing. MIZEX-84 Rawinsonde and surface radiation data were used to evaluate results from a model study of summer radiation budget (Francis et al., 1991).

PUBLICATION: Francis, J. A., T. P. Ackerman, K. B. Katsaros, K. L. Davidson and R. J. Lind, "A Summer Radiation Budget for the Fram Strait Marginal Ice Zone," Journal of Climate (in press), February 1991.

Guest, P. S., and K. L. Davidson, "Meteorological Triggers for Deep Convection in the Greenland Sea," Elsevier Oceanography Series, Second Intern. Conference on Deep Convection and Deep Water Formation, Naval Postgraduate School, Monterey, CA, 26-30 March 1990 (accepted).

Guest, P. S., and K. L. Davidson, "The aerodynamic roughness of different types of sea ice," Journal of Geophysical Research (accepted), 1991.

Overland, J. E., and K. L. Davidson, " Geostrophic Drag Coefficients Over Sea Ice," Tellus (accepted), 1991.

CONFERENCE PRESENTATION: Kenneth L. Davidson, "Overview of CEAREX (September 1989 to May 1990) Meteorology," CEAREX Workshop, University of Southern Mississippi, Long Beach, MS, 8-10 February 1990.

Kenneth L. Davidson and P. Guest, "The Seasonal Cycle of the Marine Arctic Atmosphere," AGU Ocean Science Meeting, New Orleans, LA, 13-16 February 1990.

J. E. Overland, Kenneth L. Davidson and P. Guest, "The Relationship Between Surface Wind Stress, Wind Velocity and Pressure Gradient during the Day to Night Transition over the Arctic Ocean," AGU Ocean Science Meeting, New Orleans, LA, 13-17 February 1990.

P. S. Guest and Kenneth L. Davidson, "Meteorological Conditions Likely to be Associated with Deep Convection in the Greenland Sea," Second International Conference on Deep Convection and Deep Water Formation, Naval Postgraduate School, Monterey, CA, 26-30 March 1990.

OPTICAL PROPERTIES OF THE MARINE ATMOSPHERIC BOUNDARY LAYER

K.L. Davidson, Professor of Meteorology
P.J. Boyle, Meteorologist
Sponsor: Naval Ocean Systems Center (Code 54)
Funding: Naval Postgraduate School

OBJECTIVE: Current objectives of analyses/ interpretations and data collection in these continuing studies were to verify or formulate equilibrium marine aerosol models for: (a) vertical variation in overwater regimes of mid- and subtropical regions and; (b) surface layer as influenced by advection in Marginal Ice Zone (MIZ) region.

SUMMARY: Aerosol data collected on the Coordinated Eastern Arctic Experiment (CEAREX) were reduced and interpreted in terms of concentration variations with airflow relative to the ice edge. No flow direction dependence was found, Davidson (1990). The SNI-87 R/V Point Sur obtained aerosol and meteorological data are being examined to evaluate the performance of the surface layer equilibrium component of NOVAM. During June and July of 1990, we participated, with shipboard surface layer measurements, in a NOVAM shallow convection evaluation experiment conducted off the Florida Keys, near Marathon. Layer measurement evaluations of the vertical aerosol model (NOVAM) have been performed (de Leeuw and Davidson, 1989) incorporating profiles properties of aerosol as well as temperature and humidity derived from continuing analyses.

PUBLICATIONS: de Leeuw, G. and K. L. Davidson, 1989: "Mixed-Layer Profiling with Lidar and Modeling of Aerosol Vertical Structure," Journal of Atmospheric and Oceanic Technology (submitted).

de Leeuw, G. and K. L. Davidson, 1989: "Aerosol Modeling in the Marine Atmospheric Boundary Layer," 8th World Clean Air Congress, The Hague, The Netherlands, 11-15 September 1989, Elsevier (in Press).

CONFERENCE PRESENTATIONS: Kenneth L. Davidson, "Overview of CEAREX (September 1989 to May 1990) Meteorology," CEAREX Workshop, University of Southern Mississippi, Long Beach, MS, 8-10 February 1990.

THESIS DIRECTED: William Wilson, LT, USN, "Factors Associated with the Use of an AE6-B Airborne Microwave Refractometer," Master Thesis, June 1990.

Kamran Khan, LCDR, Pakistan Navy, "Refractive Conditions in Arabian Sea and Their Effects on Radar and ESM Operations," Master Thesis, September 1990.

M. G. Maldonado, LT, Columbian Navy, "Assessment of the Effects of Refractive Conditions on Electronic Warfare in Central America," Master Thesis, September 1990.

VERTICAL MODEL FOR AEROSOL IN THE MARINE ATMOSPHERIC BOUNDARY LAYER

K.L. Davidson, Professor of Meteorology
Sponsor: Naval Ocean Systems Center (Code 54)
Funding: NOSC, Code 54

OBJECTIVE: The objectives of this continuing study were to perform coordinated evaluations of the Navy Oceanic Vertical Aerosol Model (NOVAM) with a range of aerosol and meteorological data sets, and to prepare combined [Eastern North Pacific (FIRE), Arctic (CEAREX), and west North Atlantic (FASINEX)] aerosol and meteorological data sets to improve the climatological [default] specifications in NOVAM.

SUMMARY: Final editing was performed on aerosol and meteorological data collected during the FIRE experiment from the R/V Pt. Sur. Extinction coefficients were calculated from the aerosol size distributions for visible, and near and far infrared wavelengths. The shipboard results, which also include Naval Research Laboratory quantitative values of RADON concentrations and HSS viscometer ranges, are being used to interpret the success of the surface component of NOVAM (NAM) for estimating the observed extinction.

PUBLICATIONS: de Leeuw, G. and K. L. Davidson, 1989: "Mixed-Layer Profiling with Lidar and Modeling of Aerosol Vertical Structure," Journal of Atmospheric and Oceanic Technology (submitted).

de Leeuw, G. and K. L. Davidson, 1989: "Aerosol Modeling in the Marine Atmospheric Boundary Layer," 8th World Clean Air Congress, The Hague, The Netherlands, 11-15 September 1989, Elsevier (in Press).

ATMOSPHERIC BOUNDARY LAYER STUDIES OF ARTIC REGIONS

K.L. Davidson, Professor of Meteorology
P.S. Guest, Meteorologist
Sponsor: Naval Oceanographic and Atmospheric Research Laboratory

OBJECTIVE: The goal of this project is to improve our understanding of atmospheric forcing of interior ice regimes by analyses of in situ and satellite data obtained during the Coordinated Eastern Arctic Experiment (CEAREX).

SUMMARY: Analysis of in situ data obtained during storm passages over CEAREX platforms provided information on the value of meteorological satellite imagery to describe regional variations. A data set was compiled that relates mixed-layer depth, stability, clouds, radiation, and surface fluxes to distance from the ice edge and air mass origin. The ice/snow surface temperature was found to be controlled by a balance between upward and downward longwave emission. The latter is greatly influenced by the warm isothermal layer above the inversion (Overland and Guest 1991).

PUBLICATIONS: Overland, J. E. and P. S. Guest, "Control of minimum snow and ARI temperature over arctic sea ice during winter," Journal of Geophysical Research, (accepted), 1991.

CONFERENCE PRESENTATIONS: Kenneth L. Davidson, R. Fett and P. Guest et al., "Severe Storm Formation over Polarbjorn, 11-14 October 1988," CEAREX Workshop, University of Southern Mississippi, Long Beach, MS, 8-10 February 1990.

Kenneth L. Davidson and P. Guest, "Storms over Pack Ice - An In Situ Study," XV General Assembly of the European Geophysical Society, Copenhagen, Denmark, 23-27 April 1990.

TROPICAL CYCLONE MOTION STUDIES

Russell L. Elsberry, Professor of Meteorology
Patrick Harr, Adjunct Research Professor
Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: To improve basic understanding of tropical cyclone motion. The ultimate goal in this five-year program is the development of improved methods of forecasting the track of tropical cyclones, which pose one of the primary peace-time threats to the safety of fleet operating units.

SUMMARY: Carr and Elsberry (1990) demonstrated that the sense of the propagation vector from the theoretical models is in general agreement with the published composite data studies. Evans et al. (1990) demonstrated with a high-resolution model the effects on tropical cyclone motion of the environmental vorticity on tropical cyclone motion gradients in the subtropical ridge. For the idealized case studied, the propagation vector was linearly related to the environmental vorticity gradient.

An article describing the 1990 field experiment (Elsberry 1990) also describes the three other field experiments occurring simultaneously.

Harr and Elsberry (1990) have described the factors that contribute to intraseasonal variability in western North Pacific tropical cyclone track types. Anomalous 700 mb large-scale circulations that exist during the formation of tropical cyclones are shown to determine whether the overall track will be straight or one of two types of recurvature.

PUBLICATIONS: R. L. Elsberry, "International Experiments to Study Tropical Cyclones in the Western North Pacific." Bulletin of the American Meteorological Society, 71, 1305-1316, September 1990.

L. E. Carr, III, and R. L. Elsberry, "Observational Evidence for Predictions of Tropical Cyclone Propagation Relative to Environmental Steering." Journal of Atmospheric Science, 47, 542-546, February 1990.

P. A. Harr and R. L. Elsberry, "Tropical Cyclone Track Characteristics as a Function of Large-scale Circulation Anomalies." Monthly Weather Review (accepted).

J. L. Evans, G. J. Holland and R. L. Elsberry, "Interactions Between a Barotropic Vortex and an Idealized Subtropical Ridge. I. Vortex Motion." Journal of Atmospheric Sciences (accepted).

CONFERENCE PRESENTATIONS: R. L. Elsberry, "Description of the ONR Field Experiment Observations," 1990 Tropical Cyclone Conference, Guam, February 1990.

R. L. Elsberry, "Update on the USA Tropical Cyclone Field Experiment," USA-USSR Discussions of Tropical Cyclone Research, Moscow, USSR, April 1990.

R. L. Elsberry, "Future Research with the TCM-90 Data Set," Invited talk, ESCAP/WMO Typhoon Committee SPECTRUM Technical Conference and Steering Group Evaluation Meeting, Tokyo, Japan, December 1990.

R. L. Elsberry, "Update on the Tropical Cyclone Motion (TCM-90) Field Experiment," Invited talk, ESCAP/WMO Typhoon Committee SPECTRUM Technical Conference and Steering Group Evaluation Meeting, Tokyo, Japan, December 1990.

OBSERVATION-NUMERICAL STUDIES OF SEVERE SYNOPTIC WEATHER PHENOMENA

Russell L. Elsberry, Professor of Meteorology
Patrick A. Harr, Adjunct Professor of Meteorology
Sponsor: Naval Oceanographic and Atmospheric Research Laboratory
Funding: Naval Postgraduate School

OBJECTIVE: The long-term objectives of this continuing project are to assist the Joint Typhoon Warning Center in Guam to improve tropical cyclone forecasts, and to evaluate global numerical model predictions.

SUMMARY: The time consistency of three tropical cyclone track prediction techniques has been studied in terms of errors relative to best track positions (Elsberry and Dobos 1990). The One-way influence Tropical Cyclone Model provides the most consistent forecasts in time. A 24-h forecast verification within the central one-third of the track forecasts generally provides no information about the likely correctness of the subsequent forecast. The aids have more time consistency when the error in the previous forecast is to the right of the track.

A lagged-averaged forecast technique has been applied to tropical cyclone track forecasts (Elsberry and Dobos 1990). Climatology and Persistence (CLIPER) forecasts from warning times lagging the initial times are combined at their common 24-h verifying time. When the CLIPER forecasts at 36, 48, 60 and 72-h are modified with information such as observed positions since the time those forecasts were initiated, these modified forecasts provide additional guidance as to the likely 24-h positions. Although the lagged-average technique improves the accuracy and consistency of the track predictions by about 7% in the dependent sample, only about half of this improvement is sustained in the independent sample.

Ford (1990) used an empirical orthogonal function (EOF) representation of relative vorticity to forecast recurvature of western North Pacific tropical cyclones. Classification of an individual case into time-to-recurvature or straight-mover categories is based on the Euclidean distance in EOF space. A version using the 250 mb vorticity is 72% correct in identifying recurvers or straight-movers during the 72-h forecast period.

Another aspect of this research project is improved numerical guidance of severe synoptic-scale weather features that have a large impact on Fleet operations. These include both rapidly developing and mature intense mid-latitude maritime cyclones. Statistical methods are used to identify cyclone characteristics that discriminate between forecasts that are expected to be accurate and those expected to contain large errors. A statistical decision model is then implemented to use these characteristics as parameters that help clarify some of the uncertainties involved when an operational forecaster evaluates a current numerical guidance product. This statistical framework blends knowledge of previous guidance model tendencies with current synoptic-scale characteristics that will help the Fleet forecaster better utilize the numerical guidance.

PUBLICATIONS: R. L. Elsberry and P. H. Dobos, "Time Consistency of Track Prediction Aids for Western North Pacific Tropical Cyclones," Monthly Weather Review, 118, pp. 746-754, March 1990.

R. L. Elsberry, P. H. Dobos and A. B. Bacon, "Lagged-average Predictions of Tropical Cyclone Tracks," Monthly Weather Review (accepted).

CONFERENCE PRESENTATIONS: P. A. Harr and W. M. Clune, "Comparisons Between Five Years of Analyzed Maritime Cyclone Characteristics and Those Derived from Successive Versions of an Operational Forecast Model." Preprints, 12th Conference on Weather Analysis and Forecasting, Monterey, CA, October 1989.

R. L. Elsberry and P. H. Dobos, "Recent Tropical Cyclone Research at the Naval Postgraduate School." Proceedings, Environmental Group U. S. Pacific Command Tropical Cyclone Conference, Guam, February 1990.

THESIS DIRECTED: D. M. Ford, LCDR, USN, "Forecasting Tropical Cyclone Recurvature using an Empirical Orthogonal Function Representation of Vorticity Fields." Master's Thesis, 85 pp., September 1990.

DATA MANAGEMENT AND WORKSHOP SUPPORT FOR THE TROPICAL CYCLONE MOTION EXPERIMENT

Russell L. Elsberry, Professor of Meteorology
Patrick A. Harr, Adjunct Research Professor
Tamar Neta, Meteorologist

OBJECTIVE: To provide the data management and organize workshops for the Tropical Cyclone Motion research initiative.

SUMMARY: Preparations were begun to create a data base that will be used for diagnostic and numerical modeling studies based on the Tropical Cyclone Motion (TCM-90) and three other international field experiments during August - September 1990. Data sources were identified that could be collected and archived in real-time at Fleet Numerical Oceanography Center. Arrangements were made to collect the remaining data on a delayed basis following the field experiment. A description of these procedures is contained in the Field Experiment Summary (Elsberry, et al., 1990).

PUBLICATION: R. L. Elsberry, B. C. Diehl, J. C.-L Chan, P. A. Harr, G. J. Holland, M. Lander, T. Neta and D. Thom, "ONR Tropical Cyclone Motion Research Initiative: Field Experiment Summary." Technical Report NPS MR-91-001, Naval Postgraduate School, Monterey, CA, 106 pp., December 1990.

OCEAN RESPONSE TO STRONG ATMOSPHERIC FORCING

Russell L. Elsberry, Professor of Meteorology
Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: The long-term objective of this research effort is to understand key physical processes in the ocean's thermal and momentum response on near-inertial time scales to strong atmospheric forcing events such as hurricanes. This study seeks to understand the relative roles of advective and mixing processes in the thermal response and the downward propagation of energy from a surface-intensified mixed layer. The current research task addresses the ocean current response to strong atmospheric forcing within the context of near-inertial wave dynamics that is linked to vertical current shear and mixing events in the upper ocean.

SUMMARY: An investigation (Shay, et al., 1990) of the barotropic current response to hurricane Frederic has been completed using both linear and primitive equation models with a free surface. In the wake of the hurricane, the free surface is depressed a maximum of 20 cm from the undisturbed height and induces a barotropic, near-inertial oscillation with maximum amplitude of 10 cm/s. At 90 km radius, the simulated barotropic amplitudes agree well with the observed depth-averaged current amplitudes of 10-12 cm/s from hurricane Frederic.

PUBLICATION: L. K. Shay, S. W. Chang and R. L. Elsberry, "Free-surface Effects on the Near-inertial Ocean Current Response to a Hurricane." Journal of Physical Oceanography, 20, 1405-1424, September 1990.

LARGE-EASY SIMULATION OF ARCTIC LEAD FLUXES

J.W. Glendening, Adjunct Professor of Meteorology
Sponsor: Naval Oceanic and Atmospheric Research Laboratory
Funding: Navy Reimbursable

OBJECTIVE: (1) To better understand how arctic leads transfer heat into the atmosphere, (2) to aid the design of the upcoming LEADEX (NRL/-NOAA) experiment, and (3) to help large-scale atmospheric modelers parameterize the effect of the small-scale heat transfers.

SUMMARY: The influence of arctic leads (breaks in the polar ice) on the atmospheric boundary layer was investigated with a large-eddy simulation. Leads are important for both arctic meteorology and global climate: winter time heat fluxes through the leads are often several orders of magnitude larger than those thorough the surrounding ice, so the relatively small area covered by the leads can have a major impact. LES simulations - - the "state-of-the-art" in boundary-layer model - - explicitly simulate the individual turbulent eddies which transport atmospheric properties. The lead created a field of intermittent thermals, which decayed downwind, producing a time-average "plume". Maximum development of this thermal "plume" occurred downwind of the lead rather than above it. This result is being incorporated in the LEADEX planning, i.e. measurements will also be taken downwind of the lead (previous researchers had assumed that only the lead itself was of interest and therefore made no downwind measurements). Heat flux transported by downdrafts was determined to be only slightly smaller than that due to updrafts. Although individual eddies had large upward velocities, the time-average upward movement of the plume as a whole was small. As a result, turbulence dominated mean motion in transferring heat vertically. In contrast, for horizontal transfer the turbulent heat divergence was negligible. Thus mean vertical transport and horizontal turbulent transport can be neglected in the parameterizations of large-scale models.

PUBLICATIONS: J. W. Glendening and S.D. Burk, 1991: Turbulent transport from an arctic lead: a large-eddy simulation. Submitted to Boundary-Layer Meteorology.

EDDY GENERATION MECHANISMS IN EASTERN BOUNDARY CURRENT REGIONS

Robert L. Haney, Professor of Meteorology
Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project is to investigate ocean processes that lead to the formation of jets, squirts, eddies and other turbulent phenomenon in eastern boundary current regions. Numerical model studies using data collected in the ONR-sponsored Coastal Transition Zone (CTZ) program will be carried out to test several working hypotheses for eddy and jet formation.

SUMMARY: The earliest results of this project (Bateen et al. 1989) indicated that baroclinic instability of a mean along shore coastal jet is not sufficient by itself to generate the kind of ocean features observed in CTZ (Strub et al., 1991). Attention has now been turned to the role of bottom topography as a possible forcing mechanism. The most recent results (Haney, 1991) document the numerical resolution and methods required to accurately model flow over steep topography. Data assimilation studies are presently underway using the CTZ field data, and these will enable a number of hypotheses (such as the role of topography, nonlinear effects, winds, etc.) for generating pronounced ocean variability in eastern boundary regions.

PUBLICATIONS: Batteen, M. L., R. L. Haney, T. A. Tielking, and P. G. Renaud, 1989: "A Numerical Study of Wind Forcing of Eddies and Jets in the California Current System." J. Mar. Res., 47, 493-523.

P. T. Strub, and 21 more authors including R. L. Haney, 1990: "The Nature of Cold Filaments in the California Current System," J. Geophys. Res., (accepted, September 1990).

R. L. Haney, "On the Pressure Gradient Force over Steep Topography in Sigma Coordinate Ocean Models," J. Phys. Oceanogr. (accepted November 1990).

CONFERENCE PRESENTATIONS: R. L. Haney, "On the Pressure Gradient Force over Steep Topography in Sigma Coordinate Ocean Models," AGU Ocean Sciences Meeting, 12-16 February 1990, New Orleans, LA.

K. H. Brink, J. S. Allen and R. L. Haney, "Physical Processes to be Resolved by a Coastal Ocean Prediction System," AGU Fall Meeting, 3-7 December 1990, San Francisco, CA.

THESIS DIRECTED: R. E. De Jesus, "A Diagnostic Study of the velocity Structure of a Meandering Jet off Pt. Arena, California," M.S. Thesis, September 1990.

MESOSCALE MODELING OF THE ATMOSPHERIC BOUNDARY LAYER

T. R. Holt, Assistant Professor of Meteorology
Sponsor: Office of Naval Research
Funding: NPS Research Initiation Project

OBJECTIVE: The goal of this project was to examine the importance of the marine atmospheric boundary layer and boundary layer parameterizations in a three-dimensional (3-D) numerical mesoscale model and to then use the model to investigate and compare important boundary layer structures and processes during cases of coastal cyclogenesis.

SUMMARY: To emphasize the significance of coastal cyclogenesis from an observational viewpoint first, the effect of the atmospheric coastal front on low-level baroclinic coastal processes was investigated through an examination of the 3-D mean and turbulence structure of a coastal front influenced by the Gulf Stream. Results indicated that the front plays an important role in the 3-D atmospheric circulation, causing a decoupling of the layer above the frontal surface by inhibiting the vertical transfer of fluxes from the surface. Associated with the decoupling and subsequent stabilization was the occurrence of buoyancy waves above the frontal boundary. Numerical simulations of coastal cyclogenesis using a 3-D hydrostatic, primitive equation model with a multi-level turbulent kinetic energy boundary layer parameterization were performed to investigate the influence and interaction of three major physical processes generally regarded as important factors in explosive cyclogenesis: 1) the presence of a low-level baroclinic zone; 2) latent heat release associated with convective precipitation and; 3) upper-level forcing. Results indicated an important interaction of the low-level baroclinic zone with the upper-level trough system. Modifications of the low-level baroclinic zone in the numerical simulations to examine the effects of diabatic heating in the coastal regions produced expected modifications to the low-level isentropic potential vorticity (IPV) surface, but interestingly also significantly affected the upper-level IPV surface by producing weaker lower tropospheric protrusions. Numerical studies to consider latent heat release associated with convective precipitation were examined through the use of an observing system simulation experiment (OSSE). Results indicated that assimilation of rainfall rate (such as that available from the DMSP Special Sensor Microwave/Imager) can improve numerical prediction of the coastal cyclogenesis case.

PUBLICATIONS: T.R. Holt and S. Raman, "Three-Dimensional Mean and Turbulence Structure of a Coastal Front Influenced by the Gulf Stream," submitted to Monthly Weather Review, November 1990.

T.R. Holt and S.W. Chang, "Numerical Studies of Important Physical Processes in the Evolution of the GALE IOP 2 Cyclone," Pre-print Volume of the First International Winter Storm Symposium, New Orleans, January 1991.

S.W. Chang and T.R. Holt, "Impact of SSM/I Rainfall Rate on Numerical Prediction of Cyclones: An Observing System Simulation," Pre-print Volume of the First International Winter Storm Symposium, New Orleans, January 1991.

BOUNDARY LAYER MODELING IN EXPLOSIVE CYCLOGENESIS

Wendell A. Nuss, Assistant Professor of Meteorology
Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVES: The long-range goal of this research is to understand the role of boundary layer processes in frontogensis and cyclogenesis and to better represent these processes in numerical simulations of cyclogenesis. The objectives of this research are to describe the effect that horizontally varying boundary layer structure and processes have on frontogenesis associated with oceanic cyclogenesis and to investigate the role of the sea surface temperature distribution and initial boundary layer structure in forcing warm frontogenesis in numerical simulations of oceanic cyclones.

SUMMARY: Model simulations of an intense cyclone during the Genesis of Atlantic Lows Experiment (GALE) have been used to investigate the effect of boundary layer processes on surface frontogenesis. The analysis of this actual cyclogenesis event along the East Coast of the U.S. has confirmed and helped to refine the results obtained during 1989 from idealized cyclone simulations. The analysis of these simulations have shown that surface heating plays an important role in establishing the baroclinic structure that undergoes frontogenesis during the development of ocean cyclones. Vertical motion was found to be forced primarily by frictional convergence at the surface, which depended upon both the thermal wind turning of boundary layer winds and differential momentum mixing due to boundary layer stability differences. Detailed analysis of the model boundary layer structure was done and indicated problems in the model boundary layer parameterization. These problems and the inclusion of surface wind wave effects into the model were examined and are planned to be included during 1991.

In addition to the examination of the GALE cyclone, the boundary layer forcing of two cyclones near Japan was examined both observationally and through model simulations. The model simulations were not successful due to analysis problems, which are presently being addressed.

CONFERENCE PRESENTATIONS: W.A. Nuss, Boundary layer forcing of cyclones near Japan. 4th Conference on Mesoscale Processes, Boulder, CO June 1990.

OTHER: The principle investigator has presented the results of this work as an invited speaker at a conference in early 1991. A manuscript describing the results of the GALE cyclone simulations is nearly complete and will be submitted in early 1991.

BOUNDARY LAYER INTERACTION IN CYCLOGENESIS

Wendell A. Nuss, Assistant Professor of Meteorology
Sponsor: Naval Postgraduate School Research Foundation
Funding: Naval Postgraduate School

OBJECTIVE: The aim of this study is to describe the boundary layer structure in the vicinity of warm and cold fronts in extratropical cyclones. The primary objective is to understand how boundary layer structure and processes influence the dynamics of a developing cyclone.

SUMMARY: During 1990 this project has completed the detailed analysis of the boundary layer in a cyclone that occurred during the Experiment on Rapidly Intensifying Cyclones over the Atlantic (ERICA). The analysis has demonstrated that low-level flow parallel to the Gulf Stream is associated with significant surface frontogenesis along the warm front. This pattern of surface interaction in the one ERICA cyclone has indicated a characteristic type of low-level flow that potentially favors boundary layer interaction in cyclones. The testing of this hypothesis has begun using historical data sets that were identified through an examination of archived surface charts. Digital data sets for some cases were obtained from the National Center for Atmospheric Research (NCAR) and are currently being examined. Software for the transfer of data between NCAR and diagnostic programs used at NPS were developed to facilitate this climatological study.

THESIS DIRECTED: G. Steeley, LCDR, Boundary layer structure of an explosive cyclone. Master's Thesis, March 1990.

MESOSCALE COUPLED AIR-SEA INTERACTION STUDIES

Wendell A. Nuss, Associate Professor of Meteorology
Sponsor: Naval Oceanographic and Atmospheric Research Laboratory
Funding: Naval Postgraduate School

OBJECTIVE: The overall objective of this research is to demonstrate the potential for and importance of two-way coupling on the mesoscale between the atmosphere and the ocean . This project is supported by NOARL as part of a joint effort by NOARL, NPS and Scripps Institution of Oceanography to examine coupled mesoscale air-sea interaction in ocean storms.

SUMMARY: The activity during 1990 for this ongoing project has focused on the construction of detailed surface analyses for one of the ERICA storms that occurred on Dec. 13-14 1988 (IOP 2). Mesoscale hand analyses of sea-level pressure and temperature were made every 3 hours from all available surface ship and buoy data. A method to reduce low-level aircraft data to the surface was developed to add these observations into the surface analyses. Preliminary surface flux estimates were constructed from crudely digitized forms of these surface analyses to document the potentially large contribution to cyclogenesis by the surface processes. A key early result was the rapidity by which the atmospheric boundary layer adjusts to the sea surface temperature distribution even though the air remained colder than the water. This finding was found to favor frontogenesis along the Gulf Stream and has indicated the primary direction for the ongoing research during 1991.

THESIS DIRECTED: C. Lilly, LCDR, Mesoscale Surface Analysis of ERICA IOP 2. Master's Thesis, December 1990.

OTHER: The principle investigator has consulted with the other co-investigators at NOARL and Scripps during 1990 to coordinate the analysis efforts and use standardized computer graphics map areas.

INFLUENCE OF LATENT HEAT RELEASE AND STATIC STABILITY VARIATIONS ON THE DEVELOPMENT OF RAPIDLY INTENSIFYING EXTRATROPICAL CYCLONES

P.M. Pauley, Adjunct Teaching Professor of Meteorology
Sponsor: Office of Naval Research
Funding: ONR (Subcontract through the University of Wisconsin-Madison)

OBJECTIVE: The objective of this research was to quantify the influences of latent heat release and static stability variations on model simulations of rapidly intensifying oceanic extratropical cyclones, using expanded forms of the omega and height tendency equations as well as a static stability budget.

SUMMARY: This is the third year of a three-year project begun at the University of Wisconsin-Madison. Over this past year, diagnosis of the generalized omega equation and the static stability budget were completed at the University of Wisconsin for a LAMPS model simulation of the so-called QE II storm from 9-11 September 1978. This work was associated with the two completed M.S. theses listed below. A further diagnosis of the height tendency equation was also begun for the QE II case. My current work is focussed on completing the latter diagnosis and preparing publications from the work that has already been completed.

THESIS DIRECTED: Terrie J. Fairgrieves, "Evolution of the Static Stability Field Within a Model-Simulated Rapidly Intensifying Marine Extratropical Cyclone," M.S. Thesis, University of Wisconsin-Madison, June 1990, 174 pp.

Steven J. Nieman, "A Diagnosis of Non-Quasi-Geostrophic Vertical Motion for a Model-Simulated Rapidly Intensifying Marine Extratropical Cyclone," M.S. Thesis, University of Wisconsin-Madison, May 1990, 181 pp.

OTHER: Conference preprint papers prepared in 1990:

(NR) T.J. Fairgrieves and P.M. Pauley, "Evolution of the Static Stability Field Within a Model-Simulated Rapidly Intensifying Marine Extratropical Cyclone," Preprints of the First International Symposium on Winter Storms, January 14-18, 1991, New Orleans, LA, pp. 351-354. (Written by P.M. Pauley.)

(NR) S.J. Nieman and P.M. Pauley, "A Diagnosis of Non-Quasi-Geostrophic Vertical Motion for a Model-Simulated Rapidly Intensifying Marine Extratropical Cyclone," Preprints of the First International Symposium on Winter Storms, January 14-18, 1991, New Orleans, LA, pp. 355-358. (Written by P.M. Pauley.)

(NR) B. J. Bramer and P. M. Pauley, "An Examination of Model Resolution Effects on the Depiction of Central Pressure for the ERICA IOP-4 Cyclone," Preprints of the First International Symposium on Winter Storms, January 14-18, 1991, New Orleans, LA, pp. 359-364. (Written by P.M. Pauley.)

Papers in preparation:

P. M. Pauley and B. J. Bramer, "The Effect of Resolution on the Depiction of Central Pressure for an Intense Oceanic Extratropical Cyclone," Submitted to Monthly Weather Review, January 1991.

P.M. Pauley and S.J. Nieman, "A Comparison of Quasi-Geostrophic and Non-Quasi-Geostrophic Vertical Motions for a Model-Simulated Rapidly Intensifying Oceanic Extra-tropical Cyclone. Monthly Weather Review, in preparation.

RESPONSE CHARACTERISTICS OF THE BARNES OBJECTIVE ANALYSIS SCHEME

P.M. Pauley, Adjunct Teaching Professor of Meteorology
Funding: Unfunded

OBJECTIVE: The objective of this research is to investigate the spectral characteristics (response) of the commonly used Barnes objective analysis scheme, both for the idealized continuous case as well as for the discretized version. The sensitivity of the response to the details of the discretization is also examined.

SUMMARY: This project was begun at the University of Wisconsin-Madison in conjunction with an M.S. student (Xiaohua Wu) who was funded through the Space Science and Engineering Center also at the University of Wisconsin-Madison. Ms. Wu finished her thesis in December 1988. Work has been completed and published on the spectral characteristics of the Barnes scheme for one- and two-dimensional wave fields for both a continuous two-pass version of the scheme as well as for a discrete version where the input field is defined on a uniformly spaced grid. I am currently developing computer code with Ms. Wu to examine the effects of a nonuniformly spaced input field.

PUBLICATIONS: (R) P. M. Pauley and X. Wu, "The Theoretical, Discrete, and Actual Response of the Barnes Objective Analysis Scheme for One- and Two-Dimensional Fields," Monthly Weather Review, 118, pp. 1145-1163, May 1990.

(R) P.M. Pauley, "On the Evaluation of Boundary Errors in the Barnes Objective Analysis Scheme," Monthly Weather Review, 118, pp.1203-1210, May 1990.

OTHER: Papers completed in 1990:

(R) P.M. Pauley and X. Wu, "Response to the Comment on Pauley and Wu (1990) by C. Doswell and S. Barnes," Monthly Weather Review, scheduled for May 1991 issue.

Papers in preparation:

P. M. Pauley and X. Wu, "The Sensitivity of the Barnes Objective Analysis Scheme in Practical Applications," Monthly Weather Review, in preparation. Patricia M. Pauley

A COMPARISON OF VERTICAL MOTIONS OBTAINED FROM THE FLATLAND ST RADAR AND FROM A GENERALIZED OMEGA EQUATION

P.M. Pauley, Adjunct Teaching Professor of Meteorology
Sponsor: National Science Foundation
Funding: NSF (Subcontract through the University of Wisconsin-Madison)

OBJECTIVE: The objective of this research is to compare large-scale vertical motions measured from the Flatland ST radar (located near Champaign, IL) with values calculated from a generalized form of the omega equation (based on operational NMC analyses). Values will be compared at 0000 and 1200 UTC for a year beginning in February 1990 to investigate the degree of comparability between the two vertical motion estimates and its dependence on flow patterns and other parameters.

SUMMARY: I have a continuing M.S. student (Robert Creasey) at the University of Wisconsin-Madison working with me on this project. During CY 1990, Bob completed coding various forms of the omega equation as well as a kinematic computation of vertical motion. Code to compute parameterized latent heating rates was also written latent heating rates was also written based on the widely-used Kuo cumulus scheme. NMC data through the end of the year have also been obtained. Vertical motions for a trial period in March were computed and compared against the profiler-measured values. Bob is scheduled to complete his thesis in early summer.

OTHER: Currently working on carrying out vertical motion computations and setting up the data archive (with selected hard-copy maps).

SENSITIVITY OF NUMERICAL FORECASTS OF RAPIDLY INTENSIFYING EXTRATROPICAL CYCLONES TO PRECIPITATION PARAMETERIZATION

P.M. Pauley, Adjunct Teaching Professor of Meteorology
Sponsor: Office of Naval Research
Funding: ONR

OBJECTIVE: The objective of this research is to investigate the influence of cumulus parameterization on numerical forecasts of rapid oceanic cyclogenesis. Diagnoses of height tendencies and vertical motions will be calculated using datasets described by Kuo and Low-Nam (1990) from the PSU/NCAR model, with the objective of examining the influence of latent heat release and static stability variations on storm development.

SUMMARY: This project was just begun in September 1990 and so is in the early stages. I have made contacts to obtain the model datasets and have begun the process of setting up the necessary computer codes. The proposed research will examine differences in model latent heating rates associated with differences in cumulus parameterization and investigate the sensitivity of the model dynamics to these differences. Height tendencies and vertical motions will be calculated as a means of investigating the dynamics associated with the development of the model storms.

OTHER: Currently working on computer codes

OBSERVATIONAL-NUMERICAL STUDY OF MARITIME EXTRATROPICAL CYCLONES USING FGGE DATA

C.H. Wash, Associate Professor of Meteorology
R.L. Elsberry, Professor Meteorology
Sponsor: National Aeronautics and Space Administration

OBJECTIVE: To better understand the development, maturation and decay of maritime extratropical cyclones using a combined observational and numerical modeling approach.

SUMMARY: Diagnostic studies of collections of rapid and slow developing cyclones were completed with FGGE data using potential diagnostic quantities. The recent thesis of Eric Wright illustrated that the rapid and slow development can be explained by different intensities in the upper level forcing mechanisms. Wright results were submitted for publication and the data set was expanded to include entire FGGE winter period.

PUBLICATIONS: C. H. Wash, R. A. Hale, P. H. Dobos and E. J. Wright, "Study of explosive and nonexplosive cyclogenesis during FGGE". Manuscript submitted to Monthly Weather Review.

CONFERENCE PRESENTATIONS: C. H. Wash, R. A. Hale, P. H. Dobos and E. J. Wright, "Study of explosive and nonexplosive cyclogenesis during FGGE". Preprints, First International Symposium on Winter Storms, American Meteorological Society, New Orleans, LA, 15-18 January 1991.

SATELLITE APPLICATIONS FOR TESS

C.H. Wash, Associate Professor of Meteorology
Sponsor: Direct funded project (outside sponsor-NORAL-West)
Funding: Navy Direct

OBJECTIVE: To provide NEPRF with satellite applications for the TESS 3.0 system. To prepare applications which best fit within the constraints of available data sources, available computer resources and fleet operational importance.

SUMMARY: A cloud and precipitation classification program, designed for geostationary satellite data, was evaluated using polar orbiting satellite data. Also, study was begun on the application of AVHRR multichannel data to improvement of cirrus and low stratus clouds classification algorithms.

PUBLICATIONS: F. O'Sullivan, C. H. Wash and C. Motell, "Rain estimation from infrated and visible GOES satellite data", Journal of Applied Meteorology, 29, No. 3, 209-223, March 1990.

R. C. Allan, C. Wash and P. Durkee, 1990: "Snow and low cloud discrimination from multispectral satellite measurements", Journal of Applied Meteorology, 29, No. 10, 994-1004, October 1990. C. H. Wash and T. Neu, "Real-time cloud and precipitation for the forecaster workstation", to be submitted to Weather and Forecasting.

THESIS DIRECTED: Sharon Wieman, CAPT, USAF, "Multiple Channel Satellite Analysis of Cirrus", Master's Thesis, June 1990.

Tom Neu, CAPT, USAF, "Evaluation of Generalized Thresholds in an Objective Multispectral Satellite Cloud Analysis', Master's Thesis, June 1990.

Ed Cataldo, LT, USN, "SSM/I Rain Analysis during ERICA", Master's Thesis, September 1990.

CONFERENCE PRESENTATIONS: C. H. Wash, "Near real-time cloud analysis for the forecaster workstation environment". Cloud Impacts on DOD Operations and Systems 1990 Conference, Monterey, CA, 9-11 January 1990.

EXTRATROPICAL RAPID MARITIME CYCLOGENESIS STUDIES

C.H. Wash, Associate Professor of Meteorology
R.L. Elsberry, Professor of Meteorology
P. Pauley, Adjunct Professor of Meteorology
W.A. Nuss, Assistant Professor of Meteorology
P.A. Hirschberg, Adjunct Research Professor of Meteorology
Sponsor: Office of Naval Research-Marine Meteorology
Funding: Navy Direct

OBJECTIVE: The long range goal of this research is to understand the physical processes responsible for rapid cyclogenesis at sea. The following unifying hypothesis to explain rapid maritime cyclogenesis is being applied to the diagnosis of data from the Experiment on Rapidly Intensifying Cyclones over the Atlantic (ERICA): Rapid development of marine cyclones represent a favorable superposition of upper- and lower-level forcing mechanisms under low static stability conditions. Modification of the development rate is accomplished by a favorable interaction with the distribution of sea-surface temperature as well as by substantial release of latent heat due to condensation.

SUMMARY: The ERICA observations were installed in the IDEA Lab using GEMPAK including aircraft and satellite observations to facilitate the use of this data by the various investigators and students. To refine the satellite data and analyses for the ERICA cases, an assessment of TOVS satellite sounding and SSM/I rain algorithms was made. Results have shown that excellent sounding retrievals can be made with improved surface analyses blended with model vertical structure when possible. Analysis of the SSM/I microwave data have resulted in improved rain algorithms to be applied to ERICA and other ocean storms.

Analysis of ERICA IOP's 2 and 3 continued during 1990. Model simulations of IOP 2 were done using the operational NORAPS analyses and reveal significant forecast errors due to the cumulus parameterization. These errors were found to be related to poor low-level moisture analyses in the initial conditions. Detailed surface analyses of IOP 3 have been made in order to assess the utility of applying surface Q-vector diagnostics to explosive cyclones. The results have demonstrated that accurate short range prediction is possible from relatively simple diagnostics that can easily be applied by operational forecasters.

PUBLICATIONS: C. H. Wash, S. M. Heikkinen, C.-S. Liou and W. A. Nuss, "IOP-9 Cyclogenesis Diagnostic and Numerical Forecast Studies", Mon. Wea. Rev., 118, 375-391, February 1990.

C.-S. Liou, S. M. Heikkinen, C. H. Wash and R. L. Elsberry, "Numerical Studies of GALE IOP-2 Cyclogenesis", Mon. Wea. Rev., 118-2, February 1990.

W. A. Nuss and S. I. Kamikawa, "Dynamics and Low-level Processes in Two Asian Cyclones", Mon. Wea. Rev., 118, 755-771, March 1990.

P. A. Hirschberg and J. M. Fritsch, "Tropopause Undulations and the Development of Extratropical Cyclones. Part I. Overview and observations for a cyclone event", Mon. Wea. Rev., 119, 496-517, February 1991.

P. A. Hirschberg and J. M. Fritsch, "Tropopause Undulations and the Development of Extratropical Cyclones. Part II: Diagnostic analysis and conceptual model", Mon. Wea. Rev., 119, 518-550, February 1991.

P. A. Hirschberg and J. M. Fritsch, "An Analytic Five-layer Quasi-geostrophic Model for Initial-value Problems", submitted to J. Atmos. Sci. (November 1990).

THESES DIRECTED: M. Kreyenhagen, LCDR, USN, "Comparison of the Dynamics of a Land vs. Oceanic Explosive Cyclone. Master's Thesis, December 1989.

J. Pereira, CAPT, USAF, Evaluation of the Ability of TOVS Soundings to Describe the Environment of Rapidly Developing Cyclones during ERICA", Master's Thesis, June 1990.

E. Cataldo, LCDR, USN, "Validation of SSM/I Rain Algorithms for Selective Storms in the ERICA Project", Master's Thesis, June 1990.

R. Miller, CIV, NOARL, "Numerical Modeling Study of ERICA IOP-2", Master's Thesis, June 1990.

CONFERENCE PRESENTATIONS: P. A. Hirschberg and J. M. Fritsch, "The Combined

Effects of Stratospheric and Tropospheric Structure on the Development of Extratropical Cyclones". American Meteorological Society, 1st International Winter Storm Symposium, 13-18 January 1991, New Orleans, LA.

C. H. Wash and R. J. Miller, "An Investigation of the ERICA IOP-2 Cyclone with the NORAPS Model". Preprints, 1st International Symposium on Winter Storms, New Orleans, LA, 15-18 January 1991.

W. A. Nuss and C. Lilly, "Boundary Layer Convergence along the Gulf Stream during ERICA". Preprints, 1st International Symposium on Winter Storms, New Orleans, LA, 15-18 January 1991.

AUTOMATED EARTH LOCATION OF SATELLITE DATA

C.H. Wash, Associate Professor of Meteorology
P.A. Durkee, Associate Professor of Meteorology
Sponsor: Defense Mapping Agency
Funding: Reimbursable

OBJECTIVE: To apply Defense Mapping Agency World Vector Shoreline digital database and necessary earth location technology to digital environmental satellite imagery for use in environmental command and control.

SUMMARY: Shoreline database received and read. Automatic earth location studies completed in thesis by Spaulding (1990).

PUBLICATIONS: C. Motell, C. H. Wash, P. A. Durkee and D. Burks, "AVHRR image navigation by satellite attitude correction. Part I. Manual landmarking", to be submitted to J. Atmos. Ocean. Tech.

C. H. Wash, C. Motell and B. Spaulding, "AVHRR image navigation by satellite attitude correction. Part II. Automatic landmarking", to be submitted to J. Atmos. Ocean. Tech.

THESIS DIRECTED: Brian Spaulding, CIV, DMA, "Automated Earth Location of Satellite Data", Master's Thesis, September 1990.

REGIONAL SYNOPTIC FORECASTING (PHILIPPINES)

F.R. Williams, Adjunct Professor of Meteorology
Department of Meteorology
Sponsor: Naval Oceanographic Atmospheric Research Laboratory (West)
Funding: Naval Postgraduate School

OBJECTIVE: A continuing project to produce handbooks describing the analysis and forecasting of atmospheric and oceanic conditions important to air/sea operations over key areas of interest to the Navy. In particular, the handbooks contain case studies (with analyses and satellite imagery) providing newly arriving naval personnel with examples of Navy product accuracy. The current handbook will cover the Philippine Islands and surrounding seas (4-21°N, 116-127°E).

SUMMARY: A data gathering trip was made to USN, USAF and foreign facilities in the Republic of Philippines plus to the Joint Typhoon Warning Center, Guam. Following installation of software programs, remote collection was commenced at NPS of case study material depicting weather episodes during different seasons. The software programs include the Navy Oceanography Data Distribution System (NODDS) provided by Fleet Numerical Oceanography Center, the Automated Tropical Cyclone Forecasting (ATCF) system provided by the Naval Oceanographic Atmospheric Research Laboratory, as well as satellite and conventional data programs installed on Interactive Digital Environmental Analysis (IDEA) Laboratory hardware located in Root Hall. A contract was prepared and awarded to Emeritus Professor Glenn Jung of the Oceanography Department for the coastal oceanography chapter, to be delivered in CY 1991. Collection of case study data will continue during 1991 along with compilation of the first draft of the handbook.

DEVELOPMENT OF A FINITE ELEMENT PREDICTION MODEL

R.T. Williams, Professor of Meteorology
A.L. Schoenstadt, Professor of Mathematics
B. Neta, Associate Professor of Mathematics

OBJECTIVE: To develop and test finite element atmospheric prediction models on parallel and other computers. This is a continuing project.

SUMMARY: We have started to use the Intel IPSC2 hypercube for several problems related to weather forecasting. The algorithm developed by Katti and Neta has been programmed on the hypercube available in the Mathematics Department. Lustman, Neta and Katti (1990) used this algorithm to solve a linear system of ordinary differential equations (like those obtained from semi-discretization of the shallow water equations). Encouraged by these results which showed the benefit of parallel computation, we have initiated several related ideas, the first being the solution of a rank two modified tridiagonal system of equations (i.e., the coefficient matrix is almost tridiagonal and includes a nonzero element at top right and bottom left corners). Such a system arises in the semi-Lagrangian semi-implicit scheme for the shallow water equations as formulated by Monk. An algorithm for a domain decomposition with reasonably accurate values on these interfaces was developed by Neta and Okamoto (1990). We explored the use of semi-Lagrangian methods in a situation where the spatial scale of the flow collapses to zero during the time integration (Kuo and Williams, 1990). It was shown that despite the variable manner in which the gradient of the wind field approaches infinity in the neighborhood of the shock, the semi-Lagrangian method gave accurate results even with larger time steps (Courant number greater than two or four) than are possible with Eularian methods. The solutions which form the linearized shallow water model were compared to the first order solutions (Hyde, 1984) as a function of the bottom slope (Staniforth, Williams and Neta, 1990). It was found that the phase speed dependence on the bottom slope is much more complicated than can be described by the first order theory.

PUBLICATIONS:

H.-C. Kuo and R. T. Williams, "Semi-Lagrangian Solutions to the Inviscid Burger's Equation," Monthly Weather Review, 118, pp. 1278-1288, June 1990.

B. Neta, P. Nelson and C. P. Katti, "Convergence of Inner/outer Source Iterations with Finite Terminations of the Inner Iteration," Journal of Integral Equations and Applications, 2, pp 147-174, 1990.

B. Neta, J. M. Navon and J. Yu, "Analysis of the Turkel-Zwas Scheme for the Two Dimensional Shallow Water Equations", (to be published in International Journal of Numerical Methods in Fluids).

B. Neta and N. Okamoto, "On Domain Decomposition Methods for Solving Partial Differential Equations," Naval Postgraduate School Technical Report 53-90-004, March 1990, pp. 9.

B. Neta, I. M. Navon and J. Yu, "Analysis of the Turkel-Zwas Scheme for the Two Dimensional Shallow Water Equation in Spherical Coordinates," Florida State University Supercomputer Computation Research Institute Technical Report, FSU-SCRI-90-91, May 1990, pp. 17.

THEORY OF TROPICAL CYCLONE MOTION

R.T. Williams, Professor of Meteorology
M.S. Peng, Adjunct Professor of Meteorology
Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: To understand the physical processes which control the motion of tropical cyclones. This is an ongoing project.

SUMMARY: A linear non-divergent barotropic model was developed by Peng and Williams (1990) to obtain the asymmetric circulations associated with a vortex moving on the beta plane. The model predicted both an inner gyre and an outer gyre. The outer gyre gave a vortex motion which corresponded to the motion obtained in a full numerical model. The inner gyre was related to unstable or neutral modes which could be eliminated. Peng and Williams (1991) investigated the stability of a variety of symmetric wind profiles. The stability was found to be very sensitive to the grid resolution because of the large vorticity gradients in the wind profile used. Williams and Chan (1990) used a full numerical model to study vortex motion in east-west basic current with (a) linear wind profiles (constant shear), and (b) parabolic wind profile (constant vorticity gradient). In case (a) with the beta effect the adjusted vortex trajectory was in the same direction as with no mean flow, but the speed changed for anti-cyclonic shear. For case (b), the vortex motion is more to the west and slower than the pure beta case.

PUBLICATIONS: M. S. Peng and R. T. Williams, "Dynamics of Vortex Asymmetries and their Influence on Vortex Motion on a Beta Plane," Journal of the Atmospheric Sciences, 47, pp. 1987-2003, August 15, 1990.

M. S. Peng and R. T. Williams, "Stability Analysis of Barotropic Vortices in Polar Coordinates,"Geophysical and Astrophysical Fluid Dynamics, June 1991.

M. S. Peng and R. T. Williams, "Dynamics of Vortex Motion on a Tropical Beta Plane," East Asia and Western Pacific Meteorology and Climate, World Scientific, pp. 537-546, 1990.

OTHER: R. T. Williams and J. C.-L. Chan, "Analytical and Numerical Studies of Tropical Cyclone. Part II. (in preparation)

NUMERICAL MODELING OF UNIQUE ATMOSPHERIC PHENOMENA

R.T. Williams, Professor of Meteorology
M.S. Peng, Adjunct Professor of Meteorology
Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: Develop and test better numerical techniques for use in Navy weather forecasting models. This is a continuing project.

SUMMARY: The interaction between planetary-scale motions and synoptic scale motions is very important for longer period variations in the atmosphere and for climate change. We have analyzed the energy interactions between these scales of motion in these scales of motion in terms of vertical modes (McAtee and Williams, 1990). For the first or barotropic vertical mode the energy flows from the synoptic scales to planetary scales, while for the second and third modes the energy flows from the planetary to the synoptic scales of motion. It is known that the synoptic scales of motion have the same type of interaction with the zonal mean flow. The passage of a front over a long ridge was studied with a two-dimensional numerical model (Williams, Peng and Zankofsky, 1990). The basic current was stratified with no vertical shear. Frontogenesis was forced by a horizontal deformation field that moved with the basic flow. The fronts weakened as they moved up the slope, and they strengthened as they moved down the lee slope. These solutions were compared with the semi-geostrophic solutions that were obtained by Zehnder and Bannon. For steeper mountains our solutions departed much more from the semi-geostrophic solutions. Frontal solutions with no forcing were compared with the advection of a scalar field, following the semi-geostrophic theory of Blumen and Gross. The agreement was good for the larger scale mountain, but is was poorer for the steep mountains over which they flow was less semi-geostrophic.

PUBLICATIONS: Hayes, J.L., Williams, R.T. and Rennick, M.A., "Lee Cyclogenesis, Part II: Numerical Studies," under revision for Journal of the Atmospheric Sciences.

Williams, R.T., Peng, M.S., and Zankofsky, D.A., Effects of Topography on Fronts," submitted to the Journal of the Atmospheric Sciences.

CONFERENCE PRESENTATIONS: Peng, M.S., Williams, R.T., Interaction of Fronts with Topography," Conference on Weather Analysis and Forecasting, Taipei, Taiwan (ROC), May 2-5, 1990.

Knight, D., Williams, R.T., "Baroclinic Flow over Mesoscale Mountains," Fifth American Meteorological Society Conference on Mountain Meteorology, Boulder, CO., June 25-29, 1990.

DEPARTMENT OF NATIONAL SECURITY AFFAIRS

NATIONAL SECURITY AFFAIRS

The research conducted by faculty in the Department of National Security Affairs is encompassed largely within the two broad and overlapping categories of Regional Studies and Strategic Planning. Several of the faculty research and publish in both areas, and a project may often include both. In the former are the following projects: Donald Abenheim's Navy direct funded research on The West German Armed Forces Until the Year 2000; Jan Breemer's Navy direct funded research on Transatlantic Security; Thomas Bruneau's Navy direct funded research on the Modernization of the Portuguese Armed Forces; Thomas Bruneau and Scott Tollefson's Navy direct funded research on Brazil-U.S. Naval Relations; Mikhail Tsypkin and Norm Channell's reimbursable research on The Soviet Navy; Thomas Grassey's Navy direct funded research on Soviet Naval Thought; Ralph Magnus' reimbursable research on Post-Jihad Afghanistan; Rodney Minott's research on Finland's Security Policy; Edward Olsen's Navy direct funded research on Seapower and the Asia-Pacific; Russel Stolfi's reimbursable research on German Battle Style in North Africa; Scott Tollefson's Navy direct funded research on Brazil and the Missile Technology Control Regime; and Mikhail Tsypkin's reimbursable research on Gorbachev and Soviet Navy Missions and Glasnost and Secrecy in the Soviet Military.

While many of the above-noted research projects deal to some degree with Strategic Planning, the following are more explicitly in this category: Jan Breemer's Navy direct funded research on ASW Strategy; Norm Channell's Navy direct funded research on the Relationship of War at Sea to Warfare Ashore; Edward Laurance's Navy direct funded research on the Use of Analytical Tools in Support of Navy Policy Analysis; Paul Stockton's research project on Strategic Arms Reductions; James Tritten's reimbursable research on Nuclear Assessments and Strategic Management for the Defense Department; James Wirtz' research project on the Balance of Power Paradox; and David Yost's reimbursable research on Structural Factors in Long-Term Competition. The last-noted project includes large elements of Regional Studies.

The faculty in the Department of National Security Affairs have made very good use of the research support provided by the Navy direct funding arrangement. They have produced reports and provided briefings for sponsors as well as generated scholarly books and articles. They also actively seek to increase and diversify other funding sources throughout the Department of Defense.

In 1990 the faculty published twenty-four articles in refereed journals, thirteen book chapters, five books, two edited books, thirteen technical reports, and supervised fifty-three theses.

GERMAN UNITY AND ALTERED EUROPE, HOOVER INSTITUTION STANFORD UNIVERSITY

Donald Abenheim, Assistant Professor of National Security Affairs
Agnes Peterson, Dennis Bark, Davis Gress, Lewis Gann (Hoover Institution)
Sponsor: Hoover Institution

OBJECTIVE: Within the Hoover Institution and collection program on political change within a post 1989 Europe, I have made two collecting trips to Europe in search of archival material connected with the political, social and military aspects of German unification.

The transformation of European politics and security in the wake of the Soviet withdrawal from its European glacis signifies military revolution in Europe. The Hoover Institution on War, Revolution and Peace has an ongoing research project on the shape of political change in central Europe. Within this effort, I observed the events in Berlin in November 1989, the first national election in semi-freedom in the GDR in March 1990, and the process of unification itself in September-October 1990. These events have had a direct impact on the character of U.S. strategy and the missions and functions of the U.S. armed forces, to include the U.S. Navy, in the wake of diminished tensions between East and West. All of the above contributes to my research and teaching at NPS on aspects of European security and my research sponsored by OP-OOK.

THE WEST GERMAN ARMED FORCES UNTIL THE YEAR 2000: GERMAN SOLDIER AND GERMAN UNITY

Donald Abenheim, Assistant Professor of National Security Affairs
Sponsor: CNO Executive Panel (0P-OOK)
Funding: Direct

OBJECTIVE: The present research project seeks to uncover the effects of profound political and military change upon military institutions in a united Germany. The decline of East-West tensions and the unification of Germany in 1989-1990 have altered many key features of the European security system. The present study analyzes these events from the perspective of professional German soldiers.

SUMMARY: Never before in the European experience has one army rooted in a liberal, democratic state and international alliance, absorbed the soldiers of an army that was property of a communist party. This remarkable event began in the course of early-1990, and is now in full swing in early 1991. My present research, the first chapter of which was completed at the end of 1990 and emerged as a technical report and as a chapter in an edited volume in Germany, will treat the general development of German Unity and the German Soldier. On the basis of this work, I hope to prepare a manuscript, in which the first chapter examines the past of military professionalism in Germany, with special attention to the differences and similarities of the two former opposing armies.

The second chapter will analyze the process of decay and collapse in the East German army from 1985 until 1990. The third chapter takes up the process of reform in the East German army. The succeeding two chapters treat the planning, the execution and the challenges of melding the two sets of soldiers that extends into the present. Here the focus rests chiefly on the officer corps of a United German military and its self-image in a new world.

PUBLICATIONS: "Die geistig-politische Grundlegung der deutschen Streitkraefte," in Reservist der Bundeswehr, Harald Foge, ed. (Regensburg: Walhalla Verlag) forthcoming, 1991.

"German Soldier and German Unity," Technical Report, NPS, January 1991 (NPS-NS-91-004)

CONFERENCE PRESENTATIONS: "European Security and German Unity," Stanford University, October 1990; "Red Prussians into Citizens in Uniform," Hoover Institution, November 1990.

THESIS DIRECTED: Ross Dickerson, "Emergence of a European Superpower? : The Diplomacy and Strategy of German Unification,"

BASIC RESEARCH IN ASW STRATEGY

Jan S. Breemer, Assistant Professor of National Security Affairs
Sponsor: CNO Executive Panel (OP-OOK)
Funding: Direct

OBJECTIVE: Review the ASW experience in this century in order to isolate the technological and strategic variables that appear to dominate the conduct and outcome of campaign-level ASW. Findings and conclusions will be applied to a projection of future U.S. ASW requirements. The final report will be published in bookform.

SUMMARY: This is a 2-year research effort, scheduled for completion at the close of FY 1991. Progress so far has concentrated on an exhaustive review of key primary and secondary documentation pertaining to ASW decision-making during the two world wars. Findings are presently being recorded as part of a book manuscript with the tentative title, Defeating the Submarine: A Study of Antisubmarine Warfare Strategy.

CONFERENCE PRESENTATION: Jan S. Breemer, "ASW in the New Era of Risk," Fall meeting of the Undersea Warfare Systems Division of the American Defense Preparedness Association, NPS, 23 October 1990.

RESEARCH ON TRANSATLANTIC SECURITY

Jan S. Breemer, Assistant Professor of National Security Affairs
Sponsor: OP-60
Funding: Direct

OBJECTIVE: Provide relevant U.S. Navy audiences with current factual and interpretive information on NATO-European security and maritime developments that will assist Navy strategy planners in the timely anticipation and assessment of such developments and the preparation of appropriate planning.

SUMMARY: This is a long-term (5 year) research effort, initiated in FY 1991 at the behest of ADM Hogg, USN, head U.S. Military Delegation to the Military Committee, NATO, Brussels, Belgium. The actual research requires twice-annual conferences and discussions by the Principal Investigator with pertinent U.S.-NATO and NATO-European personnel. Findings and conclusions will be summarized in twice-annual briefing papers. Key issues that will be monitored are:

- NATO-European politics on naval arms control;
- NATO-European naval strategies, force planning, and roles and missions after CFE; and
- Evolving European concepts of maritime security after the Cold War.

PUBLICATIONS: (R) Jan S. Breemer, "The Soviet Navy's SSBN Bastions: Why Explanations Matter," Journal of the Royal United Services Institute for Defence Studies (London), Winter 1989.

(NR) Jan S. Breemer, "European Maritime Concept 2000-2010: Foundation for a European Maritime Pillar?" Naval Forces (London), March 1990.

(NR) Jan S. Breemer, "Why the U.S. Must Lead Europe," Monterey Herald, 31 May 1990.

CONFERENCE PRESENTATIONS: Jan S. Breemer, "West European Perceptions of Change in East Europe," San Jose State University, 5 March 1990. (Audience: approx. 30).

Jan S. Breemer, "NATO and the Geography of Naval Arms Control," Conference on Naval Arms Limitations and Maritime Security, Dalhousie University, N.S., Canada, 27 June 1990. (Audience: approx. 150).

Jan S. Breemer, "The Future of Soviet SSBN Strategy," Royal Naval College, Greenwich, London, U.K., 17 July 1990. (Audience: approx. 20).

Jan S. Breemer, "ASW in the New Era of Risk," Fall meeting of the Undersea Warfare Systems Division of the American Defense Preparedness Association, Monterey, CA, NPS, 23 October 1990.

THE U.S. NAVY AND THE MODERNIZATION AND INTEGRATION OF THE PORTUGUESE ARMED FORCES INTO NATO

Thomas C. Bruneau, Chairman & Professor of National Security Affairs
Sponsor: OP-614

OBJECTIVE: This project seeks to analyze the potential contribution of the Portuguese Armed Forces into NATO. This project builds on one I did in 1989 which resulted in a classified technical report which was apparently very useful for OP-614. Portugal is of particular importance to the U.S. Navy due to the bases in the Azores. I will conduct the research myself and write another classified technical report for OP-614. I am one of the few civilian employees of the Navy that knows anything about Portugal, and through this project will be able to keep current with developments there. Each year at least one student writes a thesis on Iberia, and I am either the advisor or second reader. In addition I give at least one lecture each year on Portugal in a course dealing with NATO.

BRAZIL-UNITED STATES NAVAL RELATIONS: OPPORTUNITIES AND OBSTACLES IN THE 1990s

Thomas C. Bruneau, Chair & Professor of National Security Affairs
Scott Tollefson, Adjunct Professor of National Security Affairs
Sponsor: OP-613

OBJECTIVE: Brazil is a semi-industrialized country with a very professional Navy and a large foreign trade in weapons. The overall relations between the U.S. and Brazil since the mid-1970s have at times been problematic. Brazil is now governed by a civilian regime, and the governments of both countries are attempting to improve relations, including in the defense area. The research on this project in Brazil is being conducted by Adjunct Professor Scott Tollefson. As PI, I defined the project, established the agenda, and will conduct interviews in Washington, DC. The result will be a classified technical report for OP-613. We are also organizing a panel, and presenting a paper on the topic, at the April conference of the Latin American Studies Association. Since Brazil is important for the U.S. Navy, and an arms exporter, many of our students do theses focusing on this country.

RELATIONSHIP OF WAR AT SEA TO WARFARE ASHORE

Thomas C. Bruneau, Chairman & Professor of National Security Affairs
Norm Channell, Adjunct Research Professor
Sponsor: OP-603

OBJECTIVE: This project supports the RAND Strategy Assessment System at the Naval Postgraduate School. The RSAS is being used to analyze the impact of executing maritime strategies in war and their relationship to warfare ashore. This year the work in the project will result in analytical studies and the improvement of the RSAS naval models. The output will be classified and unclassified technical reports. The RSAS is also utilized in other research projects based in this department. The RSAS is integrated into the Strategic Planning curriculum. All students are required to do two courses which introduce them to forecasting and the RSAS. They are also encouraged to use the system for their theses.

THE SOVIET NAVY IN A NEW MILITARY-POLITICAL ENVIRONMENT

R.N. Channell, Adjunct Research Professor of National Security Affairs
Mikhail Tsypkin (PI), Assistant Professor of National Security Affairs
Sponsor: Naval Security Group Support Activity

OBJECTIVE: This project covers the impact of political developments on Soviet naval posture, the evolution of Soviet military strategy and its impact on the Soviet Navy, the missions of the Soviet Navy, and the system of national security decision-making. The conclusions drawn from published Soviet sources are to be verified against the results obtained from utilization of the RAND Strategy Assessment System (RSAS) here at NPS. This research project provides the U.S. Navy with early insights into the current and future trends of the naval component of Soviet military strategy, achieved via analysis of relevant Soviet published sources and via sophisticated simulations.

SUMMARY: It is anticipated that several student thesis will be written covering this broad topic. RSAS use contributes to improvements in other course utilizing the RSAS (e.g., The NSA Lab course). I am designing and conducting RSAS runs for the project, and will collate, correlate and interpret the results, fold them into the draft report, and redirect the follow-on runs. I have conducted several sample runs and have briefed them to the sponsor. I anticipate that I will also be involved in the future in providing presentations, briefings, etc., to the sponsor.

RELATIONSHIP OF WAR AT SEA TO WARFARE ASHORE

R. N. Channell, Adjunct Research Professor
Department of National Security Affairs
Sponsor: Chief of Naval Operations (OP-60)

OBJECTIVE: This project attempts to analyze the relationship of war at sea to warfare ashore, using various analytic methods including the RAND Strategy Assessment System (RSAS). While the RSAS is well developed in the areas of nuclear warfare, and the air/ground battle on the central front, the naval models are still in the development stages. The RSAS part of this project consisted largely of reiterating previous naval requirements, and assisting RAND where possible with comments and evaluations of naval models. This research project was directly related to DOD and U.S. Navy activity. OPNAV (OP-O6) is the sponsor and has commented favorably on the results thus far.

SUMMARY: The project has contributed to courses in strategic planning, intelligence, and net assessment. My own contribution to this project is I operated the overall RSAS system, conducted several runs in support of the project, and provided comments, notes and presentation to RAND and the sponsor regarding the naval models. I also drafted the technical and equipment sections to the research proposal.

NUCLEAR ASSESSMENTS

R. N. Channell, Adjunct Research Assistant
Department of National Security Affairs
Sponsor: Defense Nuclear Agency

OBJECTIVE: This project provided analysis of topics dealing with strategic and theater nuclear matters. The RSAS was used to assist in the analysis of part of this effort. Relationship to DOD/DON. This research project was directly related to DOD and U.S. Navy activity in the nuclear warfare area.

SUMMARY: The project contributed to courses in strategic planning and net assessment. I operated the overall RSAS system, and conducted several runs in support of the project. In conducted indepth analysis of ground warfare on the central front using RSAS data bases and models, as part of a study of the changing political/military situation in Europe.

RECENT SOVIET NAVAL THOUGHT

Thomas C. Grassey, Associate Professor of National Security Affairs
Sponsor: Navy Direct Funding (OP-614)

OBJECTIVE: The goal of this project was to appraise The Navy: Its Role Prospects for Development, and Employment as a possibly suggestive document on Soviet naval thinking in response to the new military strategy being promulgated by Mikhail Gorbachev.

SUMMARY: The Navy: Its Role, Prospects for Development, and Employment seems to represent one voice in the uproar or glasnost arguing the case for the future need of a Soviet Navy. It is not authoritative - - but it is both suggestive and illuminating, if futuristic, about an important portion of Soviet military thinking.

STRATEGIC ANALYSIS AND THE UTILIZATION OF ANALYTICAL TOOLS IN SUPPORT OF POLICY ANALYSIS FOR THE NAVY OFFICE OF TECHNOLOGY TRANSFER AND SECURITY ASSISTANCE (NAVOTTSA)

Edward J. Laurance, Professor of National Security Affairs
Sponsor: NAVOTTSA
Funding: Direct

OBJECTIVE: The Principal Investigator will provide strategic assessments of the international arms transfer environment, focusing on the constraints and opportunities for the export of U.S. naval technology and weapons systems. Particular emphasis will be put on Japan and the potential for a West European defense market to emerge as a result of the Single Market 1992 Act of the European Economic Community.

PUBLICATIONS: A technical report, combining this and the previous research project, will be submitted in August 1991.

THE HASHEMITE CONNECTION: CURRENT ISSUES IN JORDANIAN-PALESTINE RELATIONS

Ralph H. Magnus, Associate Professor of National Security Affairs
John W. Amos II, Associate Professor National Security Affairs
Sponsor: Under Secretary of Defense (Policy)

OBJECTIVE: The objective of this project is to define and analyze the constant factors which, over time, have promoted both conflict and cooperation in the Jordanian-Palestinian relationship.

SUMMARY: In this reporting period the portion relating to Jordanian viewpoints was completed and delivered to the sponsor. It was delivered to the sponsor's end-user, the Israel/Jordan/Palestinian desk officer in the office of the Assistant Secretary of Defense for International Security Affairs. It was favorably received and was distributed in multiple copies to interested DoD, State and Intelligence officers, necessitating an additional printing of 50 copies to go with the original 25.

The Jordanian portion of the report was written by Ralph Magnus, the Palestinian portion to be written by John W. Amos II is scheduled for completion in February 1991.

The report discusses the basic orientations of the Hashemite dynasty towards the Palestinian issue and the Palestinian people. The major policy decisions since the current situation was created following the loss of the West Bank in 1967 demonstrate the application of these orientations to policy decisions. The three major policy decisions of the 1980s: the Hussein-Arafat agreement of 1985, the suspension of the agreement in 1986, and disengagement decision of 1988 are examined in detail. The current state of relations since the intifada are examined in relation to Jordan's views of the Palestinians of the occupied territories, the PLO and the Jordanian-Palestinians of the East Bank.

POST-JIHAD AFGHANISTAN: IDEOLOGY, STRUCTURE AND ORIENTATIONS

Ralph H. Magnus, Associate Professor of National Security Affairs
Sponsor: Under Secretary of Defense (Policy)
Funding: DoD, Reimbursable

OBJECTIVE: This project describes and evaluates the likely character, structure and policies of an independent post-war government in Afghanistan. The degree to which such a government established its authority and meets the needs of reconstruction, as well as its foreign policy orientations will have major consequences for the stability of the region and hence for United States national interests.

SUMMARY: In the current period research was completed and the final report was begun, with approximately one third of the technical report having been typed by the endo of the reporting period. The sections completed to date have dealt with an overall introduction to the issues, and evaluation of other studies to describe the traditionalist, revolutionary and functional approaches to the question. The issues completed to date include ethnicity and center-periphery relations. Issues now being completed are modernization/Islam and international issues. The major new developments, which must be taken into account, deal mainly with the international environment, including the developments in Soviet Central Asia, the victory of the Islamic Alliance in the Pakistan elections and the current war in the Persian Gulf. Fortunately, the international section has not yet been completed. The estimated date of completion of the entire technical report is February 1991.

PRESENTATIONS: "The Changing Soviet Role in Afghanistan," Third Annual United States Central Command Air Force (CENTAF) Symposium on Southwest Asia, Shaw AFB, SC, March 1, 1990.

"Soviet Military-Political Activities in Afghanistan Since the Geneva Accords," The Middle East Studies Association Annual Meeting, San Antonio, TX, November 23, 1990.

ISLAMIST VIEW OF THE UNITED STATES IN A POST-COLD WAR ENVIRONMENT

Ralph H. Magnus, Associate Professor of National Security Affairs
Sponsor: OP-61/PNT
Funding: Direct Funding

OBJECTIVE: This study will examine the international viewpoints of four of the leading Islamist movements: The Jamaat-i-Islami of Pakistan, the Saudi Wahhab is, the Egyptian Muslim Brethren and the Islamic Republic of Iran, with particular reference to their views of the United States. The working hypothesis to be tested is that the views of these movements are policy oriented, varying from issue to issue, and are not generalized opposition to the United States per se.

SUMMARY: This project was approved in the last quarter of 1990 for the 1990-92 period. To date a survey of NPS library holdings and indices has turned up a three page summary of articles and books. Surveys of newspapers and the Foreign Broadcast Information Service materials are now underway and research trip to Pakistan will be scheduled for the Spring Quarter.

PUBLICATIONS: None.

THESIS DIRECTED: None.

SEAPOWER AND THE ASIA-PACIFIC

E.A. Olsen, Professor of National Security Affairs
Sponsor: CNO OP-O6
Funding: Direct

SUMMARY: This project will assess the importance of seapower in the Pacific and the changing proportional roles of the U.S. Navy and other navies. It fortuitously coincided with the end of the cold war which is likely to make the report which results that much more relevant. The initial years research was spent on an analysis of the U.S. role in post-WWII seapower and its importance for Pacific stability. The remainder of the research period will integrate that analysis with an assessment of the growth (and potentials for growth) of indigenous centers of seapower, notably in Japan and India. Much of this analysis was utilized as the basis for NS 4690 seminar in the Winter of 1990 that focused on the fading Pacific cold war. The Technical Report will likely be very relevant to DOD/DON concerns in the Pacific.

DE-ESCALATORY CONFIDENCE-BUILDING MEASURES AND STRATEGIC ARMS REDUCTIONS

Paul Stockton, Assistant Professor of National Security Affairs
Sponsor: RAND Corporation

OBJECTIVE: Under auspices of RAND, contributed chapter to Back from the Brink: De-Escalation of Nuclear Crises (New York: St. Martin's Press, forthcoming). Chapter discusses problems and opportunities created by START for de-escalatory CBMs, such as withdrawing dispersed mobile ICBMs back to their garrison as a de-escalatory negotiating signal.

THE CONGRESSIONAL PERSPECTIVE ON RECIPROCAL UNILATERAL MEASURES

Paul Stockton, Assistant Professor of National Security Affairs
Sponsor: Stanford Center for International Security
And Arms Control

OBJECTIVE: As part of larger Stanford-sponsored study on reciprocal unilateral arms control measures, I wrote a paper (and delivered it at a Stanford conference on December 12, 1990) concerning the response of Congress to such measures.

GERMAN BATTLE STYLE IN ULTRA MOBILE, HIGH INTENSITY WAR: NORTH AFRICA 1941-42

Russel H.S. Stolfi, Professor of National Security Affairs
Sponsor: Marine Corps University, Marine Corps Combat Development Command, Quantico, VA 22134-5050

OBJECTIVE: To examine the original records of the German mobile divisions in the North African Desert in 1941-42, in order to extract the German command style of war in the desert and suggest application to Marine Corps operations in similar open, level terrain today.

SUMMARY: The investigator completed the research and final written study from April-June 1990. He concluded that the German Army conducted conventional war in the desert more effectively than any other in the twentieth century and presented the following reasons why. The German:

a. Emphasized the location of the leader in combat as far forward as possible.

b. Had as the most important characteristic in their style the continuous, 24-hr/day formation of ad hoc, decentralized battle groups.

c. Formed logistics battle groups to ensure adequate protection of the mobile supply columns necessary in desert war.

d. Used every weapon possible in the antitank role and moved antitank guns in and among advancing friendly tank forces.

e. Discovered that approximately 40 percent of their tank losses came through overrunning and loss of retrieved tanks through inadequation protection of the retrieval units. The study recommended that the Marine Corps test the application of the above reasons for German success in the desert to Marine Corps operations today. The completed study was the second in a series dealing with the application of German command style to U.S. ground forces operations today.

PUBLICATIONS: The research project resulted in the publications of a 108 page study accepted and widely circulated by the Marine Corps University. The University plans to publish the study as a document that would be cited as follows:

The Marine Corps University Papers, Number 2, Russel H.S. Stolfi, German Battle Style in Ultra Mobile, High Intensity War: North African Desert 1941-42. (Quantico, VA: The Marine Corps University, 1991).

CONFERENCE PRESENTATIONS: Invited two-day seminar on the subject of desert war presented at the Marine Corps Combat Development Command, Quantico, VA on 5,6 September 1990.

The Commandant of the Marine Corps personally directed the placing of Professor Stolfi on active duty as a Colonel, USMCR, to present the results of the study to units of the 1st Marine Expeditionary Force in Saudi Arabia. The investigator led a team of four officers into "the field" in the period 12-31 October 1990, as part of which he presented the results of his study on desert war to 16 units of the Marine Corps deployed in the Eastern Province, Kingdom of Saudi Arabia and Bahrain.

THESES DIRECTED: None at present.

PATENT APPLICATIONS: Not really applicable.

OTHER: The success of the present research has led the Marine Corps Combat Development Command to approve a similarly styled project entitled, "Tailoring the Marine Division for Combat Against a Strong Armored Enemy: Battle Fighting Lessons from the Germans in World War II," for the period April-June 1991.

BRAZIL, THE UNITED STATES, AND THE MISSILE TECHNOLOGY CONTROL REGIME

Scott D. Tollefson, Assistant Professor of National Security Affairs

Sponsor: Direct Funding

OBJECTIVE: The purpose of my research project was to assess Brazil's missile and nuclear capabilities and to analyze their implications for regional and hemispheric security, especially as they relate to U.S. interests.

SUMMARY: The research analyzes Brazil's development of ballistic missiles in light of U.S. pressures to stifle that development. The first section of the technical report describes and critiques the Missile Technology Control Regime (MTCR); the second analyzes the U.S. application of MTCR guidelines toward Brazil; the third assesses Brazil's ballistic missile capabilities; and the fourth considers Brazil's response. The report concludes that the U.S. policy of restricting space and missile technology to Brazil under the MTCR has succeeded in stalling Brazil's missile program, but has also: (1) further strained Brazilian security relations with the United States; (2) weakened U.S. influence over Brazil's rocket and missile programs; (3) strengthened Brazilian ties with European suppliers (especially France) of space and missile technology and; (5) intensified Brazilian negotiations with Iraq.

PUBLICATIONS: Scott D. Tollefson, "Brazil, the United States, and the Missile Technology Control Regime," NPS Technical Report, NPS-56-90-006, March 1990.

Scott D. Tollefson, "Brazil, the United States, and the Missile Technology Control Regime," NPS Technical Report, NPS-56-90 000, March 1990.

CONFERENCE PRESENTATION: Scott D. Tollefson, "Brazil, the United States, and the Missile Technology Control Regime: A Case Study of Brazilian Autonomy," Meeting of the Latin American Studies Association Conference, Miami, 5 December 1989.

THESIS DIRECTED: Richard A. Holzknecht, Lieutenant, USN, "Ballistic Missile Proliferation in the Third World: The Threat to U.S. Naval Operations," Master Thesis, September 1990.

OTHER: The investigator has updated the study and is preparing a monograph-length manuscript for publication on the results of the project. Completion is expected in mid-1991.

BRAZIL-UNITED STATES NAVAL RELATIONS: OPPORTUNITIES AND OBSTACLES IN THE 1990s

Scott D. Tollefson, Adjunct Professor of National Security Affairs
Sponsor: OP-613

OBJECTIVE: The purpose of this research is to focus on the naval dimension of the U.S.-defense relationship and to identify those areas where obstacles can be overcome and opportunities exploited.

SUMMARY: It looks at how seemingly peripheral issues affect, or could affect, the naval dimension of the U.S.-Brazilian security relationship. The study concludes with a set of recommendations for the U.S. Navy, taking into consideration broader regional interests and commitments.

PUBLICATIONS: Report to be submitted to OP-613 in mid-1991.

CONFERENCE PRESENTATION: Co-organized panel, "Brazilian-U.S. Security Relations in the 1990s," for Latin American Studies Association, Crystal City, VA, 4-6 April 1991.

THESIS DIRECTED: Harold H. Collins, LCDR, USN, "The United States and Brazil: A Naval Partnership for the Twenty-FIRST Century?" Master Thesis, March 1991.

Robert F. Oakenell, Lieutenant, USN, "Brazilian Nuclear Submarine Construction: A Paradigm for Capability Assessment," Master Thesis, March 1991.

RELATIONSHIP OF WAR AT SEA TO WARFARE ASHORE

James J. Tritten, Associate Professor of National Security Affairs
Sponsor: Office of the Chief of Naval Operations (OP-603)

OBJECTIVE: Use of RAND Strategy Assessment System (RSAS) to analyze the impact of execution of maritime strategy on land campaigns in Europe. Multi-year project.

SUMMARY: Primary emphasis has been on analyzing and providing an evaluation of the naval models in the RSAS to OPNAV, RAND, and OSD/NA. The research team has become familiar with how to operate the RSAS and has installed sufficient components to permit analysis and limited gaming in support of teaching. Assistance has been provided to the Naval War College and other new RSAS users.

PUBLICATIONS: J.J. Tritten, "Strategic Antisubmarine Warfare and Naval Strategy," U.S. Naval Institute Proceedings, Vol. 113, No. 12, December, 1987, pp. 16-18.

P.M. Swartz, "The Maritime Strategy Debates: A Guide to the Renaissance of U.S. Naval Strategic Thinking in the 1980's," NPS 56-88-009, February 1988, 90 pp.

J.J. Tritten, "Withholding and Attacking SSBNs," NPS 56-88-004, February 1988, 21 pp.

J.J. Tritten and R.N. Channell, "The RAND Strategy Assessment System at the Naval Postgraduate School," NPS 56-88-010, March 1988, 65 pp.

J.J. Tritten, "Withholding and Attacking SSBNs," Naval Forces, Vol IX, No. II/1988, pp. 44-51.

J.J. Tritten and R.N. Channell, "the RAND Strategy Assessment System at the Naval Postgraduate School," Proceedings of the 56th MORSS, June 1988, pp. 29-44.

J.J. Tritten, "Scenarios of Nuclear Escalation Dominance and Vulnerability," NPS 56-88-013, June 1988, 38 pp.

J.J. Tritten, "Is Naval Warfare Unique?" NPS 56-88-018, August 1988, 29 pp.

J.J. Tritten, "A Soviet View of U.S. National Security Strategy," NPS 56-88-019, August 1988, 8 pp.

R.N. Channell, "Problems in Modeling Navies, NPS 56-88-022, September 1988, 31 pp.

J.J. Tritten, "A Soviet View of U.S. National Security Strategy," NPS 56-88-019, August 1988, 8 pp.

R.N. Channell, "Problem in Modeling Navies," NPS 56-88-022, September 1988, 31 pp.

R.N. Channell, "Naval Model Priorities for the RAND Strategy Assessment System," NPS 56-88-023, September 1988, 12 pp.

A.D. Capron, "Tomahawk and SSGNs - Time to Re-Think the Option?" NPS 56-88-27, September 1988, 17 pp.

R.H.S. Stolfi, "Soviet Naval Operational Art: The Soviet Approach to Naval War Fighting," NPS 56-88-015, September 1988, 165 pp.

J.J. Tritten, "Withholding and Attacking SSBNs" Proceedings of the Fourteenth DARPA Strategic Systems Symposium (U) October 24-27, 1988, DARPA/TIO-89-01, pp. 411-436.

J.J. Tritten, "Modern Sea Power," by Geoffrey Till, U.S. Naval Institute Proceedings Vol. 114, No. 12, December 1988, pp. 142 (book review).

J.J. Tritten, "Strategic Antisubmarine Warfare," The Submarine Review, January 1989, pp. 40-48.

J.J. Tritten, "Back to Basics: Maham for the 1990s," NPS 56-89-003, February 1989, pp 23.

P.T. Fennell, "U.S. Navy Strategy: Offensive Strike or Escort?" NPS 56-89-006, February 1989, pp. 19.

J.J. Tritten, "Naval Arms Control: An Idea Whose Time Has Yet to Come," NPS 56-89-015, August 1989, pp. 23.

J.F.P. Brahtz, "Modularized Ocean Basing System - A United States Option in a Strategy of Discriminate Deterrence (Circa 2000)," R-928, Naval Civil Engineering Laboratory Technical Report, November 1989, pp. 101.

J.J. Tritten, "Is Naval Warfare Unique?" The Journal of Strategic Studies, Vol. 12, No. 4, December 1989, pp. 494-507.

J.J. Tritten, "Naval Arms Control: A Poor Choice

of Words and an Idea Whose Time Has yet to Come," NPS 56-90-012, July 1990, pp. 63.

J.J. Tritten, "Scenarios of Nuclear-Escalation Dominance and Vulnerability," in Superpower Maritime Strategy in the Pacific, Frank C. Langdon & Douglas A. Ross, Eds., London & New York: Routledge Press, 1990, pp. 109-130.

J.J. Tritten, "Thinking RED in War Games," Phalanx, Vol. 23, No. 4, December 1990, pp. 27-28.

J.J. Tritten, "Naval Arms Control: An Idea Whose Time Has Yet to Come," U.S. Naval Institute Proceedings (accepted for publication).

J.J. Tritten "Naval Arms Control: A Poor Choice of Words and an Idea Whose Time Has Yet to Come," in yet untitled book sponsored by Dalhousie University, (forthcoming).

F.M. Teti, "The Relationship of War at Sea to Warfare Ashore" (forthcoming).

CONFERENCE PRESENTATIONS: J.J. Tritten, "Withholding and Attacking SSBNs," presented to faculty and students at UC Santa Cruz and University of Miami, March 1988.

J.J. Tritten, "Scenarios of Nuclear Escalation Dominance and Vulnerability," presented to the Maritime Security and Arms Control in the Pacific Region conference at the University of British Columbia, May 1988.

J.J. Tritten and R.N. Channell, "The RAND Strategy Assessment System at the Naval Postgraduate School," presented at the 56th Military Operations Research Society (MORS) Symposium, at the Naval Postgraduate School, Monterey, California, June 1988.

J.J. Tritten, "Is Naval Warfare Unique?" presented to the Thinking RED in Wargaming workshop at the National Defense University, Washington, D.C., June 1988.

R.H.S. Stolfi, "Soviet Naval Operational Art: The Soviet Approach to Naval War Fighting," presented to the Thinking RED in Wargaming workshop at the National Defense University, Washington, D.C., June 1988.

R.N. Channell, "Naval Model Priorities for the RAND Strategy Assessment System," presented to the Thinking RED in Wargaming workshop at the National Defense University, Washington, D.C., June 1988.

J.J. Tritten, "Is Naval Warfare Unique?" presented at the 56th Military Operations Research Society (MORS) Symposium at the Naval Postgraduate School, Monterey, CA, June 1988.

J.J. Tritten, "Withholding and Attacking SSBNs," presented at the 14th Defense Advanced Research Projects Agency (DARPA) Strategic Systems Symposium, Naval Postgraduate School, Monterey, CA, October 1988.

J.J. Tritten, "Is Naval Warfare Unique?" presented to the MITRE Corporation, McLean, VA, October 1988.

R.H.S. Stolfi, "Soviet Naval Operational Art: The Soviet Approach to Naval War Fighting," presented to the MITRE Corporation, McLean, VA, October 1988.

J.J. Tritten, "Naval Arms Control," presented to National Security Studies Program at California State University, San Bernardino, CA, April 1989.

J.J. Tritten, "Naval Arms Control," presented to the National Defense University Strategic Concepts Development Center, Washington, D.C., April 1989.

J.J. Tritten, "Naval Arms Control: An Idea Whose Time Has Yet to Come," presented to the Atlantic Council NATO Youth Exchange Program, Naval Station Treasure Island, San Francisco, CA, September 1989.

J.J. Tritten, "Naval Arms Control: An Idea Whose Time Has Yet to Come," Science Applications International Corporation (SAIC) Arms Control Seminar - a part of the Crisis Stability and the Offense/Defense Relationship Project, sponsored by the Arms Control and Disarmament Agency (ACDA), the Strategic Defense Initiative Organization (SDIO), the Defense Nuclear Agency (DNA), the Department of Energy (DOE), and the Office of the Assistant Secretary of Defense for International Security Policy, McLean, VA, January 1990.

J.J. Tritten, "Naval Arms Control: A Poor Choice of Words and An Idea Whose Time Has Yet to Come," Naval Arms Limitation and Maritime Security Conference, Dalhousie University, Halifax, N.S., June 1990.

J.J. Tritten, "Neither Confirm Nor Deny," Naval

Arms Limitation and Maritime Security Conference, Dalhousie University, Halifax, N.S., June 1990 (excerpts broadcast on Canadian television and radio and the subject of multiple newspaper reports).
J.J. Tritten, "Naval Arms Control: A Poor Choice of Words and An Idea Whose Time Has Yet to Come," CNO Center for Naval Analyses Strategic Policy Analysis Group (SPAG), Monterey, CA, July 1990.

THESES DIRECTED: D. Ricker, "The Nuclear Depth Bomb: Nemesis or Solution? (U)," Master's Thesis, June 1988.

K. Brown, "Canadian SSNs and Their Employment," Master's Thesis, September 1988.

L.D. Marquet, "The Strategic Employment of the Soviet Submarine Force," Master's Thesis, December 1988.

M.K. Johnnston, "The Political Utility of Nuclear Weapons in Nuclear War Termination," Master's Thesis, June 1989.

B.A. Ditzler, "Naval Diplomacy Beneath with Waves: A Study of the Coercive Use of Submarines Short of War," Master's Thesis, December 1989.

P.W. Siegrist, "SDI and the U.S. Maritime Strategy: The Impact of Advancing Technology on the Employment of Navies (U)," Master's Thesis, March 1990.

M.J. Salvato, "The Soviet Pacific Threat: Prospects for Change (U)," Master's Thesis, March 1990.

S.D. Kennedy, "Sea Launched Cruise Missiles: Their Role as a Strategic and Theater Force Integrator (U)," Master's Thesis, March 1990.

NUCLEAR ASSESSMENTS

James J. Tritten, Associate Professor of National Security Affairs
Sponsor: Defense Nuclear Agency

OBJECTIVE: Use of RAND Strategy Assessment System (RSAS) to analyze role of strategic nuclear forces including impact of INF Treaty and SDI on strategy. Multi-year project.

SUMMARY: Work is in four main areas; the implication of the new INF Treaty on NATO, the U.S., and naval strategy; the integration of theater and strategic nuclear forces; SDI and strategy; and the role of the nuclear reserve force.

PUBLICATIONS: S.A. Garrett, "NATO Deterrence and Defense After the INF Treaty," NPS 56-89-010, June 1989, pp. 110.

J.J. Tritten and R.N. Channell, "The RAND Assessment System at the Naval Postgraduate School," NPS 56-89-011, June 1989, pp. 75.

K.M. Kartchner, "Issues and Options for Post-START Secure Reserve Forces (U)," NPS 56-89-001-PR, July 1989, pp. 35.

K.M. Kartchner, "Summary of National Policy Guidance for Secure Reserve Forces (U)," NPS 56-89-013-PR. August 1989, pp. 16.

D.L. Bradford, "On-site Inspection as an Enhancement to Verification," NPS 56-89-014, August 1989, pp.53.

P.L. Hays, "SDI and Strategy," NPS 56-89-021, December 1989, pp. 46.

J.J. Tritten and E.M. Alvarez, Eds., "A Strategic Force Structure and Net Assessment for a 1995 Post-START Environment (U)," NPS 56-90-002, March 1990, pp. 82.

R.T. Ackley, "Trident SSBNs in START," NPS 56-90-008, April 1990, pp. 18.

J.J. Tritten, "War Termination: The Maritime Component," NPS 56-90-009, May 1990, pp. 68.

J.J. Tritten, "Naval Arms Control: A Poor Choice of Words and an Idea Whose Time Has Yet to Come," NPS 56-90-012, July 1990, pp. 63.

P. Shemella, "Sheltering the Genie: The Low Intensity Conflict Threat to Nuclear Systems," NPS 56-90-013, August 1990, pp. 35.

J.J. Tritten, Ed., "A Conventional and Nuclear Force Structure and Net Assessment for a 1995 Post-CFE II Environment (U)," Ed. NPS 56-90-014, September 1990, pp. 169.

E.M. Alvarez, "Strategic Nuclear Planning with Gaming Assistance (U)," NPS 56-90-003, September 1990, pp. 79.

A.D. Capron, "Sea Launched Cruise Missiles in the Post-INF Environment" (U), NPS-56-90-016, September 1990, pp. 59.

J.J. Tritten, "War Termination: The Maritime Component," The Journal of Soviet Military Studies, Vol. 4, No. 1, March 1991, (forthcoming).

J.J. Tritten, "War Termination: The Maritime Component," in yet untitled book, Stephen J. Cimbala & Sidney Waldman, Eds., Greenwood Press, (forthcoming).

J.J. Tritten, "Naval Arms Control: An Idea Whose Time Has Yet to Come," U.S. Naval Institute Proceedings (accepted for publication).

CONFERENCE PRESENTATION: J.J. Tritten and R.N. Channell, "The RAND Strategy Assessment System at the Naval Postgraduate School," presented
at the Naval Postgraduate School," presented at the Joint National Meeting of the Operations Research Society of American (ORSA) and The Institute of Management Sciences (TIMS), Vancouver, B itish Columbia, May 1989.

J.J. Tritten, "Naval Arms Control," presented to National Security Studies Program at California State University, San Bernardino, CA, April 1989.

J.J. Tritten, "Naval Arms Control," presented to the National Defense University Strategic Concepts Development Center, Washington, D.C., April 1989.

J.J. Tritten, "Naval Arms Control: An Idea Whose Time Has Yet to Come," presented to Atlantic Council NATO Youth Exchange Program, Naval Station Treasure Island, San Francisco, CA, September 1989.

J.J. Tritten, "Naval Arms Control: An Idea Whose Time Has Yet to Come," Science Applications

International Corporation (SAIC) Arms Control Seminar - a part of the Crisis Stability and the Offense/Defense Relationship Project, sponsored by the Arms Control and Disarmament Agency (ACDA), the Strategic Defense Initiative Organization (SDIO), the Defense Nuclear Agency (DNA), the Department of Energy (DOE), and the Office of the Assistant Secretary of Defense for International Security Policy, McLean, VA, January 1990.

J.J. Tritten, "War Termination: The Maritime Component," Bi-College Peace Studies Program of Haverford and Bryn Mawr Colleges, Haverford, PA, April 1990.

J.J. Tritten, "Scenarios, Simulations and Games" 31st Annual International Studies Association Convention, Washington, D.C., April 1990.

R.N. Channell, "The RAND Strategy Assessment System (RSAS) at the Naval Postgraduate School," 31st Annual International Studies Association Convention, Washington, D.C., April 1990.

E.M. Alvarez, "Strategic Nuclear Planning with Gaming Assistance," 31st Annual International Studies Association Convention, Washington, D.C., April 1990.

J.J. Tritten, "Scenarios, Simulations and Games" 58th Military Operations Research Society (MORS) Symposium at the U.S. Naval Academy, Annapolis, MD, June 1990.

E.M. Alvarez, "Strategic Nuclear Planning with Gaming Assistance (U)," 58th Military Operations Research Society (MORS) Symposium, at the U.S. Naval Academy, Annapolis, MD, June 1990.

J.J. Tritten, "Naval Arms Control: A Poor Choice of Words and An Idea Whose Time Has Yet to Come," Naval Arms Limitation and Maritime Security Conference, Dalhousie University, Halifax, N.S., June 1990.

J.J. Tritten, "Naval Arms Control: A Poor Choice of Words and An Idea Whose Time Has Yet to Come," CNO Center for Naval Analyses Strategic Policy Analysis Group (SPAG), Monterey, CA, July 1990.

THESES DIRECTED: A.D. Capron, "Sea Launched Cruise Missiles in the Post-INF Environment" (U), Master's Thesis, March 1988.

D. Mitchell, "Strategic Nuclear Options for a Degraded Triad (U), " Master's Thesis, December 1988.

J.G. Rivenburg, "Implications of Nuclear Free Zones in the International System," Master's Thesis, December 1988.

C.K. Reece, "The RAND Strategy Assessment System as a Decision Support System for Nuclear Command, Control, and Communications Net Assessment," Master's Thesis, March 1989.

R.K. Myers, "Political and Technical Verification Issues of Limitations On Sea-Launched Cruise Missiles," Master's Thesis, March 1989.

M.K. Johnston, "The Political Utility of Nuclear Weapons in Nuclear War Termination," Master's Thesis, June 1989.

J.A. Greene, "The Nuclear Threat to the Carrier Battle Force: The Problem and the Alternatives," Master's Thesis, June 1989.

D.A. Leary, "Optimizing the Post-START U.S. Strategic Nuclear Force Mix," Master's Thesis, June 1989.

D.C. Hulse, "Putting TLLAM to Work for the U.S. Navy: Moving From Concept to Fleet Asset (U)," Master's Thesis, December 1989.

J.R. Anderson, "Alternative Futures in U.S. Nuclear Strategy," Master's Thesis, December 1989.

P.W. Siegristi, "SDI and the U.S. Maritime Strategy: The Impact of Advancing Technology on the Employment of Navies (U)," Master's Thesis, March 1990.

M.J. Salvato, "The Soviet Pacific Threat: Prospects for Change (U)," Master's Thesis, March 1990.

S.D. Kennedy, "Sea Launched Cruise Missiles: Their Role as a Strategic and Theater Force Integrator (U)," Master's Thesis, March 1990.
R.S. Voter, "Holding the SS-24 and SS-25 at Risk Using Submarine Launched Ballistic Missiles (U)," Master's Thesis, March 1990.

C. Lumsden, "The Nordic Nuclear Free Zone Proposal," Master's Thesis, June 1990.

T.D. Klepper, "Triad or Dyad for the 1990's: A Balance of Reality," Master's Thesis, June 1990.

C.C. Swicker, "Countering Nascent Nuclear Capability with Conventional SLOM: Intelligence Requirements," Master's Thesis, September 1990.

P.J. Kolbas, "The Trends Towards Minimum Deterrence and the Effects and Implications for U.S. Nuclear Strategy," Master's Thesis, expected completion June 1991.

STRATEGIC MANAGEMENT FOR THE DEFENSE DEPARTMENT

James J. Tritten, Associate Professor of National Security Affairs
Sponsor: Director Net Assessment (OSD/NA), OSD/Competitive Strategies Office, Office of the Under Secretary of Defense - Acquisitions/Directorate for Program Integration, Strategic Planning Branch, and Director of Defense Policy on the National Security Council (NSC) Staff

OBJECTIVE: Historical and current research and analysis in the area of strategic management for the DoD. Examination of DoD philosophy and mission, to establish long and short-range objectives for the DoD, strategies to be used in achieving those objectives; and strategic implementation with the goal to develop an organizational strategy, create functional activities necessary to support the strategy, and design control systems to monitor the effectiveness of the strategy in achieving DoD objectives. Multi-year project.

SUMMARY: Investigators have visited businesses and government agencies that have strategic planning staffs and programs, interviewed civilian and military personnel connected with the varying aspects of strategic management within DoD, and obtained the cooperation of industrial leaders in the project. They have revised two graduate seminars in strategic planning and strategic management for the National Security and Administrative Sciences Departments and routinely offer these revised courses. They were instrumental in a thorough over haul of the National Security Affairs Strategic Planning Curriculum. They have developed initial historical cases for use in these courses.

PUBLICATIONS: J.J. Tritten, "Creating Strategic Vision," by P.M. Smith, J.P. Allen, J.H. Stewart, and F.D. Whitehouse, The Friday Review of Defense Literature, No. 88-17, 6 May 1988, pp. 4 (book review).

J.J. Tritten, "Creating Strategic Vision," by P.M. Smith, J.P. Allen, J.H. XLI, No. 3, Summary 1988, pp. 139-141 (book review).

J.J. Tritten and N.C. Roberts, "Strategic Management for the Defense Department," NPS-56-88-030PR, September 1988, pp. 144.

J.J. Tritten and N.C. Roberts, Eds., "Student Reports in Strategic Planning," NPS 56-88-031PR, September 1988, pp. 301.

J.J. Tritten, "Defending America's Security," by Frederick Hartmann and Robert Wendzel, The Friday Review of Defense Literature, No. 88-38, 28 October 1988, pp. 4-5 (book review).

N.C. Roberts and P.J. King, "Policy Entrepreneurs: Catalysts for Innovative Public Policy," Best Paper Proceedings, Frank Hay, Ed., Academy of Management, pp. 313-317.

N.C. Roberts and P.J. King, "The Stakeholder Audit Goes Public," Organizational Dynamics, Winter 1989, pp. 63-79.

J.J. Tritten and N.C. Roberts, "Strategic Management or Strategic Planning for Defense?" NPS-56-89-002, February 1989, pp. 34.

D.G. Wegmann, "Net Technical Assessment" NPS 56-89-008, March 1989, pp. 47.

R.T. Bradley and N.C. Roberts, "Network Structure From Relational Data: Measurement and Inference in Four Operational Models," Social Networks, Vol 11, No. 2, 1989, pp. 89-134.

N.C. Roberts and P.J. King, "The Process of Public Policy Innovation," Research on the Management of Innovation, Andrew Van de Ven, Harold L. Angle, and Marshall Poole, Eds., New York, New York: Harper & Row, 1989, pp. 303-335.

R.T. Bradley and N.C. Roberts, "Relationship Dynamics of Charismatic Organization: The Complementarily of Love and Power," World Futures, Vol. 27, pp. 1-37.

J.M. Kenny, "The Dibb Report: Three Years

After," NPS-56-89-016, August 1989, pp. 70.

J.J. Tritten, Ed., "Case Studies in Strategic Planning," NPS-56-90-005, March 1990, pp. 142.

J.J. Tritten, Ed., "A Conventional and Nuclear Force Structure and Net Assessment for a 1995 Post-CFE II Environment (U)," Ed. NPS-56-90-014, September 1990, pp. 169.

J.J. Tritten, Ed., "Student Reports in Soviet Military Doctrine and Strategy," Ed., NPS 56-90-015, September 1990, pp. 169.

J.J. Tritten, Ed., "A Conventional and Nuclear Force Structure and Net Assessment for a 1995 Post-CFE II Environment (U)," Ed. NPS-56-90-014, September 1990, pp. 169.

J.J. Tritten, Ed., "Student Reports in Soviet Military Doctrine and Strategy," Ed., NPS-5690-015, September 1990, pp. 169.

J.J. Tritten, "America Promises to Come Back: A New National Strategy," NPS NS-91-003, December 1990, pp. 78.

CONFERENCE PRESENTATIONS: N.C. Roberts & P.J. King, "Policy Entrepreneurs: Catalysts for Innovative Public Policy," Academy of Management, Anaheim, CA, August 1988.

J.J. Tritten and N.C. Roberts, "Strategic Management for the Defense Department," Annual Meetings of the National Defense Executive Reserve in Chicago, IL, Monterey, CA, Atlanta, GA, and Washington, D.C., September 1988.

N.C. Roberts and P.J. King, "Public Entrepreneurship: A Typology," Academy of Management, Washington, D.C. August 1989.

N.C. Roberts, "Strategy-Making Process," Joint Staff (J-5) Strategy Division, Washington, D.C., August 1989.

J.J. Tritten, "Analysis of the Competitive Strategies Methodology," Master's Thesis presented by his advisor, 58th Military Operations Research Society (MORS) Symposium, at the U.S. Naval Academy, Annapolis, MD, June 1990.

J.J. Tritten, "America Promises to Come Back: A New National Strategy," What if Peace? A National Science & Technology Policy Conference Engineering Foundation and Aviation Week & Space Technology, Costa Mesa, CA, November 1990.

"America Promises to Come Back: A New National Strategy," at a meeting of the Military Operations Research Society (MORS) Board of Directors and Sponsors, McLean, VA, December 1990.

THESES DIRECTED: J.R. Hafey, "A Theory of Naval Strategic Planning," Master's Thesis., June 1988.

P.K. Siddons, "The RAND Strategy Assessment System: A New Perspective on Decision Support System," Master's Thesis, September 1988.

A.D. Konecny, "Net Assessment: An Examination of the Process and Recommendations for Practical Applications," Master's Thesis, December 1988.

R.D. Kropp, "JCS Planning: Assessment and Recommendations," Master's Thesis, September 1989.

N.L. Tanner & N.K.S. Young-Aranita, "Naval Postgraduate School: An Organizational Assessment," Master's Thesis, September 1989.

M.C. Vitale, "Analysis of the Competitive Strategies Methodology (U)," Master's Thesis, December 1989.

M.J. Leahey, "History of Defense Reform Since 1970," Master's Thesis, December 1989.

W.S. Jesson & T.L. Hilliker, "The Marine Corps Service Planning Process--The Continual Forging and Tempering of the Sword," Master's Thesis, December 1989.

D.J. Wilson, "A Comparative Analysis of Public and Private Section Graduate Programs in Public Policy," Master's Thesis, December 1989.

R.K. Knapper, "The United States Marine Corps Information Blockage A Case Study," Master's Thesis, December 1989.

E.S. Clark, "A Comparative Analysis of Intermediate Service College (ISC) Phase I Joint Professional Military Education (JPME)," Master's Thesis, March 1990.

G.H. Swain, "Understanding the Organizational Decision Process at the Theater Commander in Chief - Level of Command," Master's Thesis, March 1990.

J. Powell, "Prototype Development and Design: A Case Study," Master's Thesis, March 1990.

K.V. Adolphson, "The Fulcrum of Necessity: Strategic Planning Before Pearl Harbor," Master's Thesis, June 1990.

C.R. Graham, "Limited Objective Warfare: Components and Applications for the United States," Master's Thesis, expected completion June 1991.

GLASNOST' AND SECRECY IN THE SOVIET MILITARY

Mikhail Tsypkin, Assistant Professor of National Security Affairs
Sponsor: Office of the Secretary of Defense

OBJECTIVE: Establish the degree to which Gorbachev's glasnost (openness) has reduced the degree of genuine secrecy in the Soviet military and eliminated the danger of deception and no-compliance with arms control agreements.

SUMMARY: Glasnost' has eliminated the more absurd excesses of secrecy in Soviet military affairs, and has made the Soviet system of state secrecy more rational in the age of satellite intelligence. In the short term the Soviets are unlikely to conduct strategic deception operations, although their bureaucratic culture is so prone to deception that compliance with arms control agreements might be complicated. In the longer term, the political instability in the Soviet Union and the growing anti-Western sentiment in a nascent Russian nationalist movement are likely to reduce the degree of military glasnost.' This will make verification of Soviet compliance with arms control agreements more problematic.

PUBLICATIONS: Glasnost' and Secrecy in the Soviet Military, NPS Research Press, accepted for publication, December 1990.

CONFERENCE PRESENTATIONS: Mikhail Tsypkin, "Glasnost' and Secrecy in the Soviet Military," A Seminar at the Russian Research Center, Harvard University, Cambridge, MA, June 5, 1990.

Mikhail Tsypkin, "The Soviet Military in Crisis," Seminar Presentation, Centre d'etudes et de recherches internationales of the Fondation nationale des sciences politiques, Paris, France, April 23, 1990.

THESIS DIRECTED: None.

OTHER: Paper "The Soviet Military: Glasnost' Against Secrecy" submitted to several journals.

IMPACT OF GORBACHEV'S POLITICS ON SOVIET NAVY MISSIONS

Mikhail Tsypkin, Assistant Professor of National Security Affairs
Sponsor: NPS and Naval Security Group Support Activity

OBJECTIVE: The goals of this project was to investigate any possible change in the Soviet Navy mission priorities as a result of current political change in the USSR.

SUMMARY: The likely impact of current political change will be higher relative priority to the strategic offensive mission of the Soviet Navy. The strategic ASW is unlikely to acquire the preemptive character proposed in some recent Soviet statements. There are indications that SLOC interdiction might get a higher priority, although carious factors (the situation in Europe, the outcome of the Persian Gulf blockade) can affect the importance of this mission. The mission of destruction of enemy groupings of forces is likely to concentrate more on direct support for land operations at the expense of attempts to establish sea control. This mission of supporting national liberation and leftist regimes in the Third world seems to be practically eliminated by the decline of communist ideology and the wide unpopularity of aid to such regimes.

PUBLICATIONS: Impact of Gorbachev's Politics on Soviet Navy Missions, NPS Research Press, accepted for publication, December 1990.

CONFERENCE PRESENTATIONS: None.

THESIS DIRECTED: CAPT Kenneth Knotts, Mikhail Gorbachev's "New Thinking": Implications for Western Security.

OTHER: The investigator is seeking a publisher for a short monograph based on the research project.

NATIONAL STRATEGY IN THE ASIA-PACIFIC REGION: CRITICAL ISSUES FOR THE U.S. ARMY

David Winterford, Adjunct Professor of
National Security Affairs
Sponsor: Study Property Management Agency, Chief of the Staff,
U.S. Army

OBJECTIVE: The goal of this project is to bring together some of this nation's foremost civilian specialists on the Asia-Pacific and key Flag rank and other senior Army officers in order to examine the impact of this vital region on national strategy. This project addresses the compelling nature of the strategic changes in the Asia-Pacific in terms of their decisive influence on the evolving doctrine, strategy, policy, force structure and missions of the U.S. Army in the region.

SUMMARY: It is increasingly apparent that the Asia-Pacific region is rapidly assuming vital importance for the United States in terms of American security, economic, and political interests. It is in this region that: (a) the global and regional security issues are assuming proportions co-equal to the traditional Atlanticist focus of U.S. policy; (b) the most dynamic and intensive economic interactions involving the United States are currently taking place, heralding even closer economic links between the Asia-Pacific and the United States as the nation enters the 1990s and; (c) the United States is witnessing the troubling, halting and unsettling transition of several developing nations toward free political and economic arrangements co-existing with the continued rule by Marxist regimes in neighboring states.

In light of the challenges that each of these trends signify for the United States, this research project examines the impact of this crucial and sometimes volatile region on national strategy. In particular, it is imperative to address the compelling nature of the strategic changes in the Asia-Pacific area in terms of their decisive impact on the evolving doctrine, strategy, policy, force structure and missions of the U.S. Army in the region.

PUBLICATIONS: David Winterford, "Gorbachev's 'New Thinking' and Soviet Foreign Policy in Asia: Evolving Sino-Soviet Relations," In The Pacific Interest, edited by William Berberet and Ronald Loftus.

CONFERENCE PRESENTATIONS: David Winterford, "Political Consequences of Pacific Economic Power," presented at the conference on The Pacific Rim and American National Interests, MIIS, March, 1990.

David Winterford, "International Organizations in the Asia-Pacific: Promoting Cooperation or Conflict in the Pacific Rim?", presented at the Conference of the Learned Societies of Canada, Victoria, Canada, May 1990.

David Winterford, "U.S.-Southeast Asia Relations: Redefining the Agenda," presented at the 1990 ASPAC conference, Stanford University, June 1990.

THESES DIRECTED: Annette Haynes, Lt., USN, "Indian Naval Development: Power Projection in the Indian Ocean," Master's Thesis, December 1990.

Kenneth Harbin, Maj., USMC, "The Expanding Sino-Thai Military Relationship: Implications for U.S. Policy in Thailand," Master's Thesis, December 1990.

Tenise Pettigrew, Lt., USN, "Reintegrating Vietnam into Southeast Asia," Mater's Thesis, December 1990.

OTHER: (1) This project has been of direct relevance to two new courses that the investigator has developed and offered in the Far East program in the NSA Department; (2) The investigator is preparing a monograph length manuscript for publication on Toward New Strategic Cooperation in the Asia-Pacific: Security, Sovereignty and Economics.

STRUCTURAL FACTORS IN THE LONG-TERM COMPETITION

David S. Yost, Associate Professor of National Security Affairs
Sponsor: Under Secretary of Defense for Policy
and Director of Net Assessment
Funding: Under Secretary of Defense for Policy
and Director of Net Assessment Office of the
Secretary of Defense

OBJECTIVE: When the research began in 1986, the research monitor, the Director of Net Assessment in the Office of the Secretary of Defense, directed that the research effort focus on the analysis of security issues relating to Western Europe.

SUMMARY: The research involved analysis of primary sources dealing with European security problems, including West European views on topics such as the Conference on Security and Cooperation in Europe and possible Western responses to potential crisis in Eastern Europe and the Soviet Union. Special attention was devoted to France, Britain, and Germany, especially with respect to the future of NATO and nuclear deterrence in Europe as well as West European security cooperation.

PUBLICATIONS: D.S. Yost, "La France et la securite europeene: un point de vue americain," Defense Nationale, Vol. 45 (October 1989(, pp. 39-56.

D.S. Yost, "la dissuasion nucleaire en question?" Politique Etrangere, Vol. 55 (Summer 1990), pp. 389-407.

D.S. Yost, "France in the New Europe," Foreign Affairs, Vol. 69 (Winter 1990-1991), pp. 107-128.

D.S. Yost, "La France dans la nouvelle Europe," Politique Etrangere, Vol. 55 (Winter 1990-1991), pp. 887-901.

D.S. Yost, "Frankreich in einem neuen Umfeld," Europa-Archiv, No. 23 (10 December 1990), pp. 691-702.

D.S. Yost, "La prospettiva francese per la cooperazione di difesa europea occidentale," in Luigi Caligaris, ed., La Difesa Europea: Proposte e Sfide (Milano: Edizioni di Communita, 1990), pp. 110-134.

D.S. Yost, "Franco-German Defense Cooperation," in Stephen Szabo, ed., The Bundeswehr and Western Security (London: Macmillan and New York: St. Martin's Press, 1990), pp. 217-258.

CONFERENCE PRESENTATION: D.S. Yost, "Security Implications of 1992," American Foreign Service Club, Washington, DC, at the Conference on "The Future of NATO Security Planning" sponsored by Science Applications International Corporation, 16 January 1990.

THESES DIRECTED: D.W. Bates, LT, USN, "British and French Strategic Nuclear Force Modernization: Programs, Strategies, and Implications," Master Thesis, December 1989.

D.D. Gasper, CPT, USAF, "Soviet Strategic Air Defenses in Turbulence: A Comparative Analysis of the KAL 007 Shootdown and the Mathias Rust Flight to Red Square," Master Thesis, June 1990.

J.J. Ziegler III, CPT, USAF, "U.S.-Greek Security Relations and the 17 November Terrorist Threat," Master Thesis, June 1990.

DEPARTMENT OF OCEANOGRAPHY

DEPARTMENT OF OCEANOGRAPHY

Waves and Nearshore Processes

Professors E.B. Thornton, C.S. Wu, N. Dodd and L. Shemer are measuring and developing models of nearshore wave dynamics. Models have been developed to describe wave transformation and mean alongshore currents. Shear waves developed due to instability of the wave induced alongshore current are shown to be responsible for turbulent mixing in the nearshore. A field experiment, Delilah, was conducted in October. The technical sponsor for these studies is ONR.

Professor Zambresky continues to contribute to the development of spectral ocean wave models (SWOM). The technical sponsor is NPS.

Acoustical Oceanography

Professor C.S. Chiu and Professor A. Semtner are conducting simulation studies of cross-basin sound transmissions using output of the Semtner-Chervin global eddy-resolving ocean model. By interfacing an acoustic model with the ocean model output, the variability of acoustic rays emitted by a Heard Island sound source, cycling through the Southern and Pacific Oceans, and reaching the California coast was analyzed. This research is sponsored by ONR.

Professor R.H. Bourke continued studies of the ambient noise generated in Arctic ice-covered waters based on noise measurements acquired by drifting buoys and, as part of Project CEAREX, from hydrophones north of Svalbard. Additionally, under ice scattering as modeled by ICECAP was compared to measured transmission loss data. The sponsor is the Arctic Submarine Laboratory.

Professor C.-S. Chiu is studying the circulation of the Greenland Sea gyre using acoustic tomography data collected by WHOI and SIO in the Greenland Sea Project (GSP). To prepare for the inverse analysis of the real data, resolution and variance of maps obtained by the GSP tomographic array, and their sensitivity to the failure of two transceivers were simulated. This research is sponsored by WHOI.

Professor C.-S. Chiu is conducting a feasibility study of a Norwegian Continental shelf-Barents Sea acoustic tomography experiment. The accuracy of acoustic tomography in estimating advective heat flux in the Norwegian Sea was assessed. This research is sponsored by ONR.

Mesoscale and Coastal Oceanography

Professor S.R. Ramp has been a participant in two projects. He is completing the analysis and interpretation of hydrographic data which he collected for the "Coastal Transition Zone" project. Professor Ramp is currently making direct measurements of the currents on the shelf and slope off Point Sur using moored current meters. The technical sponsor for these studies is ONR.

Professor J.A. Nystuen has completed a study of sea ice classification using synthetic aperture radar. Professors Nystuen and Gascard are studying sea-ice data from SSM/I to detect strong ocean currents on the Yermak Plateau.

Professor R.H. Bourke and R.G. Paquette are involved in studies of water mass and mesoscale circulation associated with ice edges of the Atlantic and Pacific Oceans as well as studies of Arctic sea ice. Most recently, they have studied the characteristics of the Jan Mayen Current from two summertime cruises as part of the Greenland and Sea Project. Other on-going studies have examined the spatial and seasonal distribution of under ice roughness parameters and the accuracy of modelled ice drift trajectories. The Arctic Submarine Laboratory sponsors this research.

Professor C.A. Collins and Professor N. Garfield are studying the kinematics of the currents across the continental margin off Pt. Sur using velocity sounding techniques. The sponsor for this study is ONR. Professor Collins, Professor Garfield, and Professor Rosenfeld also collected data in the region to the west of the Farallones; this study was sponsored by the U.S. Geological Survey.

Professor Rosenfeld is studying the circulation of Monterey Bay using shipboard CTD and acoustic doppler current measurements and moored temperature and current measurements.

Professor Garfield is utilizing AVHRR data to assist in the analyses of different coastal phenomenon in the Central California region.

A conference on "Deep Convection" was held at NPS in March. Professor Pecheng Chu and Professor Gascard are editing a collection of papers from this conference.

Air-sea Interaction and Ocean Turbulence

Professor R.W. Garwood, Jr., and Professor P. Chu are sponsored by ONR and NSF to investigate the thermodynamic and dynamic coupling between the oceanic and atmospheric turbulent boundary layers. A new mechanism for feedback between the oceanic mixed layer and cloud formation in the tropics has been discovered and studied. Also, an entrainment model has been used to explain the deep penetration of turbulence into the equatorial undercurrent.

Professor E.B. Thornton demonstrated the feasibility of interferometric SAR (two doppler radars mounted on an airplane) to study the near surface velocity field (the velocity due to ocean currents, wind and capillary waves). The technical sponsor was ONR.

Professor J.A. Nystuen is developing techniques for monitoring air/sea interaction processes at sea through ambient sound measurements. He is continuing laboratory analysis of the small scale physics of sound production by raindrops. He is collecting field measurements of sound generated by heavy rain in the Gulf of Mexico. He is continuing efforts to develop an acoustic ocean drifting buoy to acoustically monitor the ocean in conjunction with satellite measurements. Drifting acoustic buoys have been deployed off the California coast. The technical sponsor is NOARL.

Professor Nystuen completed a study of the difference in satellite derived wind speed measurements from passive microwave (SSM/I) and altimeter (GEOSAT) satellite platforms. Professor Nystuen and Professor Garwood have completed a study of the formation of a rain-induced turbulent layer at the ocean surface. Professor Nystuen also developed a theory to explain how a rain induced turbulent surface layer will affect surface gravity waves. The technical sponsor is ONR.

Professor T.P. Stanton and Professor E.B. Thornton are studying the properties of velocity shears and density gradients in the upper ocean. A towed package and coherent and incoherent doppler velocimeters have been developed to measure finescale shear and turbulent microstructure. The sponsor is ONR.

Numerical Prediction and Data Assimilation

Under sponsorship of the NSF, Professor A.J. Semtner, Jr., completed a numerical simulation of global ocean circulation with mesoscale resolution. This calculation has established the feasibility of ocean prediction using modern large-scale computers. An analysis of the ocean general circulation of the model is underway.

Under sponsorship of ONR, through the "Coastal Transition zone" (CTZ) and Eastern Boundary Current (EBC) research initiatives, Professor M.L. Batteen has been using an eddy-resolving, primitive equation model to understand the role of wind forcing in eddy and jet formations in EBCs. The EBCs have expanded from the California Current system to the EBCs off Portugal and Chile. Under sponsorship of NSF, Professor Batteen has expanded her research efforts to include thermal as well as wind forcing in the EBC region off Western Australia.

Professor Carter began studies data assimilation into numerical ocean models. The sponsor for this work is NPS.

Mapping Charting and Geodesy

Professor J.R. Clynch is working on advanced techniques of high precision position location on moving

platforms using the Global Position Satellites. His work is sponsored by the Defense Mapping Agency.

Marine Operations

Commander F.M. Reynolds, USN, managed shipboard support for NPS at sea research projects off the Central California coast. Seventy-nine days of operations were carried out on the R/V Point Sur and an additional thirty-seven days at sea were supported on other research vessels including the USNS DeSteiguer and USNS Bartlett. 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.

MODELING STUDIES OF THE EASTERN BOUNDARY CURRENT FLOW OFF WESTERN AUSTRALIA

Mary L. Batteen, Associate Professor of Oceanography
Department of Oceanography
Sponsor: National Science Foundation

OBJECTIVE: The objectives of this project are to investigate (1) why the eastern boundary flow off Western Australia (W.A.) is generally poleward rather than equatorward, and (2) why mesoscale eddies are present in this region. To accomplish these goals, we propose to (1) adapt an existing primitive equation (PE) ocean model presently being used in the eastern boundary flow region off California to the eastern boundary flow region of W.A.; (2) incorporate different initial conditions appropriate for the W.A. region into the model and; (3) run a series of numerical model experiments using the different initial conditions. Analysis of the results from each experiment should determine under what conditions a poleward flow (called the Leeuwin Current) and/or mesoscale eddies are generated. The ultimate goal is to provide the physical understanding necessary for high resolution ocean prediction in this region.

SUMMARY: Different numerical model experiments in a regional primitive equation ocean model are being run to investigate the eastern boundary flow off W.A. Particular attention is being given to investigating: (1) why the flow is generally poleward rather than equatorward as in other eastern boundary currents and; (2) why there are mesoscale eddies present. The roles of thermal and wind forcing studies have been completed, while the study of seasonal wind and thermal forcing effects on the ocean circulation off W.A. is ongoing.

PUBLICATIONS: Batteen, M.L. and M.J. Rutherford, 1990: Modeling studies of eddies in the Leeuwin Current: The role of thermal forcing. Journal of Physical Oceanography,20,1484-1520.

Batteen, M.L. and M.J. Rutherford, 1989: A numerical modeling study of the Leeuwin Current eddy field. Trans. Am. Geophys. Union, 70, 1140.

Batteen, M.L. and M.J. Rutherford, 1989: Numerical studies of the Leeuwin Current. Research Activities in Atmospheric and Oceanic Modeling (George J. Boer, Editor). WMO/JSC Working Group on Numerical Experimentation, 12, 8.65.

CONFERENCE PRESENTATION: Batteen, M.L., "A numerical modeling study of Leeuwin Current eddy field, American Geophysical Union (AGU) Fall Meeting, San Francisco, California, 4-8 December, 1990.

THESIS DIRECTED: E.J. Bayler, LCDR, U.S. Navy, A Numerical Study of Seasonal Wind and Thermal Forcing Effects on the Ocean Circulation off Western Australia," Master's Thesis, September 1991.

WIND FORCING EFFECTS ON EDDIES AND JETS IN THE CCS

Mary L. Batteen, Associate Professor of Oceanography
Sponsor: Direct Funded, Office of Naval Research

OBJECTIVE: The objective of this project is to understand the role of wind forcing in eddy and jet formations in the CCS (California Current System). To accomplish these goals we proposed primitive equation (PE) model of the California Current, vary the type of wind forcing, and compare the results with observations. The ultimate goal is to provide the physical understanding necessary for high resolution ocean prediction in EBC regions.

SUMMARY: Wind forcing has been incorporated into the model development of including surface heating to prevent continuous heating nearshore when coastal upwelling occurs. The effects of wind forcing have been analyzed by varying the type of forcing. In particular, we have focussed on cases of steady/transient winds, with and without the curl, in a flat-bottom ocean. Preliminary results show the development of eddies and jets. Model improvements in these studies are to incorporate topography and finer horizontal and vertical resolution (to look at fronts).

MARGINAL SEA-ICE ZONE STUDIES 1990

Robert H. Bourke, Professor of Oceanography
Robert G. Paquette, Emeritus Professor of Oceanography
Sponsor: Arctic Submarine Laboratory

OBJECTIVE: Carry out physical oceanographic research, including field measurements, in the marginal sea-ice zone of the Bering, Chukchi, and Greenland Seas. This work has the long-term applied objective of facilitating the operation of submarines under ice. It is part of the continuing MIZPAC and MIZLANT programs.

SUMMARY: This is an ongoing program to study the oceanographic and acoustic phenomena associated with the ice edges of the Atlantic and Pacific Oceans. Measurements, primarily CTD lowerings, have been carried out from ice breakers since 1971 and include observations both in summer and winter. Data were obtained in September 1989 to monitor the water mass and flow characteristics of the Jan Mayen Current as part of the international Greenland Sea Project. The data were edited, analyzed and reported in a thesis and at several conferences. In August 1990, we returned to the area to repeat the survey to establish the nature of the interannual variability. The data are presently undergoing editing and analysis. We have completed the study of ambient noise in the Beaufort Sea and its relation to the summertime reversal of the Beaufort Gyre. Contrary to our expectations, the noise level remained high during these periods of ice divergence. A study was commenced to assess the accuracy of the ice motion forecasts generated by the Navy's PIPS model. Inaccuracies were noted under conditions of near calm winds and in direction of ice movement under high wind speeds. The analysis of under ice roughness parameters with application for under ice acoustic propagation was completed and the results reported.

PUBLICATIONS: A. S. McLaren, R. G. Barry and R. H. Bourke, "Could Arctic Ice be Thinning?", **Nature, 345 (6278)**, 762, 1990.

R. H. Bourke and A. S. McLaren, "Contour Mapping of Arctic Basin Ice Draft and Roughness Parameters,"submitted to **J. Geophys. Res.**

R. H. Bourke and R. G. Paquette, "Formation of Baffin Bay Bottom and Deep Water," in: **Deep Convection and Deep Water Formation**, ed. Gascard, J. C. and Chu, P. C., Elsevier, accepted for publication.

R. H. Bourke, R. F. Blythe and F. G. Paquette, "USNS BARTLETT Cruise to the Greenland Sea in September 1989 Data Report," NPS 68-90-006, July 1990.

CONFERENCE PRESENTATIONS: R. H. Bourke, R. F Blythe and F. G. Paquette, "The Jan Mayen Current and the Deep Waters of the Greenland Sea," Ocean Sciences Meeting of the Am. Geophys. Union, New Orleans, 12-16 February 1990.

R. H. Bourke and R. G. Paquette, "Formation of Baffin Bay Deep and Bottom Water," Deep Convection and Deep Water Formation Workshop, Monterey, 26-30 March 1990.

R. H. Bourke, R. H. Blythe and R. G. Paquette, "The Jan Mayen Current and the Deep Waters of the Greenland Sea," XV General Assembly of the European Geophysical Society, Copenhagen, 23-27 April 1990.

T. O. Manley, R. H. Bourke and K. L. Hunkins, "Upper-Layer Circulation of Northern Fram Strait," 22nd International Liege Colloquium, Belgium, May 1990.

A. S. McLaren, R. H. Bourke and R. L. Weaver, "Contour Mapping of Arctic Basin Ice Roughness Parameters," International Conference on the Role of the Polar Regions in Global Change, Fairbanks, 11-15 June 1990.

THESES DIRECTED: F. W. Garcia, LCDR, USN, "Sea Ice Classification Using Synthetic Aperture Radar," Master's thesis, June 1990.

M. D. Higgins, LT, USN, "Ambient Noise in the Arctic Ocean and Its Relation to the Summertime Reversal of the Beaufort Gyre," Master's thesis, March 1990.

R. L. Blythe, LT, USN, "The Jan Mayen Current and the Deep Waters of the Greenland Sea," Master's thesis, September 1990.

G. N. Lundeen, LT, USN, "A Comparison of Ice Drift Motion from Modeled and Buoy Data," Master's thesis, December 1990.

GREENLAND SEA PROJECT DATA ANALYSIS

Ching-Sang Chiu, Assistant Professor of Oceanography
Sponsor: Woods Hole Oceanographic Institution
Funding: Woods Hole Oceanographic Institution ($14K)

OBJECTIVE: The objectives of this project are: (1) to develop an inverse method integrating the various types of data obtained from the Greenland Sea Project (GSP), as well as dynamical constraints, for the construction of optimal ocean field estimates and; (2) to assist in the acoustic and oceanographic analysis of the Greenland Sea Project array data.

SUMMARY: An acoustic tomography array consisting of six transceiver moorings was jointly deployed by Woods Hole Oceanographic Institution and Scripps Institution of Oceanography in the Greenland Sea during the late summer to early fall of 1988. The array had a pentagonal geometry, with five transceiver moorings occupying each of the five corners plus one more in the middle of the pentagon. The diameter of the pentagon was 200 km. Supplementary to the acoustic observations, there were in situ temperature, salinity and current measurements made by other investigators using moored sensors and meters as well as surveying ships. Aircraft and satellites had also provided remote-sensing coverage of the area, measuring sea surface temperature, wind direction, and speed, periodically. The latter two products were also measured by shore and ship-based meteorological stations. The tomography array was recovered in the summer of 1989. The data are currently being processed, and will be available for detailed acoustic and oceanographic analyses in 1991. Two primary goals of this year-long experiment are to investigate the processes leading to the ventilation of the deep waters and to study the dynamics of the Greenland Sea Gyre. A three-dimensional inversion code was developed, specifically for application to the GSP tomography array data. To prepare for the analysis of the real data, the system performance of the GSP tomography array was simulated in a computer experiment. The resolution and variance of maps obtained by the GSP array was analyzed using the inversion code developed. In particular, the sensitivity of the ocean field estimate to uncertainty in the specification of the covariance of the ocean field, errors in the data, and failure of acoustic projectors and receivers were studied in detail. Furthermore, preliminary simulation studies on the use of Kalman filters to blend acoustic tomography observations with known ocean dynamics for improved ocean field estimates were performed. This investigation will be continued in 1991, the second year of this two-year project.

This research has direct naval impacts. The research of methods for data integration and assimilation into ocean dynamic models is essential for the development of ocean monitoring/prediction systems in support of naval operations.

An invited paper entitled "On the use of ocean dynamics to improve ocean acoustic tomography estimates" by Ching-Sang Chiu and James H. Miller in the upcoming Baltimore meeting of the Acoustical Society of America is a direct academic contribution of this project.

COMPUTER SIMULATION STUDIES OF LOW-FREQUENCY CROSS-BASIN ACOUSTIC TRANSMISSIONS

Ching-Sang Chiu, Assistant Professor of Oceanography
Albert J. Semtner, Professor of Oceanography
Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVES: Munk and Forbes (1989) have suggested that climate induced changes in ocean temperature may be monitored by decadal measurements of cross-basin acoustic travel time variability. The feasibility of such a monitoring system depends on the variability and stability of the cross-basin acoustic paths and the associated arrivals in the presence of a wide spectrum of ocean variability. Using a gridded set of temperature and salinity data generated by the Semtner-Chervin Eddy Resolving Global Ocean General Circulation Model, our task is to realistically simulate the acoustic variability induced by the mesoscale, gyre-scale, and seasonal ocean variability over a period of a few years. Emphasis is placed on studying the transmissions from Heard Island in the Indian Ocean, the proposed location for the sound source, to the west coast of the United States. Our objectives are to provide immediate acoustic modeling/ analysis support to the 12-day Global Ocean Variability Acoustic Reliability Measurement Experiment (GLOVARM) in January 1991 and, in the long run, to support the design of the decadal experiment. The PI of this project is also involved in the deployment of a listening array off Monterey Bay in GLOVARM. The combination of experimental and simulation efforts will answer many crucial questions concerning the usefulness of such a global acoustic monitoring system.

SUMMARY: A procedure to interface a three-dimensional Hamiltonian acoustic raytracing code (HARPO) with the global data set was developed. Furthermore, we have computed cross-basin sound rays using 11 consecutive instantaneous fields, extracted from the ocean model data set at 30-day simulation time intervals. These 11 fields contain meso- and gyre-scale ocean variability only since no seasonal forcing was applied during this particular model year. The exclusion of seasonal variability has allowed for a ray variability study isolating the meso- and gyre scale effects from the seasonal effects. A reliable ray envelope, containing rays having less than five bottom interactions and not impeded by land masses, insonifying the California coast was found. The envelope dimensions are invariant in time near the source, but can be quite variable at the California coastline due mainly to the large variability in the Southern Ocean. The variabilities of the focal point, center of the envelope, ray trajectories, travel times, and azimuthal arrival angles were analyzed. Ray paths to Oregon were also computed. However, the Oregon paths are much less reliable due to frequent bottom interactions in the relatively shallow Tasman Sea.

This two-year project is continued in 1991 with a focus on including seasonal variability in our ray analysis, so that we can quantify the impact of seasonal change through comparison with the present results. In addition to checking the feasibility of the proposed acoustical monitoring system, these calculations will also enhance our understanding of the effects of large-scale ocean variability on cross-basin low-frequency sound propagation in support of naval operations.

CONFERENCE PRESENTATIONS: Chiu, C.S. and A.J. Semtner, "A simulation study of cross-basin sound transmission from Heard Island to California," San Diego ASA Meeting, November 26-30, 1990. (Invited paper with published abstract)

Ehret, L.L. and C.S. Chiu, "Coupled-mode propagation through the transition zone between the Antarctic Circumpolar Current and the Pacific Ocean," San Diego ASA Meeting, November 26-30, 1990. (with published abstract)

THESIS DIRECTED: Coenraad M. Ort, LT, Netherlands Navy, "Spatial and temporal variability of cross-basin acoustic ray paths," Master's Thesis, December 1990.

FEASIBILITY STUDY FOR A NORWEGIAN CONTINENTAL SHELF - BARENTS SEA ACOUSTIC TOMOGRAPHY EXPERIMENT

Ching-Sang Chiu, Assistant Professor of Oceanography
James H. Miller, Assistant Professor of Electrical and Computer Engineering
Sponsor: Office of Naval Research

OBJECTIVES: Our primary objective is to assess the adequacy of ocean acoustic tomography for monitoring the circulations in the adjacent Norwegian Sea and Barents Sea. The Barents Sea is a complex acoustic environment. It contains variable shallow bathymetry as well as different water mass types. The transmission of sound there is expected to be highly three-dimensional. An outstanding question is whether acoustic tomography, traditionally used in deep water, is applicable in such coastal area. The understanding of both the forward and inverse problems requires the use three-dimensional (3-D) sound propagation models. The development of 3-D acoustic models appropriate for investigating ray/mode identifiability and stability and ocean-acoustic interactions in long ranges constitute the other near-term objective.

SUMMARY: The design of a full-scale Norwegian Continental Shelf - Barents Sea tomography experiment requires, as an important first step, a systematic feasibility study. This study consists of three phases. In the first phase, tomographic array performance in the Norwegian Sea was simulated in the computer. These simulations gave estimates of system resolution and variance for various array geometries and were essential for assessing the adequacy of acoustic tomography and the selection of optimal configurations in the deep locations. The second phase addresses the acoustic issues of ray/mode identifiability, resolvability, and stability in the Barents Sea. These issues are critical for solving the forward problem of acoustic tomography in this coastal environment and can be investigated through data-model comparisons. Preliminary data will be collected in a transmission test in the spring of 1992. Three-dimensional acoustic models with environmental input data will be required in the comparisons. Once the forward problem is understood, synthetic and real-data inversions will be conducted to evaluate system performance in the Barents Sea in the final phase.

The first phase of this systematic feasibility study was completed in 1990. In addition, we have made progress in the second phase. The progress includes the development/upgrade of two 3-D sound propagation models and a linear predictive filter to track arrival times of partially resolved acoustic rays. The two acoustic models, a mode and a ray code, are useful for the quantification of 3-D environmental effects on the acoustic wavefield and for ray identification in shallow, bathymetry-varying environments, respectively. The predictive filter is useful for providing additional travel time data from partially resolved rays in coastal tomography experiments.

CONFERENCE PRESENTATIONS: Smith, D.F., L.L. Ehret, J.H. Miller and C.S. Chiu, "Eigenray solutions for cross-shelf propagation," San Diego ASA Meeting, November 26-30, 1990; (with published abstract).

Barock, R.T., C.S. Chiu, J.H. Miller and J.F. Lynch, "Acoustic tomographic measurement of oceanic advective heat flux," 119th ASA Meeting, 1990, (with published abstract).

Lynch, J.F., A.E. Newhall, J.H. Miller, C.S. Chiu, R.C. Dees, K.P. Schaff and S. Paulsen, "Surface wave, wave group, and internal wave observations in the 1988 Monterey Bay Tomography Experiment," 119th ASA Meeting, 1990, (with published abstract).

THESES DIRECTED: R. Timothy Barock, LCDR, U.S. Navy, "Acoustic tomographic estimate of ocean advective heat flux: a numerical assessment in the Norwegian Sea," Master's Thesis, June 1990.

Donald F. Smith, "Acoustic modeling of the Monterey Bay Tomography Experiment," Master's Thesis, December 1990.

COUPLED OCEANIC AND ATMOSPHERIC BOUNDARY LAYERS

Pecheng Chu, Adjunct Resident Professor of Oceanography
Roland W. Garwood, Jr., Professor of Oceanography
Sponsor: NPS Direct Fund

OBJECTIVE: To provide a theoretical basis for ice drift prediction, which benefits the submarine activity in the polar regions.

SUMMARY: Based on the intensive survey on the feedback mechanism among three components (air, ice, and ocean) in the polar regions for the last several years, we found that the same mechanism is also valid for longer time-scale. The theoretical air-ice-ocean coupled model developed in this project shows a possible positive/negative feedback mechanism, induced by the hydrological cycle, among atmosphere, ice, and ocean. The theory predicts the generation of oscillations in ice-coverage, ice thickness, air and ocean temperatures, and sea level height.

PUBLICATIONS: Chu, P.C., 1990. "Air-ice-ocean feedback mechanism and ice oscillation on millennial time scales". **Annals of Glaciology, 14,** 28-31.

Chu, P.C. and R.W. Garwood, 1990. "Thermodynamic feedback between sea ice and oceanic mixed layer". **Ice Covered Sea and Ice Edge,** 11.

Chu, P.C. 1990. "Wind effect on ocean wave propagation in a solid ice pack". **Trans. Am. Geophys. Union,** 71, 1232.

CONFERENCE PRESENTATIONS: Chu, P.C. and R.W. Garwood, 1990. "Thermodynamic Feedback between Sea Ice and Oceanic Mixed Layer", **22nd International Liege Colloquium on Ocean Hydrodynamics,** sponsored by the **European Association of Marine Sciences,** Liege, 7-11 May 1990.

Chu, P.C., "Atmosphere and flexural-gravity wave interaction". **Amer. Geophys. Union,** San Francisco, 3-4 December, 1990.

OCEAN CIRCULATION TO THE WEST OF THE FARALLION ISLANDS IN AUGUST 1990

C.A. Collins, Professor and Chairman of Oceanography
N. Garfield, Adjunct Research Professor of Oceanography
L. Rosefeld, Adjunct Research Professor of Oceanography
Sponsor: U.S. Geological Survey

OBJECTIVE: To measure the ocean circulation in a region to the west of the Farallon Islands in 1990.

SUMMARY: Shipboard measurements were carried out in the region to the west of the Farallon Islands on July 6-9, August 5-10, August 27 - September 1, and October 18-22. These cruises were made by USNS DeSteiguer except the August 5-10 cruise used the R/V Pt. Sur. Measurements on the DeSteiguer included Pegasus (an acoustically tracked dropsonde) and CTD measurements; the Pt. Sur measurements also included ADCP.

CTD and ADCP data have been processed. The flow regime is variable on the approximately monthly time scale of the cruises. The August 5-10 cruise indicated poleward flow off the Farallones, while the August 27 - September 1 cruise indicated equatorward flow. Data from the August 5-10 cruise is being interpreted by LT Erhan Gezgin, Turkish Navy, as a thesis project. Three Pegasus sites were established off the Farallones. One site, C11, is located at an old Navy dump site and was co-located with a USGS current meter mooring in about 2600m of water. Other Pegasus sites were located inshore: C12 in 1700m of water and C14 in 900m of water. Pegasus data collected at C12 and C14 have not been processed as we were unable to survey the beacons; we have ordered the correct filter and anticipate surveying the beacons in early 1991.

CONFERENCE PRESENTATION: C. A. Collins, M. A. Noble, L. K. Rosenfeld, T. A. Rago, F. B. Schwing, and D. M. Husby, Oceanographic conditions on the continental shelf and slope between Pt. Reyes and Pt,. Sur in August 1990. Fall National Meeting, American Geophysical Union, San Francisco, December 1990. Abstract printed in EOS 71: 1351.

MARINE OPERATIONS

C.A. Collins, Professor and Chairman of Oceanography
F.M. Reynolds, Commander, USN, Military Instructor
Sponsor: Commander, Naval Oceanography Command

OBJECTIVE: To provide administrative and logistical support for shipboard operations necessary for research and instruction.

SUMMARY: The marine operations program supported 79 days at sea in FY90 on the R/V Pt. Sur. An additional 37 days at sea were supported on other research vessels including the USNS DeSteiguer, USNS Bartlett, DSV Seacliff and M/V Laney Chouest. Activities included the Operational Oceanography course (OC/MR 3570) in spring and fall quarters, and Descriptive Physical Oceanography (OC 3230) in winter, summer, and fall. Research along the Pt. Sur transect included current meter moorings and direct current observations. CTD data were collected in the Greenland Sea, and CTD and Pegasus data were obtained at a proposed Navy dumpsite off the Farallones. The marine operations program maintains equipment which is routinely used at sea: CTDs, XBTs, and a shipboard data aquisition system. Salinometers and calibration facilities are also maintained. The program actively interfaces with other local ship users through the Central California Consortium (CENCAL), with other national academic ship users through the University National Ocean Laboratory System (UNOLS), and with Navy research vessels through the Naval Oceanographic Office. Two mooring buoys were obtained and will be installed near the Coast Guard pier in Monterey harbor during 1991; replacement of existing buoys (used by the **Acania** and other UNOLS vessels) is necessary because of the advanced age and increasing difficulty of maintenance.

PUBLICATIONS: Abbott, M. R., K. H. Brink, C. R. Booth, D. Blasco, L. A. Codispoti, P.P. Niiler, and S. R. Ramp, 1990, Observations of phyto-plankton and nutrients from a Lagrangian drifter off northern California, J. Geophys. Res., 95, 9393-9409.

Marom, M., R. M. Goldstein, E. B. Thornton, L. Shemer, Remote sensing of ocean waves by interferometric SAR, Nature 345 (6278): 793-795.

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C. A. Collins, California Undercurrent observations," Pacific Oceanic Conference, Timberline Lodge, Oregon, October 1990

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S. R. Ramp and T. Anderson, Preliminary results from the Point Sur transect (POST) moored array: low frequency current, temperature, and conductivity variability, Eastern Pacific Oceanic Conference, October 1990 and Fall National Meeting, American Geophysical Union, San Francisco, December 1990. Abstract printed in EOS 71, 1351.

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L. Washburn, B. H. Jones, D. C. Kadko, P. M. Kosro, T. Cowles, T. Hayward, and T. P. Stanton, Water mass subduction and the transport of phytoplankton in a coastal upwelling system, Fall National Meeting, American Geophysical Union, San Francisco, December 1990. Abstract printed in EOS 71, 1361.

THESES DIRECTED: The Jan Mayen Current and the deep waters of the Greenland Sea, LT. R. Blythe, USN, September 1990

Measurements of ocean currents across the continental margin off Point Sur, California, during January 1990, LT. K. Buckley, USN, December 1990.

A diagnostic study of the velocity structure of a meandering jet off Point Arena, California, using a primitive equation model with normal mode initialization, LT. R. DeJesus, USN, September 1990.

Circulation of the California Undercurrent near Monterey, LT. A. J. Robson, USN, June 1990

Determination of near-surface velocity fields in the CTZ using combined altimetric and inverse modelling, LCDR D. M. Taggart, USN, September 1990.

Seasonal Variability of the geostrophic velocity and water mass structure off Point Sur, California, Lt. T. D. Tisch, NOAA, September 1990

Source of cold water in Monterey Bay observed by AVHRR satellite imagery, CDR D. E. Tracy, NOAA, December 1990

Submesoscale structure of the California Current near San Clemente Island, LCDR Tsai, Taiwan Navy, June 1990.

NPS DRIFTING AMBIENT NOISE BUOY PROGRAM

Jeffrey A. Nystuen, Assistant Professor of Oceanography
Sponsor: NOARL external funding ($20K), Direct Funding,
NOARL Review ($19K), Attn: Harry Selsor, Code 311
NOARL, Stennis Space Center, MS

OBJECTIVE: To assess the feasibility of monitoring and predicting geophysical quantities (wind stress, precipitation rate, ambient bubble populations) using ambient underwater sound measurements made from remote drifting buoys. This research includes drifters, laboratory and theoretical work.

SUMMARY: During 1990 significant process has been accomplished. In the laboratory, the characteristics of sound produced by large raindrops at terminal velocity has been examined for the first time. Several new sound generation mechanisms have been discovered. Most exciting was a newly described bubble formation mecha-nism from a turbulent jet formed during the splash of a large raindrop. Acoustically the frequency of the bubble sound from this mecha-nism is inversely proportional to the drop size suggesting that the drop size distribution of the rain can be measured directly using ambient sound. It is true, this will result in an excellent measurement of rainfall rate. A patent for this idea has been submitted. Recent acoustic improvements to the laboratory tank have been made and further studies are underway. Under-standing the interaction of rain generated sound with wind is essential to have confidence in acoustical measurement of precipitation. A previously unexplained field observation was the reduction in sound levels produced by light rain as the wind speed increases. This observation was explained using laboratory results from the thesis of A. Kurgan (1989). A major development was the installation of a hydrophone and precipitation recording system at the Ocean Test Platform in the Gulf of Mexico. This facility is operated by the National Data Buoy Center. The experiment was designed to collect extensive environmental data together with high quality digital tape recordings of the underwater sound spectrum during conditions of heavy precipitation. Heavy precipitation had not been studied previously. Several exciting discoveries have already been made. First, the extensively studied spectral peak characteristic of the underwater sound spectrum during light rain is absent during heavy rain. Second, the correlation of underwater sound levels with rainfall rate is high, 0.5-0.9, and frequency dependant. Furthermore, very heavy rainfall (over 150 mm/hr) produces an extensive ambient bubble cloud similar to that produced by extensive breaking waves. This is the first field evidence of near surface mixing by rain itself and supports an independent theory of the attenuation of surface gravity waves by heavy rain.

The drifter component of this project is finally underway. The first buoy was deployed in May and lasted through September. A second buoy was deployed in October and is still operating. Data was successfully collected via the ARGOS satellite network. Collaborating passive microwave satellite data (SSM/I) has been requested for the first buoy. The NPS IDEA Lab has developed an automated SSM/I data link to FNOC. This data link is operational, although software for processing the data need further development. More buoys have been ordered.

PUBLICATIONS: Nystuen, J.A., "An Explanation of the Sound Generated by Light Rain in the Presence of Wind", to appear in Natural Physical Sources of Underwater Sound, ed. B.R. Kerman, Kluwer Academic Press (1991).

Medwin, H., A. Kurgan and J.A. Nystuen, "Impact and Bubble Sound from Raindrops at Normal and Oblique Incidence", J. Acoust. Soc. Am. **88**, 413-418 (1990).

CONFERENCE PRESENTATIONS: "An Explanation of the Sound Generated by Light Rain in the Presence of Wind", NATO Advance Research Workshop, Cambridge, England, July 1990.

"The Underwater Sound Generated by Light and Heavy Rain", INVITED, Acoustical Society of America Meeting, San Diego, Fall 1990.

"Characteristics of Sound Radiation from Large Raindrops", David E. Snyder, P.W. Jacobus, H. Medwin and J.A. Nystuen, Acoustical Society of America Meeting, San Diego, Fall 1990. (Presented by D. Snyder.)

THESIS DIRECTED: David E. Snyder, "Characteristics of Sound Radiated from Large Raindrops", co-advisor H. Medwin, December 1990.

Chih-Lung Tan, "A Characterization of Underwater Sound Produced by Heavy Precipitation", December 1990.

INFLUENCE OF RAIN AT THE AIR/SEA INTERFACE

Jeffrey A. Nystuen, Assistant Professor of Oceanography
Sponsor: Direct Funding, ONR approval ($2K)

OBJECTIVE: To explain the formation of a thin turbulent surface layer by rainfall and to predict the influence of that layer on the attenuation of surface gravity waves on the ocean.

SUMMARY: An analytic theory describing how a rain-induced turbulent layer will subsequently attenuate surface gravity waves was revised and published. This theory was developed using published laboratory results and classical wave theory. Field data supporting this theory has previously been lacking (although numerous qualitative observations are reported). Recent results from the Acoustic Rain Experiment at the Ocean Test Platform in the Gulf of Mexico (part of the NPS Drifting Ambient Sound Buoy Program) indicate that heavy rainfall is capable of generating significant underwater bubble clouds. This is the first field evidence of near surface mixing by rainfall and supports the theory described above. A manuscript on the attenuation of surface gravity waves by rainfall was reviewed. This work exposed the weakness of using non-terminal velocity drops to study rain processes at the air/sea interface. Recent results using the NPS Raindrop Tower have identified a turbulent jet mechanism for transferring drop kinetic energy into subsurface mixing (and bubble formation). Further studies are anticipated. A study modeling the growth of a rain-induced mixed layer was completed. The NPS wind mixing bulk model was modified to the case of rain mixing. The model was tuned using published laboratory data. These data were insufficient to fully specify the model, however one conclusion is that less than 1% of the drop kinetic energy goes into subsurface mixing. The remaining energy apparently stays at the ocean surface as ripples. The mixing length is proportional to both drop size and rainfall rate.

PUBLICATIONS: Nystuen, J.A., "A Note on the Attenuation of Surface Gravity Waves by Rainfall", J. Geophys. Res. **95**, 18353-18355 (1990).

THESIS DIRECTED: Hur, Hong-Beom, "Modeling a Rain Induced Mixed Layer", June 1990.

COUPLING WITH OCEAN INTERIOR AND ATMOSPHERE

Ronald W. Garwood, Jr., Professor of Oceanography
Pecheng Chu, Adjunct Professor of Oceanography
Sponsor: NPS Direct Funding

OBJECTIVE: To understand the thermodynamic and dynamic processes that couple the oceanic and atmospheric planetary boundary layers. Included are: (1) the dynamic instability of the oceanic mixed layer entrainment zone; (2) the role of energy and momentum fluxes due to wind waves at the ocean surface on the OPBL and MABL; and (3) the combined effects of the storage of heat and water mass between the upper ocean and clouds.

SUMMARY: The classical assumption that the cause of oscillations between the atmosphere and oceans is fundamentally dynamical, i.e., various planetary/gravitational wave solutions. Our results show that without such wave dynamics, the two adjacent boundary layers (OPBL and MABL) also have oscillatory thermodynamical modes. Among these modes OPBL-Cloud feedback is an important mechanism. A series of our sensitivity studies confirms the importance of this feedback mechanism. First, clouds reduce the incoming solar radiation at the ocean surface, which cools (relatively) the ocean mixed layer by increasing mixed layer entrainment. The cooling of ocean mixed layer lowers the evaporation rate, which will diminish the clouds. This is a negative feedback. Second, precipitation dilutes the surface salinity, stabilizing the upper ocean and reducing mixed layer deepening. The mixed layer may be caused to shallow if the downward surface buoyancy flux is sufficiently enhanced by precipitation. The reduction in mixed depth will increase the SST by concentrating the net radiation plus heat fluxed downward across the sea surface into a thinner layer. The increase of SST augments the surface evaporation, which in turn produces more clouds. This is a positive feedback mechanism. Based on this positive-negative feedback mechanism, the coupled OPBL and cloud system may oscillate strongly in the regions of heavy precipitation. The equatorial mixed layer system has been found to have two distinct components: (1) a well-mixed turbulent boundary layer having a mean depth corresponding to the Obukhov length scale, 10-30 m; and (2) an entrainment zone that is intermittently turbulent and can be more than 100 m deep. Mixing and dissipation in the deep entrainment zone is triggered by a dynamic instability that is initiated in the overlying well-mixed layer on a diurnal basis in response to nocturnal cooling. Our predictions of diurnal variability in the dissipation and Reynolds stress profiles appear to explain the observations of Paka and Fedorov (Izv. Atm. Ocean Phys., 1982) which have been confirmed by Gregg et al. (Nature, 1985).

The most important accomplishment this past year has been the demonstration (see References) of the potential role of two-phase (temperature and salinity in the ocean and temperature and humidity in the atmosphere) thermodynamic air-sea interaction in causing positive feedback between the ocean and the atmosphere on time scales from diurnal to annual and longer. With only one phase, most thermodynamic air-sea feedback is negative.

THE COASTAL TRANSITION ZONE PROGRAM

Steven R. Ramp, Assistant Professor of Oceanography
Paul F. Jessen, Oceanographer
Sponsor: Office of Naval Research
Funding: NPS and ONR

OBJECTIVE: The objective of the CTZ program is to enhance our understanding of the kinematics and dynamics of the cold upwelling filaments which are often observed in the satellite AVHRR and CZCS imagery of the central California coastal waters, and to assess the impact of these features on the across-shelf transport and the biological productivity of the region.

SUMMARY: Detailed results from the papers submitted are too numerous to discuss in detail, so a short summary of the key results from some of the group descriptive papers follows. The 1987 large scale surveys between Point Reyes and north of Cape Mendocino (Kosro et al., submitted) provided evidence that the occurrence of the cold filaments is seasonal, with strong features first appearing in late spring. These four surveys (in February, March, May, and June 1987) also provided evidence that a continuous, meandering equatorward jet could play an important role in filament formation. A real time feature mapping cruise in June 1987 (Ramp et al., submitted) successfully described the structure of a large cold filament off Point Arena, several smaller, more transient features within it, and pieces of the surrounding eddy field, using CTD (conductivity, temperature, and depth), ADCP (acoustic Doppler current profiler) and remotely sensed sea surface temperature data. The large filament had a depth which exceeded the sample depth (500m), and was bounded by a meandering current with strong offshore currents to the north and onshore flows to the south. A net offshore transport of 2.6 - 3.8 x 106 m2 s-1 was observed. The smaller, shallower features within the large filament were correlated with bursts of equatorward wind stress, but not with local convergence / divergence of the wind stress between Point Arena and Eel River to the north, or between Point Arena and Bodega Bay to the south. Some interesting observations of the near surface heating during a wind relaxation event (Ramp et al., submitted) were also made during this cruise. The 1988 sequence of six surveys near Point Arena during July - August 1988 (Huyer et al, submitted) provided evidence that lower salinity waters are advected into the region from the north by the strong equatorward jet. The core of the jet lay between the 8.6 and 9.4 J kg-1 contours of geopotential anomaly (relative to 500 dbar), and had maximum baroclinic velocities exceeding 50 cm s-1 at the surface which transported about 3.8 x 10-6 m3 s-1 of water offshore. The maximum offshore velocities lay along the thermal gradient between the cold upwelled water and the warmer oceanic water, rather than along the core of the cold filament itself. The region of highest nutrients and biological activity coincided with the cold water (Chavez et al., submitted), which did move offshore, but much more slowly than the maximum observed velocities in the jet core.

PUBLICATIONS: Abbott, M. R., K. H. Brink, C. R. Booth, D. Blasco, L. A. Codispoti, P. P. Niiler, and S. R. Ramp, 1990: Observations of phytoplankton and nutrients from a Lagrangian drifter off northern California. J. Geophys. Res., 95, 9393-9409.

Ramp, S. R., R. W. Garwood, C. Davis, and R. L. Snow: Surface Heating and Patchiness in the Coastal Ocean off Central California During a Wind Relaxation Event. *Submitted to* J. Geophys. Res.

Ramp, S. R., P. F. Jessen, K. H. Brink, P. P. Niiler, F. L. Daggett, and J. S. Best: The physical structure of cold filaments near Point Arena, California, during June 1987. Submitted to J. Geophys. Res.

Brink, K. H., R. C. Beardsley, P. P. Niiler, M. R. Abbott, A. Huyer, S. R. Ramp, T. P. Stanton, and D. Stuart: Statistical properties of near surface flow in the California coastal transition zone. Submitted to J. Geophys. Res.

Chavez, F. P., R. T. Barber, A. Huyer, P. M. Kosro, S. R. Ramp, T. P. Stanton, and B. Rojas de Mendiola: Transport of nutrients and phytoplankton by the jets of the coastal transition zone. Submitted to J. Geophys. Res.

Huyer, A., P. M. Kosro, J. Fleischbein, S. R. Ramp, T. Stanton, L. Washburn, F. P. Chavez, and T. J. Cowles: Currents and water masses of the coastal transition zone off northern California, June to August 1988. Submitted to J. Geophys. Res.

Kosro, P. M., A. Huyer, S. R. Ramp, R. L. Smith,

F. P. Chavez, T. J. Cowles, M. R. Abbott, P. T. Strub, R. C. Barber, P. F. Jessen, and L. F. Small: The structure of the transition zone between coastal waters and the open ocean off northern California, winter and spring 1987. Submitted to J. Geophys. Res.

Stanton, T. P., J. A. Stockel, M. L. Batteen, and S. R. Ramp: Upper ocean response to a wind relaxation event in the coastal transition zone. Submitted to J. Geophys. Res.

Strub, P. T. P. M. Kosro, A. Huyer, K. H. Brink, T. L. Hayward, P. P. Niiler, C. James, R. K. Dewey, L. J. Walstad, F. P. Chavez, S. R. Ramp, D. L. Mackas, M. S. Swenson, L. Washburn, J. A. Barth, R. R. Hood, M. R. Abbott, D. C. Kadko, R. T. Barber, D. B. Haidvogel, M. L. Batteen, and R. L. Haney: The nature of cold filaments in the California current system. Submitted to J. Geophys. Res.

CONFERENCE PRESENTATIONS: Washburn, L., D. C. Kadko, B. H. Jones, T. Hayward, P. M. Kosro, T. P. Stanton, A. Huyer, S. R. Ramp, and T. J. Cowles: Water mass subduction and the transport of phytoplankton in a coastal upwelling system. Submitted to J. Geophys. Res.

Daggert, D. M., S. R. Ramp, N. Garfield, and K. A. Kelly. "Ocean current estimates from satellite AVHRR image pairs and synthetic GEOSAT altimeter data." Presented at the AGU annual fall meeting, December 1990. Abstract printed in EOS, 71, 1360.

Ramp, S. R., F. L. Daggett, and P. F. Jessen. "Observations of the velocity structure near a cold filament in the coastal transition zone (CTZ) using CTD and ADCP data." Presented at AGU Ocean Sciences Meeting, January 1990. Abstract printed in EOS, 71, 146.

Chavez, F. P., A. Huyer, P. M. Kosro, and S. R. Ramp: "Transport of nutrients by the jets of the coastal transition zone, 1988." Presented at AGU Ocean Sciences Meeting, January 1990. Abstract printed in EOS, 71, 144.

Huyer, A., J. Fleischbein, P. M. Kosro, S. R. Ramp, and T. P. Stanton. "Structure and water properties of the coastal transition zone, 1988." Presented at AGU Ocean Sciences Meeting, January 1990. Abstract printed in EOS, 71, 145.

THESIS DIRECTED: Taggart, D. M., LCDR, USN. "Determination of near-surface velocity fields in the CTZ using combined altimetric and inverse modelling." Master of Science in Meteorology and Physical Oceanography, September 1990 (co-advised with Prof. Newell Garfield).

THE POINT SUR TRANSECT (POST) PROGRAM

Steven R. Ramp, Assistant Professor of Oceanography
Dale Pillsbury, College of Oceanography, Oregon State University
Paul Jessen, Oceanographer
Todd Anderson, Oceanographer
Marla Stone, Oceanographer
Sponsor: Research Administration Office
Funding: Naval Postgraduate School

OBJECTIVE: To resolve the physical and biological variability of the California Current System off Point Sur, CA at seasonal and longer time scales, using both shipboard and moored measurements maintained for a period of at least 5 years. Two problems of particular interest are the dynamics and kinematics of the California Undercurrent and the resolution of El Nino/Southern Oscillation (ENSO) events.

SUMMARY: Two subsurface pilot moorings were successfully deployed and recovered from May to August and August to December 1989 on the 800 isobath off Point Sur. The complete array consisting of this mooring plus an upward looking moored ADCP (acoustic Doppler current profiler) at the shelf break and two additional subsurface moorings at the 1800 m isobath along 36_ 20' N and at 1100 m off Point Piedras Blancas were deployed from February to May 1990. The two subsurface moorings at 800m and 1800m off Point Sur have been maintained continuously from May 1990 to the present. Data processing has been progressing using programs transported to the NPS MicroVAX computer from Oregon State University. Clean time series have now been produced and the data quality is good, with the exception of the moored conductivity which has not been up to our expectations. The NOAA offshore buoys will be used to examine the local and remote wind forcing. The most interesting preliminary results come from the 18 month time series at 100, 350, and 500 m depth on the 800 m isobath, 25 km offshore from Point Sur on the continental slope. The goal was to deploy these instruments in the California Undercurrent, and indeed the flow is mostly poleward and highly coherent over these depths. Speeds commonly exceeded 35 cm s-1 with maxima exceeding 50 cm s-1 at 100 m, and were only slightly weaker at the deeper depths. Low frequency variability is apparent in two frequency bands: 4 - 20 days, and a very low frequency of about 7 months, which is the most energetic and dominates the signal. Equatorward flow at all depths during the first summer was unexpected, and may be due to meandering of the current and/or the dominance of the 7-month signal, which was not phase locked with the seasons. Additional scientific results are anticipated as the field work continues.

PUBLICATIONS: None. This project is still in the data acquisition phase.

CONFERENCE PRESENTATIONS: Ramp, S. R. and T. Anderson. "Preliminary results from the Point Sur Transect (POST) moored array: Low frequency current, temperature, and conductivity variability." Presented at the AGU annual fall meeting, December 1990. Abstract printed in EOS, 71, 1351.

Tisch, T. D., S. R. Ramp, and C. A. Collins. "A study of seasonal variability of the geostrophic velocities and water mass structure off Point Sur, CA along 36_ 20' N." Presented at the AGU annual fall meeting, December 1990. Abstract printed in EOS, 71, 1351.

Ramp, S. R., and T. Anderson. "Preliminary results from the Point Sur Transect (POST) moored array: Low frequency current, temperature, and conductivity variability." Presented at the Eastern Pacific Ocean Conference (EPOC), October, 1990.

Tisch, T. D., S. R. Ramp, and C. A. Collins. "A study of seasonal variability of the geostrophic velocities and water mass structure off Point Sur, CA along 36_ 20' N." Presented at the Eastern Pacific Ocean Conference (EPOC), October, 1990.

THESIS DIRECTED: Tisch, Timothy D., LT, NOAA Corps. "Seasonal variability of the geostrophic velocity and water mass structure off Point Sur, CA." Master of Science in Physical Oceanography, September 1990. (Co-advised with Prof. Curtis A. Collins).

MIXING IN THE UPPER OCEAN DUE TO FINE SCALE SHEAR

T.P. Stanton, Adjunct Research Professor of Oceanography
Sponsor: Office of Naval Research Physical Oceanography

OBJECTIVE: The objectives of this ongoing research were to develop doppler profiling systems capable of measuring 3 component profiles from 10m down to cm scales, and to deploy them in two field programs involved with upper ocean turbulence. A study of turbulence in the velocity field just below deep water surface gravity waves was executed as a component of the SAXON experiment, which was staged from Chesapeake Lighthouse in October 1989. A second field deployment measured sub-ice boundary layer turbulence and thermal microstructure at the CEAREX "O" camp during March 1988, northwest of Spitzbergen.

SUMMARY: Two different acoustic velocity measuring systems have been developed: (1) The first is a bistatic geometry, coherently sampled, doppler profiler operating at 300hz, which measures 3 component velocities every 10cm from scatterers in an 0(1 liter) volume along a narrow transmitter beam. Phase coherent sampling of the doppler shift frequencies has provided high temporal accuracy in good scattering conditions; (2) A 5 MHz doppler velocimeter and temperature/conductivity microstructure system is being developed to resolve sub-cm scale velocity structure in front of a loose tethered profiling instrument. A computer controlled servo winch to handle the kevlar / fiber optic tether line has also been implemented to allow automated profile timeseries to be measured. The combined 3 component velocity and thermal microstructure measurement allows small scale momentum and scale fluxes to be estimated. Measurements of finescale velocity structure immediately below a wind driven surface gravity wave field have been successfully made with a non-invasive acoustic doppler instrument which resolves three component velocity estimates every 10cm from a single small sample volume, allowing vertical Reynolds stress components to be directly estimated and compared with atmospheric forcing. The same system and similar processing methods have been used to measure a sub-ice boundary layer under a wide range of mean flow and turbulent conditions. A small, loose tethered microstructure instrument with a doppler velocimeter was used to measure a 3 week time series of temperature, salinity and thermal microstructure in the Arctic, allowing mixing activity in the upper thermocline to be studied.

PUBLICATIONS: Itsweire, E. C. T. R. Osborn and T. P. Stanton, 1989: Horizontal Distribution and Characteristics of Shear Layers in the Seasonal Thermocline. J. Phys Oceanogr., 19,301 - 320.

Stanton, T.P., 1991: A Bistatic Geometry Coherent Acoustic Doppler Profiler for Oceanic Turbulence and Wave Measurements. In prep.

Stanton, T. P., 1989: Estimation of Reynolds stresses using a bistatic coherent doppler profiler. TOS Poster T3.OA.04,42.

Stanton, T. P., 1989: Momentum fluxes in a wind driven surface gravity wave field. Trans. Am. Geophys. Union, 70,1166.

CONFERENCE PRESENTATIONS: Stanton, T. P., "Ocean Turbulence Measurements Using a Bistatic Velocity Profiler. Paper J2, ASA May meeting, JASA, Vol 87, p S26.

Stanton, T. P., "Measurements of the Sub-Ice Boundary Layer Using a High Resolution Acoustic Doppler Profiler". Ocean Sciences meeting, New Orleans, Feb 1990. Trans Am. Geophys. Union, 71, p. 130.

Abreu, M. and T. P. Stanton., "Finescale Current Profiles and Directional Wave Spectra During SAXON 1988". Ocean Sciences Meeting, Feb.,1990. Trans. Am. Geophys. Union, 21, p. 82.

THESIS DIRECTED: M. Abreu, "Kinematics Under Wind Waves", M.S., September 1989.

MIXING ASSOCIATED WITH UPWELLING JETS IN THE COASTAL TRANSITION ZONE

T.P. Stanton, Adjunct Research Professor of Oceanography
E.B. Thornton, Professor of Oceanography
Sponsor: Office of Naval Research Physical Oceanography

OBJECTIVE: The primary objective of these studies is to understand whether there are enhanced mixing rates due to double diffusive conditions, and high horizontal and vertical current shear near strong offshore jets. As these features also appear to change rapidly in response to wind forcing, the sudden disappearance of cool surface features seen in AVHRR satellite imagery is being studied in terms of the estimated mixing rates and atmospheric fluxes.

SUMMARY: Five cross-jet transects of velocity, CTD, and conductivity microstructure data, gathered during the OPTOMA21 cruise in July 1986, are being analyzed to identify mixing patches and their relationship to the jet flow axis and temperature and salinity fronts, as the jet evolves offshore. The high horizontal resolution towyo and ADCP transects have allowed vertical shear regions and thermohaline intrusions to be identified, and the conductivity microstructure measurements provide estimates of mixing activity. Three of the six sequential hydrographic mappings of the "CTZ domain" off Point Arena are being used with AVHRR imagery sequences of the same domain to study the changes in both the surface and subsurface structure of the jet following a sudden drop in upwelling favorable winds in late July 1988. Results of a dynamic adjustment model and a mixed layer model simulating the relaxation event have been submitted for publication together with 5 other collaborative papers.

PUBLICATIONS: Stanton, T. P.,J. A. Stockel, M. L. Batteen and S . R. Ramp, 1990: Upper Ocean Response to a Wind Relaxation Event in the Coastal Transition Zone. Submitted to J. Geophys. Res. Brink, K. H., R. C. Beardsley, P. P. Niiler, M. Abbott, A. Huyer, S. R. Ramp, T. P Stanton, and D. Stuart: Statistical Properties of Near Surface Flow in the California Coastal Transition Zone: Submitted to J. Geophys. Res.

Huyer A., P. M. Kosro, J. Fleischbein, S. R. Ramp, T. P. Stanton, L. Washburn, F. Chavez, and T. Cowles, 1990: Currents and Water Masses of the Coastal Transition Zone off Northern California, June to August 1988. Submitted to J. Geophys. Res.

Washburn, L., D. C. Kadko, B. H. Jones, T. Hayward, P. M. Kosro, T. P. Stanton, A. Huyer, S. R. Ramp, and T. Cowles, 1990: Water Mass Subduction and the Transport of Phytoplankton in a Coastal Upwelling System. Submitted to J. Geophys. Res.

Jones, B. H., R. Flegal, C. N. K. Mooers, M. Reinecker, T. P. Stanton, and L. Washburn: Chemical and Biological Structure Observed off Northern California in July 1986. Submitted to J. Geophys. Res. 1990.

CONFERENCE PRESENTATIONS: Washburn, L. and T. P. Stanton, "Intrusions and Strong Mixing in an Upwelling Filament". Ocean Sciences Meeting, New Orleans, Feb.,1990. Trans. Am. Geophys. Union, 71, p87.

THESIS DIRECTED: R. E. DeJesus, "A Diagnostic Study of the Velocity Structure of a Meandering Jet Off Point Arena, California, Using a Primitive Equation Model with Normal Mode Initialization", M.S. thesis in Meteorology and Oceanography, September 1990.

NEARSHORE WAVE PROCESSES

E.B. Thornton, Professor of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: Predict the wave-induced three-dimensional velocity field over arbitrary bathymetry in the nearshore describing the waves with a nonlinear directional wave spectrum.

SUMMARY: The data from the just completed, month-long, comprehensive nearshore dynamics experiment DELILAH will be used to test the various models developed. It is planned to participate in the prototype-scale wave dynamics laboratory experiment SUPERTANK to be held during the month of July 1991 at Oregon State University. Dodd, Oltman-Shay and Thornton (1991) demonstrated by model comparison with data that the strong low frequency motions observed during SUPERDUCK were due to shear instabilities on the longshore current. Dodd and Thornton (1990) showed that a necessary condition for the growth of the instability is that there be a transfer of momentum of the mean flow to the cross-shore gradient of the covariance of the horizontal velocity of the perturbed flow. i.e. a cross-shore gradient of the Reynold's stress for the shear instability must exist. Thornton and Dodd (1990) used the model for longshore currents by Thornton and Guza (1986) and the numerical model results of shear waves by Dodd et al (1990) as a framework to study mixing by shear instabilities. It is hypothesized here that this cross-shore gradient of the Reynold's stress is responsible for the turbulent mixing necessary to explain the observed cross-shore distribution of the longshore current in the nearshore. They calculate the shear instability spectrum using an initial base state longshore current cross-shore distribution before mixing can occur (neglecting the Reynold's stress) and a steady state, developed state after mixing takes place (including the Reynold's stress described by shear instability velocity covariance). The spectrum of the shear instabilities is described by the five fastest growing modes from 0 to 0.01 Hz. The amplitude of the shear instabilities was calibrated using the SUPERDUCK field data. The model results provide evidence that shear instabilities may be a substantial agent for mixing of momentum in the nearshore.

PUBLICATIONS:

Whitford, D. J. and E. B. Thornton 1991: Comparison of Wind and Wave Forcing of Longshore Currents, J. of Coastal Engineering, Forthcoming.

Dodd, N. and E. B. Thornton, 1990, "Growth and Energetics of Shear Waves in the Nearshore". (J. of Geophysical Research), Vol. 95, Mo. C9, p 16,075-16,083.

Guza, R. T. and E. B. Thornton, 1989, Chapter 4: Measuring Surf Zone Dynamics: A. General Measurements, Nearshore Sediment Transport, R. J. Seymour editor, Plenum Press, New York, NY, 51-60.

Thornton, E. B. and R. T. Guza, 1989, Chapter 8: Wind Wave Transformation, Nearshore Sediment Transport, R. J. Seymour editor,Plenum Press, New York, NY, 137-172.

Guza, R. T. and E. B. Thornton, 1989, Chapter 9: Runup and Surf Beat, Nearshore Sediment Transport, R.J. Seymour editor, Plenum Press, New York, NY, 173-182.

Thornton, E. B. and R. T. Guza, 1989,Chapter 10: Nearshore Circulation: A. Conservation Equations for Unsteady Flow, Nearshore Sediment Transport, R. J. Seymour editor, Plenum Press, New York, NY, 183-204.

Thornton, E. B. and R. T. Guza, 1989, Chapter 16: Models for Surf Zone Dynamics, Nearshore Sediment Transport, R. J. Seymour editor, Plenum Press, New York, NY, 337-370.

Committee on Coastal Engineering Measurement Systems (Member), 1989, Measuring and Understanding Coastal Processes for Engineering, National Academy Press, Washington, D. C., 117p.

Whitford, D. J. and E. B. Thornton, Longshore Currents over a Barred Beach, I: Field Experiment, J. Phys. Oceanogr., (resubmitted)

Thornton, E. B. and D. J. Whitford, Longshore Currents over a Barred Beach, II: Model, J. Phys. Oceanogr.,(resubmitted)

Shemer, L., N. Dodd, and E. B. Thornton, Slow-time Modulation of Finite Depth Nonlinear Water Waves: Relation to Longshore Current Oscillations, J. Geophys. Res.(accepted)

Dodd, N., J. Oltman-Shay, and E. B. Thornton, Instabilities of Longshore Current: Comparison of Observation and Theory, J. Geophys. Res.,(submitted)

CONFERENCE PRESENTATIONS: Scott, K. and E. B. Thornton, Mean Cross-Shore and Longshore Currents on a Barred Beach, Fall AGU Meeting, San Francisco, 3-5 Dec 1990.

Thornton, E. B. N. Dodd, and L. Shemer, Broad-band Wave Forcing of Longshore Current, 22nd Int. Conf. Coastal Eng., The Hague, Netherlands, 1-6 July, 1990.

Thornton, E. B. and W. Birkemeier, Longshore currents measured at DELILAH, Fall AGU Mtg., San Francisco, 3-5 Dec 1990.

Thornton, E. B. and W. Birkemeier, "Field Experiments of Nearshore Dynamics: Fernandina Beach to Delilah and Beyond", Advances in Coastal Engineering Conf., Newark, Delawave, 1-2 Nov 1990.

INTERFEROMETRIC SAR IMAGING OF OCEAN CURRENT

E.B. Thornton, Professor of Oceanography
Sponsor: Office of Naval Research

OBJECTIVE: The objectives of this research are to perform ground truth experiments, develop the Interferometric SAR image processing techniques and develop a theoretical basis for inferring ocean surface currents and directional wave spectra.

SUMMARY: Interferometric Synthetic Aperture Radar (INSAR) is a relatively new method of imaging ocean surface velocity fields. The basic technique consists of aligning two physically separated antennas located along the radar platform flight path. The received signals are processed separately into two complex maps. These two maps are combined interferometrically into a single image. Unlike conventional SAR, which provides a map of covariance of complex reflectivity, the phase of each pixel in the resulting interferogram is directly proportional to the velocity component of the ocean surface in the viewing direction. A ground truth experiment was performed September 8, 1989 in the nearshore region of Monterey Bay. Remote imagery of the ocean surface was carried out by INSAR mounted on JPL/NASA DC-8 aircraft. The area imaged by INSAR was about 11km X 11km, centered on a four pressure-sensor-array located offshore at 16m water depth, which provided directional spectra at the time of INSAR measurements. The aircraft flight pattern consisted of four orthogonal legs providing large coverage with high resolution (11m x 12m) of ocean surface variability. In addition, extensive simultaneous ground-based measurements were performed, including the above mentioned shallow water array, deep water pitch and roll buoy, Lagrangian surface drifters deployed from a ship following the mean surface current, and wind velocity. The sea and weather conditions were ideal for INSAR imagery of dominant wave systems. The wind velocity was about 1 -2 m/s, the mean near surface currents as inferred from 10 Lagrangian drifters were about 25 cm/s.Two dominant wave systems are clearly seen in the INSAR image. Refraction of a long-fetched background swell system propagating from the southeast with a wavelength of about 400m (16s period) is observed. A second wave system with the wavelength of about 130m (9s period) was propagating from the northwest. The directional spectrum of the surface elevation obtained by simultaneous ground-based measurements exhibits two distinct peaks at the frequencies corresponding to the wave systems observed in the image. The velocity field 2-D wavenumber spectrum was calculated from the INSAR images and the correspondingly adjusted directional frequency spectrum estimated from the shallow water array data compare well.

DEPARTMENT OF OPERATIONS RESEARCH

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 results 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 1990. 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, operational studies, 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 elsewhere. Also, research involving security classified matters are not reported here.

OPTIMIZATION

A broad spectrum of mixed integer programming applications have been treated as a general class. The identification and exploitation of special problem structure is a continuing theme (Bradley, Brown, Wood) in treating large scale optimization problems. Specialized decomposition and relaxation methods have been developed for the sub problems. Also some network basis factorizations have been successfully implemented. Applications include the modernization of the Army's helicopter fleet, mobilization of Officer's, determination of re-enlistment bonuses, and multicommodity flow.

Vehicle routing heueristics are being studied (Dell) with the incorporation of equity constraints. Algorithms for linearly constrained convex programs are under analysis; some decomposition methods have been effectively applied to some traffic assignment problems (Lawphongpanich). Implementation on micro computers of some large scale manpower optimization models has been successfully accomplished (Rosenthal). Integer programming techniques are being applied to the allocation of receivers to frequencies in order to maximize the number of detections (Brown, Washburn).

Special purpose algorithms are being developed for the analysis of stimulus-response compatibility interfaces (Theise).

STOCHASTIC MODELING AND SIMULATION

Probabilistic models are under development for describing aspects of the Data Defense Network and for evaluation of performance (Gaver, Jacobs, Purdue). Some general stochastic modelling and data analysis methods with special reference to applications in the government and the military continue to be researched (Gaver, Jacobs). The description and statistical analysis of non-linear time series and point processes continues to be studied (Lewis). Probabilistic models are under development for describing the damage aggregation for weapons salvos (Esary).

Development of reliability growth assessment techniques continues (Woods). Progress has been made in finding lower confidence limits on mechanical reliability and system reliability. Reliability and quality assurance thresholds for major caliber ammunition are being developed (Bailey, Kang, Bartroli, Callahan).

Markovian manpower models were adapted to study the impact of force reductions on the promotion pattern of officers (Milch).

STATISTICS AND DATA ANALYSIS

Important sources of systematic error have been identified which affect the calibration of three dimensional underwater tracking ranges (Read). Study of sequential decision problems and optimal maintenance policies continues (Whitaker). Sensitivity testing using Bayesian and sequential designs are under development (Kuo).

Interfaces between large scale data sets and interactive data analysis and graphics packages continue to be treated (Lewis). Seasonality considerations are being added to the building of an officer attrition rate generator for the USMC (Read).

OPERATIONS STUDIES

Mathematical and computational tools are under development to treat the problem of allocating airborne tactical electronic warfare assets (Bailey). The networking and optimal allocation of frequency hopping radios for the marine corps is under study (Bailey, Sovereign, Kemple). A decision aid for optimal two dimensional routing has been developed (Washburn).

Analysis of ASW search and detection models continues (Forrest, Eagle). Static and dynamic human measures are being investigated for the problem of identifying personnel and permitting access (Poock).

WARGAMING AND COMBAT ANALYSIS

A ten step process for implementing a future state look-ahead capability for the EAGLE combat model was developed (Parry). A micro-processor based system for planning replenishment of ordnance and fuel in carrier battle group operations has been developed (Schrady, Wadsworth). Specifications of a prototype war game has been completed for use by planners to relate to the products of C3 systems (Sternberg, Jones, Sovereign).

Work continues on the development of a comprehensive theory of combat science (Hughes). Support for the modeling of Soviet military ground force combat units in the EAGLE model has begun (Taylor). Work continues on Phase II of Soviet control of combat means and troops (Taylor).

OPTIMAL ALLOCATION OF AIRBORNE TACTICAL ELECTRONIC WARFARE ASSETS

M.P. Bailey, Assistant Professor of Operations Research
Sponsor: NAVAIRSYSCOM
Funding: Naval Postgraduate School

OBJECTIVE: The objective of this study is to establish the mathematical and computational tools required to optimally allocate EW assets in the face of detection assets which communicate, share data and issue commands.

SUMMARY: This study is concerned with developing a mathematical model for the propagation of data through a land-based air defense network. This model will be used to model the effects of employing tactical airborne EW assets against radar and communication systems, and to develop a methodology for allocating jamming assets to the different radars in an optimal way.

Professor Bailey is responsible for the analytical development of this model and its analysis. This project has also produced two theses, one in OA and one in the EW curriculum. Most importantly, the Navy is currently implementing this model within the TEAMS (EA-6 Mission Planning System). The model will be deployed within the year.

PUBLICATIONS: M. P. Bailey, "Measuring Performance of Integrated of Air Defense Networks Using Stochastic Networks," Proceedings of the IEEE CDC, submitted to Operations Research, 2nd revision.

CONFERENCE PRESENTATIONS: IADS Stochastic Model, ORSA/TIMS Joint National Conference, Philadelphia, PA, October 1990.

IADS Phased Hazard Algorithm, IEEE Conference on Decision and Control, Honolulu, HI, December 1990.

Operational Employment of an IADS Stochastic Model, COMMATVAQWINGPAC, Whidbey Island, WA, April 1990.

THESES DIRECTED: T.J. Bernota, "Accessing Performance of IADS," Master Thesis in the EW Curriculum, October 1990.

J.S. Sterling, "An EA-6B Transmitter Loading and Assignment Model," Master Thesis in Operations Research, March 1990.

OTHER: The Navy is currently sponsoring implementation of this model within the EA-6B mission planning system, and plans to deploy this system aboard aircraft carriers and within man-portable systems.

RELIABILITY AND QUALITY ASSURANCE OF MAJOR CALIBER AMMUNITION

M.P. Bailey, Assistant Professor of Operations Research
K. Kang, Adjunct Professor of Administrative Sciences
M. Bartroli, Adjunct Professor of Operations Research
A. Callahan, LCDR, USN, Department of Operations Research
Sponsor: Naval Weapons Support Center
Funding: Naval Weapons Support Center

OBJECTIVE: The objective of this study is to provide the Major Caliber Ammunition Program Office with a tool with which reliability thresholds may be established for ammunition components.

SUMMARY: The relationship of the failure modes of major caliber ammunition components, gun components, and weapon guidance is explored. Each failure mode causes a different delay to the gunfire system, thus the importance of each failure mode must be measured in terms of its impact to the whole system. The goals for this project are: 1) develop an effectiveness measure with which gun/round/guidance reliability are reflected; 2) a simulation model is developed which will relate the performance of the gun system's MOE with the battle goals established within a scenario; 3) statistical analysis tools to analyze the simulation output; 4) automated decision aids for making procurement and rework decisions for ammunition lots and component lots.

Professor Bailey is responsible for procuring the funding for this project, which is now entering its fourth year and has produced over $0.5M. He is also the developer of the effectiveness measure, the stochastic model, and the simulation program used in this study. Along with Professor Kang, he did the analysis of simulation output and the development of the simulation experiment. The model for this project has been used in the course OA3302, as an example of a discrete event simulation model. Students are also required to perform output analysis using this model.

PUBLICATIONS: M.P. Bailey, K. Kang, M. Bartroli, and A. Callahan, "Establishing Reliability Goals for Major Caliber Ammunition," NPS Technical Report submitted to OR Practices - Operations Research.

K.D. Glazebrook, M.P. Bailey, and L. Whitaker, "On Cost Rate Heuristics for Equipment Replacement Policies," NPS Technical Report submitted to Mathematics of Operations Research.

CONFERENCE PRESENTATIONS: Simulation Output Analysis, ORSA/TIMS Joint National Conference, Philadelphia, PA, October 1990.

Procurement and Surveillance Decision Processes, hosted meetings of JMEMS-MEWG, Monterey, CA, November 1990.

Stochastic Modeling and Prototype MOE, hosted meetings with USN Major Caliber Ammunition Program Office, Monterey, CA, June 1990

Procurement and Surveillance Decision Processes, hosted meetings with USN Major Caliber Ammunition Program Office, Monterey, CA, September 1990.

THESIS DIRECTED: D. Harrington, "Alternate Acceptance Sampling in Manufacturing," Thesis in Operations Research, October 1990.

OTHER: The Navy is currently sponsoring data collection during fleet exercises in support of implementation of this model. Use of this decision support system has the potential of saving the Navy millions of dollars annually.

C3 ANALYSIS METHODOLOGY

M.P. Bailey, Assistant Professor of Operations Research
M.G. Sovereign, Professor of Operations Research
W. Kemple, Assistant Professor of Operations Research
Sponsor: MCCDC Warfighting Center, USMC
Funding: MCCDC Warfighting Center, USMC

OBJECTIVE: The objective of this study is to support the USMC in allocating frequency hopping radios within the MAGTF organization.

SUMMARY: The USMC is in the process of upgrading its tactical communications equipment by purchasing new frequency hopping radios SINCGARS, PRC-117) which are intended to replace the currently deployed single-channel radio (PRC-77). Due to fiscal constraints, the USMC is unable to replace radios on a one-for-one basis. Furthermore, the networking and collocation of radios becomes rather complex if the radios are SINCGARS. The SINCGARS is believed to afford higher security, and greater MTBF. Our study will attempt to produce: 2) optimal allocation of SINCGARS within MAGTF organizational structures; 3) optimal networking of radios in the mixed SINCGARS/single-channel environment.

To achieve this end, the system of radios, messages, and tasks will be modeled using discrete event simulation. The simulation system will be produced in MODSIM, an object oriented simulation language. It is hoped that the resulting simulation model will be reusable in the analysis of other USMC C3 problems.

The model for this project has been used in the P.I.'s OA4333 course as an example. The MODSIM language is taught in this course, as well as advanced simulation output analysis.

CONFERENCE PRESENTATIONS: Modeling Opportunities in MAGTF C3, MCCDC-Warfighting Center, Quantico, VA, June 1990 and September 1990.

Object Oriented Simulation Programming, CACI, Inc., LaJolla, CA, June 1990.

OTHER: This project began in November 1990. Two theses are being supported by this project.

EXPLOITING SPECIAL STRUCTURE IN LARGE-SCALE OPTIMIZATION

G.H. Bradley, Professor of Operations Research
G.G. Brown, Professor of Operations Research
R.K. Wood, Associate Professor of Operations Research
Sponsor: Air Force Office of Scientific Research
Funding: Air Force Office of Scientific Research

OBJECTIVE: Develop theory and algorithms for solving real-world optimization problems which exploit the special structure of those problems.

SUMMARY: This research exploits special problem structure found in most linear and mixed integer programs. Basis factorization methods exploiting pure and generalized networks have been implemented within a primal-dual simplex algorithm. Special structure inherent in production/ inventory models as been exploited in an aggregation/disaggregation algorithm to more efficiently solve these problems. Some of these techniques are now in use for strategic nuclear targeting by JSTPS/Omaha and for conventional ammunition procurement and sortie planning by HQ/USAF. In addition, a computer workstation environment has been designed to support optimization experts as they build models and design, analyze and test innovative algorithms. A prototype system was implemented on a NeXt workstation to build inter-deployment schedules for Naval warships.

PUBLICATIONS: G.G. Brown, C.E. Goodman and R.K. Wood, "Annual Scheduling of Atlantic Fleet Naval Combatants," Operations Research, Vol. 38, No. 2., pp. 249-259, March 1990.

W. Avery, G.G. Brown, J.A. Rosenkranz and R.K. Wood, "Optimization of Purchase, Storage and Transmission Contracts for Natural Gas Utilities,"Operations Research, accepted for publication.

G.G. Brown, R.D. Clemence, W.R. Teufert and R.K. Wood, "An Optimization Model for Modernizing the Army's Helicopter Fleet," Interfaces, accepted for publication.

D.O. Bausch, G.G. Brown, D.R. Hundley, S.H. Rapp and R.E. Rosenthal, "Mobilizing Marine Corps Officers," Interfaces, accepted for publication, (1989 Koopman Prize Winner).

D. DeWolfe, J. Stevens, and R.K. Wood, "Determination of Military Reenlistment Bonuses," submitted for review.

G.G. Brown and A.L. Vassiliou, "ARES: A System for Real-Time Operational and Tactical Decision Support," submitted for review.

G.G. Brown and M.P. Olson, "Dynamic Row Factorization in Large-Scale Optimization," submitted for review.

G.G. Brown, D.M. Coulter and A.R. Washburn, "Optimization of Munitions Procurement," in progress.

G.G. Brown, G. Graves, H. Lange, C. Staniec and R.K. Wood, "Dual Decomposition Methods for Solving Multicommodity Flow Problems," in progress.

R.K. Wood, "Aggregation and Disaggregation for Solving Large-Scale Production/ Inventory Models," in progress.

CONFERENCE PRESENTATIONS: G.H. Bradley and S.R. Banham, "Graphical Interface to Optimization Models---Mathematical Programming Modeling Project (MP2)," TIMS/ORSA Joint National Meeting, Las Vegas, May 7-9, 1990.

G.H. Bradley and C. Jones, "Impact of Computer Technology and New Theories on Research and Practice in OR/MS," ORSA/TIMS Joint National Meeting, Philadelphia, October 29-31, 1990.

G.H. Bradley, "Presentation and Analysis of Optimization Results Using a Computer Workstation Graphical User Interface," ORSA/TIMS Joint National Meeting, Philadelphia, October 29-31, 1990.

G.G. Brown and R.K. Wood, "Optimization of Purchase, Storage and Transmission Contracts for Natural Gas Utilities," ORSA/TIMS Joint National Meeting, Philadelphia, October 29-31, 1990.

H. Lange and R.K. Wood, "Solution of Large-Scale Multicommodity Network Flow Problems Via a

Logarithmic Barrier Function Decomposition," Operations Research 1990, International Conference on Operations Research, Vienna, Austria, August 28-31, 1990.

THESES DIRECTED: T. Kawakami, "An Aid for Flight Squadron Scheduling," Master's Thesis, March 1990.

M.B. Ryoo, "Constraint Branching for Solving Set Partitioning Problems," Master's Thesis, March 1990.

R.W. Drash, "An Integer Programming Model for Navy's Maritime Patrol Aviation Fleet," Master's Thesis, September 1990.

R. Clemence, Jr., "Type Calculus for Executable Modeling Languages," Ph.D. Dissertation, September 1990.

S.Banham, "TaskMaster: A Prototype Graphical User Interface to a Scheduling Optimization Model," Master's Thesis, March 1990.

J. Schneider, "Models for Computer Aided Embarkation of Amphibious Ships," Master's Thesis, March 1990.

K. Solveson, "Dynamic analysis and control of network optimization algorithms," Master's Thesis, September 1990.

LARGE-SCALE OPTIMIZATION

G.H. Bradley, Professor of Operations Research
G.G. Brown, Professor of Operations Research
R.K. Wood, Associate Professor of Operations Research
Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: Develop theory and algorithms for solution of large-scale optimization models (continuing project).

SUMMARY: A continuing research effort emphasizing exploitation of special problem structure. Decomposition and relaxation methods have been developed and applied in concert with specialized algorithms to solve the subproblems produced. Additionally, pure and generalized network basis factorizations have been successfully implemented in the framework of a primal-dual simplex algorithm. The main impetus of this work is provided by large mixed-integer models arising in contexts ranging from weapons systems management to manpower planning. A mathematical programming modeling system to allow direct execution of optimization models is under development. Each component of this system is thoroughly tested on real-life problems provided by other researchers, government agencies and commercial sources. A new research effort is directed at designing and prototyping a computer-based system to support researchers who are developing optimization models and algorithms. Among our most recent contributions to military applications are a USMC mobilization model, a USAF sortie planning model and a USN employment scheduling model.

PUBLICATIONS: G.G. Brown, C.E. Goodman and R.K. Wood, "Annual Scheduling of Atlantic Fleet Naval Combatants," Operations Research, Vol. 38, No. 2., pp. 249-259, March 1990.

W. Avery, G.G. Brown, J.A. Rosenkranz and R.K. Wood, "Optimization of Purchase Storage and Transmission Contracts for Natural Gas Utilities," Operations Research, accepted for publication.

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G.G. Brown, G. Graves, H. Lange, C. Staniec and R.K. Wood, "Dual Decomposition Methods for Solving Multicommodity Flow Problems," in progress.

R.K. Wood, "Aggregation and Disaggregation for Solving Large-Scale Production/ Inventory Models," in progress.

CONFERENCE PRESENTATIONS: G.H. Bradley and S.R. Banham, "Graphical Interface to Optimization Models--- Mathematical Programming Modeling Project (MP2)," TIMS/ORSA Joint National Meeting, Las Vegas, May 7-9, 1990.

G.H. Bradley and C. Jones, "Impact of Computer Technology and New Theories on Research and Practice in OR/MS," ORSA/TIMS Joint National Meeting, Philadelphia, October 29-31, 1990.

G.H. Bradley, "Presentation and Analysis of Optimization Results Using a Computer Workstation Graphical User Interface," ORSA/TIMS Joint National Meeting, Philadelphia, October 29-31, 1990.

G.G. Brown and R.K. Wood, "Optimization of Purchase, Storage and Transmission Contracts for Natural Gas Utilities," ORSA/TIMS Joint National Meeting, Philadelphia, October 29-31, 1990.

H. Lange and R.K. Wood, "Solution of Large-Scale Multicommodity Network Flow Problems Via a Logarithmic Barrier Function Decomposition," Operations Research 1990, International Conference on Operations Research, Vienna, Austria, August 28-31, 1990.

THESES DIRECTED: T. Kawakami, "An Aid for Flight Squadron Scheduling," Master's Thesis, March 1990.

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J. Schneider, "Models for Computer Aided Embarkation of Amphibious Ships," Master's Thesis, March 1990.

K. Solveson, "Dynamic analysis and control of network optimization algorithms," Master's Thesis, September 1990.

HEURISTIC DEVELOPMENT OF CONSTRAINED VEHICLE ROUTES

R.F. Dell, Assistant Professor
Sponsor: Research Initiation
Funding: Naval Postgraduate School

OBJECTIVE: As part of a continuing research effort, this project seeks the development of effective heuristics for vehicle routing problems operating under demanding service requirements. In particular, the issue of equity has been explored as an improvement in service provided by delivery routes.

SUMMARY: Incorporating equity into more conventionally accepted objectives has recently received the attention of researchers in the Operations Research community. In this project, equity is demonstrated as a viable improvement to service in a vehicle routing environment. With the explicit consideration of equity, we develop a modified multiple Traveling Salesman Problem with Time Window formulation and an optimal column generation technique for its solution. Based on this optimal procedure, heuristic variations were derived and preliminary analysis has been conducted on realistic data sets. When a multiple day horizon is considered, these preliminary finding indicate that equity can be incorporated into more conventionally accepted objectives at little or no increase in direct operating costs.

OTHER: As part of the investigators first quarter at NPS, the following papers are in progress: 1) Equitable Vehicle Routes for Overnight Parcel Deliveries; 2) The Shortest Path Problem with Time Windows and Cost on Nodal Arrival Times.

DAMAGE AGGREGATION MODELS FOR WEAPONS SALVOS

J.D. Esary, Professor of Operations Research
Sponsor: Naval Weapons Center, China Lake, CA
Funding: Naval Postgraduate School

OBJECTIVE: Develop reasonable planning models for estimating the aggregate damage caused by multiple hits from weapons salvos.

SUMMARY: This project is a continuation of a project started during the previous year under the same title. The estimation of the aggregate damage to be achieved as the result of multiple weapons hits is a fundamental aspect of strike planning. At least two measures of effectiveness are pertinent, the expected percentage of the target which is damaged, and the probability that the damage to the target exceeds a threshold sufficient to regard the target as "killed." Models for estimating these measures are of interest generically, and specifically to various subgroups of the Joint Technical Coordinating Committee for Munitions Effectiveness. Results documented during the previous year concerned empirical rules for estimating the expected percentage of damage to an area target compared to a rule derived from a plausible model. Results documented during this year concern the first of an emerging family of target configuration and weapons impact scenarios which lead to he plausible model, now called a proportional effects damage aggregation mechanism. In addition to salvos directed against area targets, pertinent scenarios may include attacks on submarines by multiple lightweight torpedoes and the defense of task forces against incoming missiles with and without target allocation.

PUBLICATIONS: J.D. Esary, "A Stochastic Model for Hit Overlap in a Weapons Salvo Directed Against an Area Target that Leads to a Proportional Mechanism for Damage Aggregation," Working Paper on Damage Aggregation, Naval Postgraduate School, June 1990.

J.D. Esary, "Studies on Damage Aggregation for Weapons Salvos ," Naval Postgraduate School Technical Report NPS-55-90-16, July 1990. (A record of working papers to date on this subject)

CONFERENCE PRESENTATIONS: J.D. Esary, "Models for Damage Aggregation," JMEM/SS Munitions Effects Working Group Meeting, Naval Postgraduate School, 27-28 November 1990.

STATISTICAL ANALYSIS OF MULTIVARIATE OBSERVATIONS

D.P. Gaver, Distinguished Professor of Operations Research
P.A. Jacobs, Professor of Operations Research
Sponsor: Naval Ocean Systems Center
Funding: Naval Ocean Systems Center

OBJECTIVE: The objective of this project was to develop and study procedures for categorical inference from data that is of a time series nature but is obtained sporadically.

SUMMARY: Bayesian procedures were used to calculate the posterior probability of an observation coming from a particular category. The category having the maximal posterior probability was taken to be the estimate. It was found that the underlying model distributional assumptions can bias the probability of estimating the correct category. Combining information from several models would be more robust to model assumptions.

PUBLICATIONS: P.A. Jacobs and D.P. Gaver, "Classification of Intermittent Dependent Reservations," NPS Technical Report, NPS-OR-91-02, October 1990.

DDN PERFORMANCE ANALYSIS

P. Purdue, Chairman and Professor of Operations Research
D.P. Gaver, Distinguished Professor of Operations Research
P.A. Jacobs, Professor of Operations Research
Sponsor: Defense Communications Agency
Funding: Defense Communications Agency

OBJECTIVE: To develop probabilistic models of aspects of the Defense Data Network and to evaluate their impact on system performance.

SUMMARY: Probability models were constructed for: a) guiding selection of packet size when transmission errors occur at a given, non-bursty rate; and b) describing delay at a Packet Switching Node when all traffic sources to the node follow the same re-transmit policy. "Exponential backoff" was modeled and the optimal choice of retransmit intervals was discussed.

PUBLICATIONS: D.P. Gaver and P.A. Jacobs, "Defense Data Network (DDN) Performance Using Probability Modeling," NPS Technical Report, NPS-55-90-13, July 1990.

CONFERENCE PRESENTATIONS: D.P. Gaver and P.A. Jacobs, "Probabilistic evaluation of packet retransmission in packet switching networks," TIMS/ORSA Joint National Meeting, Las Vegas, May 1990.

D.P. Gaver, P.A. Jacobs, and P. Purdue, "Probability models for packet switching protocol evaluation," SIAM conference on Applied Probability in Science and Engineering, New Orleans, March 1990.

D.P. Gaver, "Probabilistic analysis in telecommunications: problems and opportunities," ORSA Special Interest Group meeting on Telecommunications: OR in Telecommunications, Boca Raton, FL, March 1990.

THESIS DIRECTED: J.R. Kirwan, CDR, USN, "Analysis of a Data Communication Network's Performance Under Varying Retransmission Disciplines," Master Thesis, September 1990.

STOCHASTIC MODELING AND DATA ANALYSIS

D.P. Gaver, Distinguished Professor of Operations Research
P.A. Jacobs, Professor of Operations Research
Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: The objectives of this project were to develop, apply and test and validate new methods of statistical data analysis and probability modeling for solving problems arising in applications, with special reference to problems in the Navy and the Government and military in general.

SUMMARY: A number of different problems were addressed. Simple probabilistic models for describing random shapes were introduced. Latent factor regression models and hierarchical regression models were developed for task response times for human operators; procedures for parameter estimation and prediction were presented and studied. Probabilistic models for ship replenishment during conflict and for multi-item adaptive repair were developed and studied.

PUBLICATIONS: D.P. Gaver and P.A. Jacobs, "On Inference Concerning Time-Dependent Queue Performance: the M/G/1 Example," Queuing Systems, Vol 6, pp 261-276, 1990.

E.G. Coffman, Jr., L. Flatto, and D.P. Gaver, "Performance Analysis of a Buffer Under Locking Protocols, "In Modeling Techniques and Tools for Computer Performance Evaluation, ed. Puigjaner and D. Potier, Plenum Press, pp 163-178, 1990.

D.P. Gaver, P.A. Jacobs, and I.G. O'Muircheartaigh, "Regression Analysis of Hierarchical Poisson-Like Event Rate Data: Superpopulation Model Effect on Predictions," Communications in Statistics: Theory and Methods, Accepted for Publication.

D.P. Gaver, K.D. Glazebrook, and S.E. Pilnick, "Optimal Sequential Replenishment of Ships During Combat," Naval Research Logistics, Accepted for Publication.

D.P. Gaver, J.A. Morrison, "Heavy Traffic Analysis of Multi-Type Queuing Under Probabilistic Load-Preferential Service Order," SIAM Journal of Applied Mathematics, Accepted for Publication.

D.P. Gaver and P.A. Jacobs, "Modeling and Simulation of Random Shapes by Sculptured Wraparound: Preliminary Report," NPS Technical Report, NPS55-90-17, August 1990.

D.P. Gaver and I.G. O'Muircheartaigh, "Latent Factor Models and Analyses for Operator Response Times," NPS Technical Report, NPS55-90-20, September 1990.

CONFERENCE PRESENTATION: D.P. Gaver, P.A. Jacobs, and S.E. Pilnick, "Multi-Item Adaptive Repair," TIMS/ORSA Joint National Meeting, Las Vegas, 1990.

THESES DIRECTED: C-F Wang, LTJG Navy, Taiwan, "A Hierarchical Gamma/Weibull Regression Model for Target Detection Times," Master Thesis, September 1990.

R.G. Silveira, LT, Navy Brazil, "Adaptive Logistics Support for Combat," Master Thesis, September 1990.

"COMBAT SCIENCE: AN ORGANIZING STUDY"

W.P. Hughes, Jr., Adjunct Professor of Operations Research
Sponsor: Office of CNO: OP-914
Funding: Naval Postgraduate School

OBJECTIVE: To combine and extend concepts in the investigator's book, Fleet Tactics, with his research with The Military Conflict Institute, to develop a comprehensive theory of combat that escapes the straitjacket of attrition-centered tactical planning and analysis of combat.

SUMMARY: The research paper is completed in draft and has been circulated for review. It establishes basic premises and structure for the study of combat. Combat science is taken to be organized knowledge of the physical, mental, and motivational aspects of lethal conflict, including their components, functions, and related dynamic processes. The foundation is a set of definitions and six fundamental axioms. Core concepts and their relationships are differentiated and described. Some of these are: 1) Force, forces and combat as force-on-force; 2) States and attributes of force elements; 3) Functions and processes of component elements; 4) The command function and the command-control process; 5) Fire, attrition, suppression and neutralization; 6) Designed and available combat potential; 7) Combat power and effectiveness; 8) Mission, task, and objective; 9) Measurement of results, outputs, and outcome; 10) Domination and control; 11) Friction and resistance; 1) Uncertainty, risk, chance, deception and surprise.

CONFERENCE PRESENTATIONS: T. R. Beall and W. P. Hughes, Jr. "Survivability of Warships: The Historical Data," 58th MORS Symposium," 13 June 1990.

W. P. Hughes, Jr. "The Value of Staying Power," David Taylor Research Center, Carderock, Md., 4 October 1990.

THESES DIRECTED: Thomas R. Beall, LT., USN, "Development of a Naval Battle Model and Its Validation Using Historical Data," Master Thesis, March 1990.

Jeffrey R. Cares, LT., USN, "The Fundamentals of Salvo Warfare," Master Thesis, March 1990.

John H Gibson, CAPT., USAF, and Joel L. Swanson, LT., USN, "Combat Modeling and Analysis for Command, Control and Communications: A Primer," Master Thesis, March 1990.

Epaminondas A. Hatzopoulos, LT., Greek Navy, "A Modern Naval Combat Model," Master Thesis, September 1990.

BAYESIAN AND SEQUENTIAL DESIGN FOR SENSITIVITY TESTS

L. Kuo, Adjunct Professor of Operations Research
Sponsor: Research Administration Office
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project is to obtain optimal designs which allocate the subjects to be tested at different levels of a stimulus.

SUMMARY: In sensitivity testing, subjects are divided into groups which are administered with different levels of a stimulus. Optimal designs for the sensitivity tests are to be studied to learn about the subjects' distribution of tolerance. We propose to obtain the design with the smallest Bayes risk. The Bayes risks incorporate sampling costs, penalty for the wrong assessment of the tolerance distribution, and our prior belief about the tolerance distribution.

There are three types of optimization problems to be considered: 1) allocation of sample sizes with fixed levels of stimulus; 2) allocation of sample sizes and their corresponding levels of stimulus; and 3) sequential adaptive design of the second problem.

ANALYSIS OF ALGORITHMS FOR LINEARLY CONSTRAINED CONVEX PROGRAMS

S. Lawphongpanich, Associate Professor of Operations Research
Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this research is to identify effective and efficient algorithms for linearly constrained convex programs. The investigation includes both theoretical and computational studies of competing algorithms. The project lasts three years and the summary below reports the research effort during the first year.

SUMMARY: In this project, we considered the implicit formulation of a linearly constrained convex program. Using this formulation, it was established that von Hohenbalken's algorithm is equivalent to the manifold suboptimization technique of Zangwill. This result is important in that it distinguishes von Hohenbalken's algorithm from other simplicial decomposition algorithms. In addition, the result suggests a hybrid algorithm which combines manifold suboptimization technique with simplicial decomposition and motivates the restriction of the number of extreme points to be retained from one iteration to the next in manifold suboptimization. During this initial phase, two new applications of simplicial decomposition were identified. One involves routing of messages in a communication network to maximize the overall residual capacity and the other involves finding an optimal randomized strategy in a two person zero sum game.

CONFERENCE PRESENTATION: S. Lawphongpanich, "Two Algorithms for Linearly Constrained Convex Programs," ORSA/TIMS Meeting, October 1989.

OTHER: A technical report for the above result is in preparation. A graduate student at NPS began the investigation for the game theory application in December 1990 and he is expected to complete in September 1991.

DECOMPOSITION TOPICS IN LARGE SCALE OPTIMIZATION

S. Lawphongpanich, Associate Professor of Operations Research
Sponsor: National Science Foundation
Funding: National Science Foundation

OBJECTIVE: To develop effective algorithms for large-scale optimization models. The development includes both theoretical and computational investigation of decomposition techniques which allow division of the problem into more tractable subproblems. The summary below reports the second year effort of the three year research project.

SUMMARY: The research effort during this period can be divided into three areas. First is the unification of the convergence properties for the cutting plane algorithm in two different fields: optimization and variational inequalities. This unification led to the classification of acceleration strategies and the identification of when each strategy would be effective. Second is the application of the proximal minimization algorithm to nondifferential problems. This application led to a new cutting plane algorithm in which the master problem is quadratic and all nonbinding cuts can be discarded. The last is the investigation into the possibility of combining two decomposition techniques: the cutting plane and simplicial decomposition techniques. This combined algorithm would be suitable for large scale nondifferential optimization.

PUBLICATIONS: D.W. Hearn and S. Lawphongpanich, "A Dual Ascent Algorithm for Traffic Assignment Problems," Transportation Research, Vol. 24B, pp. 423-430, 1990.

D.W. Hearn and S. Lawphongpanich, "Decomposition Topics in Large-Scale Optimization," Proceedings of NSF Design and Manufacturing Systems Conference, January 1990.

CONFERENCE PRESENTATION: D.W. Hearn and S. Lawphongpanich, "Decomposition Topics in Large-Scale Optimization,' NSF Design and Manufacturing Systems Conference, January 1990.

STOCHASTIC MODELLING, TIME SERIES ANALYSIS AND SIMULATION

P.A.W. Lewis, Distinguished Professor of Operations Research
Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: The purpose of this research is to develop new mathematical models and statistical methodology for the analysis of nonlinear time series and stochastic point processes; to develop new statistical methodology for use in simulations which are required in mathematical statistics and in the analysis of stochastic systems and to develop methods for the analysis, display and editing of large scale, non-normal time series.

SUMMARY: Multivariate Adaptive Regression Splines (MARS) is a new methodology, due to Friedman, for nonlinear regression modelling. By letting the predictor variables in MARS be lagged values of a univariate time series, one obtains an adaptive spline threshold autoregressive (ASTAR) model, which is a new method for nonlinear modelling of time series. This method was tested by simulation and by application to the Wolff Sunspot data; better predictions were obtained than have been obtained by any other method. Moreover the methodology is quite systematic. A semi- multivariate extension of (ASTAR) was obtained in which the time series to be modelled has not only its own lagged variables as predictors, but also lagged variables of other related time series. The approach has been shown to be well suited for taking into account complex interactions among multivariate, cross correlated, lagged predictor variables of a (possibly nonlinear) time series. In simulation, this methodology has been applied to output analysis of the clearly nonlinear systems; an extension to take into account in the model other co-commitment variables has been undertaken.

PUBLICATIONS: Y. Ameniya and T.W. Anderson and P.A.W. Lewis, "Percentage Points for a test of rank in multivariate components of variance," Biometrika, 77, 1990, pp. 637--641.

P.A.W. Lewis and R. Ressler, "Variance reduction for Quantile Estimates in Simulations via Non-linear Controls," Communications in Statistics -- Simulation and Computation, 19, 3, 1990, pp. 1045--1078.

P.A.W. Lewis and J.G. Stevens, "Smoothing Time Series," Proceedings of the 1990 Winter Simulation Conference", IEEE Press, pp. 678-81.

P.A.W. Lewis and J.G. Stevens, "Nonlinear Modelling of Time Series Using Multivariate Adaptive Regression Splines (MARS)," April 1990, NPS55-90-10; to appear in Journal of the American Statistical Association.

P.A.W. Lewis and A.J. Lawrance, "Reversed Residuals in Autoregressive Time Series Analysis," April 1990, NPS55-90-11; accepted for publication in The Journal of Time Series Analysis.

P.A.W. Lewis and R. Ressler, "Variance Reduction for Quantile Estimates in Simulation via Nonlinear Controls," April 1990, NPS55-90-09.

P. A. W. Lewis and E. McKenzie, "Minification Processes." To appear in Journal of Applied Probability 1991.

CONFERENCE PRESENTATIONS: "Nonlinear Modelling of Time Series using Multivariate Adaptive Regression Splines (MARS)." IMA Summer Program on New directions in Time Series Analysis, University of Minnesota, Minneapolis, July 1990.

"Nonlinear Modelling of Time Series using Multivariate Adaptive Regression Splines (MARS)." Computer Science/ Statistics Interface Conference, University of East Michigan, East Lansing, Michigan, 17 May 1990.

"Using MARS to investigate Nonlinear Time

Series, " IMSL Annual Users Conference Meeting, Monterey, California, May 9 --10, 1990. "Minification Processes." Department of Mathematics Seminar, UC San Diego, May 1990.

"Nonlinear Modelling of Time Series using Multivariate Adaptive Regression Splines (MARS)." Department of Statistics Seminar, University of Arizona, Tucson, Arizona, December 5, 1990.

"Smoothing Time Series Data" Tutorial given at 1990 Winter Simulation Conference, New Orleans, December 8, 1990.

"Remarks on the Statistical Analysis of Series of Events in Seismology," Department of Statistics Seminar, Stanford University, December 1990.

OTHER: Work has been started, with Professor Sir D. R. Cox, on revision and extension of the book "The Statistical Analysis of Series of Events," first published in 1966 and still in print.

EXPLORATORY ANALYSIS OF LARGE SCALE (PERSONNEL SECURITY) DATA SETS

P.A.W. Lewis, Distinguished Professor of Operations Research

Sponsor: PERSEREC
Funding: Naval Postgraduate School

OBJECTIVE: The purpose of this research is to investigate interfaces between large scale data sets, statistical data bases and interactive data analysis and graphics packages. The object is to make the data rapidly available for analysis, and in particular to use modern statistical and graphical methods to identify outliers and aberrant facets of the data.

SUMMARY: We have supplied support to PERSEREC on the analysis of several data sets. One is a data base of all known American spies. The other is a data base on data on security background investigations. Issues examined were the extent of coverage in time which was productive and the relevance of several types of questions asked during the investigation. Primary emphasis has been on the completion of the APL2 based scrollable input/output data editor and analyzer (UEDIT).

Outstanding features of this editor are the ability to do categorical data analysis and to do the aggregation of data which is usually required for these analyses. This is a microcomputer based package and will interface with the experimental IBM package GRAFSTAT, which will supply the other types of analysis needed. Eventually it is hoped to link these packages up with SQL databases under the OS2 operating system.

CONFERENCE PRESENTATION: P.A.W. Lewis and U. Steinfeld, "Draftsmans displays for the contingency tables using a full-screen, scrollable APL2 spreadsheet input/output editor," Computer Science/ Statistics Interface, East Lansing, Michigan, May 17, 1990.

THESES DIRECTED: U. Steinfeld, Captain, German Army, "Draftsmans displays for the contingency tables using a full-screen, scrollable APL2 spreadsheet input/output editor, with application to the PERSEREC database of Security Background Investigations," Master Thesis, March 1990.

NAVY OFFICER CORPS CAREER STRUCTURE ANALYSIS (FY90)

P.R. Milch, Professor of Operations Research and Statistics
Sponsor: Officer Allocation and Distributable Strength
Projection Branch
Funding: Naval Military Personnel Command (NMPC-454)

OBJECTIVE: To provide personnel managers of various Navy and Marine Corps Officer communities with a tool to analyze their communities for the purpose of ascertaining the likely future consequences of actual or planned policy changes on force structure or officer career paths.

SUMMARY: The FORECASTER and FORCE models were adapted to analyze such issues as the allocation of generalist billets in the URL community of the Navy, the impact of force reduction on the career paths of Surface Warfare officers, the feasibility of separate specialist career paths in the General URL Community, the impact of force reduction on the promotion pattern of Navy Medical Service Corps Officers, and the likely effect of the current reorganization of the Marine Corps Warrant Officer Corps community on its future force structure.

PUBLICATIONS: "FORECASTER, A Markovian Model to Analyze the Distribution of Naval Officers," Naval Postgraduate School Technical Report NPS 55-90-07, April 1990.

THESIS DIRECTED: Lawrence G. Bertolino, "The Effect of a U.S. Navy Reduction in Forces on the Career Path of Surface Warfare Officers Progressing to Command at Sea," Master's Thesis, September 1990.

Lori Turley, "The Feasibility of Specialized Sub-Communities Within the General Unrestricted Line Officer Community," Master's Thesis, September 1990.

Terri L. Butler, "The Impact of Force Reductions on Promotions in the Navy Medical Service Corps," Master's Thesis, December 1990.

Oke I. Johnson, "Marine Corps Warrant Officers: A Community in Turmoil," Master's Thesis, December 1990.

NAVY OFFICER HARDILL ALLOCATION AND DISTRIBUTION ANALYSIS (FY91)

P.R. Milch, Professor of Operations Research and Statistics
Sponsor: Officer Allocation and Distributable Strength
Projection Branch
Funding: Naval Military Personnel Command (NMPC-454)

OBJECTIVE: To construct a near-term Navy officer allocation and distribution model to be used by NMPC-4.

SUMMARY: Due to the late transmittal of funds, project got under way in mid-November, at which time the first attempt to obtain data were made. Work to begin on this project is in January 1991.

EAGLE-NPS

S.H. Parry, Associate Professor of Operations Research
Sponsor: U.S. Army TRADOC Analysis Command
Funding: U.S. Army TRADOC Analysis Command

OBJECTIVE: The goal of this continuing research was to develop a Generalized Value System to provide a future state prediction in lieu of current state decision tables for the EAGLE combat Model.

SUMMARY: A ten step process for implementing a future state Look-ahead process for the EAGLE combat model was developed. This process is applicable, in principal, for any combat simulation which models decision processes using current state decision tables. The fundamental concept is that current state decision tables ignore the intelligence input to Operation Plan Development, since NO decision is ever based solely on current state. The process involves mathematical extrapolations based on decay functions and experimentally derived Power functions. This methodology has not been implemented in EAGLE, although it was previously demonstrated in VIC, the current Army Corps/Division Simulation Model.

PUBLICATIONS: S. Parry and A. Schoenstadt, "Application of Future State Decision Making in the EAGLE Combat Model," Naval Postgraduate School Technical Report, NPS55-90-21, September 1990.

OTHER: Several Theses and Conference Presentations related to this research are documented in FY88 and FY89 research summaries.

CONTROLLING SHIPBOARD ACCESS WITH FINGER, SIGNATURE, AND TYPING BIOMETRIC MEASURES

G. K. Poock, Professor of Operations Research Department
Sponsor: Naval Ocean Systems Command
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project was to investigate the use of various biometric measures of the human form or action which can be used for identification, which would then allow access to physical devices such as computers, or allow entry into secured spaces, and in general any type of ship board access. A measure of the human form might be a finger print and a measure of a human action might be a speech or signature verification technique. This was the first year of a three year continuing project.

SUMMARY: This project is investigating the use of static and dynamic measures of humans which can then be used to identify the person and permit access to ships, doors, computers, and to anything which requires permission for access. The literature was thoroughly searched and on-line bibliography searches were conducted, both revealing very little in the way of past scientific investigations into the use and reliability of currently available biometric equipment. There are no journals in this new field yet and very *little* is published. In addition to NPS, Sandia Labs have been doing methodical investigations, and their results show up in conference proceedings as well as ours, due to lack of a journal in the area. This year NPS ran two studies, one on speech verification which is reported below. The other on finger prints is being analyzed and will be published in 1991. Results were not so promising for speech verification, more promising for finger print verification.

PUBLICATIONS: G.K. Poock, "Voice Verification for Access Control", NPS Research Report, October 1990.

CONFERENCE PRESENTATION: G.K. Poock, "Know Your Speech Recognizer's Personality/ Capability", Biennial Conference of International Society for Augmentative Communication, August,1990.

THESIS DIRECTED: L. Tirado, USAF, study on finger print verifiers, in preparation.

OTHER: Two papers in preparation by the author and to go to press in 1991. One on finger print verification and one on signature verification biometric techniques. Both based on several thousand access attempts through both technologies.

ATTRITION RATE GENERATION FOR LARGE SCALE MANPOWER MODELS

R.R. Read, Professor of Operations Research
Sponsor: HQ USMC
Funding: Naval Postgraduate School

OBJECTIVE: The Marine Corps is transferring its manpower planning to a computerized system. There are a number of flow models and uses. Manpower models are affected by three general factors: existing inventory (personnel), projected gains, projected losses. The projected losses can only be anticipated in a statistical sense. Moreover these must be done cell by cell. Cells are defined by cross classifying variables such as grade, years of commissioned service, military occupation specialty, service component, commissioning source, etc. depending upon the application. This situation leads to a large number of low inventory cells. The problem is to build a stable attrition rate generator for these cells. Millions of dollars can be saved with the use of a quality attrition rate generator.

SUMMARY: This is a continuing project. Previous work has produced an acceptable one year forecast technique using annual data. This year we looked into the question of shorter term, within year forecasts. Some quarterly data were acquired. A literature search yielded a number of techniques and four of these were selected for study; all of the exponential smoothing type. The Harrison-Stevens multi-state technique appeared to do the best job. It appears to handle the "overshoot" problem better than others. Also we developed our own seasonal factor update technique. It too appears to be the best. The project is hindered by data quality problems and we continue to see what can be done.

THESIS DIRECTED: C.J. Mehalic, Major USMC, "Multiparameter Forecasting Techniques for Marine Corps Officer rate Generator," Master Thesis, September 1990.

RANGE CALIBRATION STUDIES

R.R. Read, Professor of Operations Research
Sponsor: Naval Undersea Weapons Engineering Station
Funding: Naval Postgraduate School/NUWES

OBJECTIVE: NUWES (Naval Undersea Weapons Engineering Station) operates a number of short baseline ranges for tracking underwater vehicles. The calibration problems of concern are related to the discontinuity of track in the array overlap regions. There are a number of possible systematic error sources that may contribute to this condition: inexact knowledge of the individual array locations and orientations; timing signal synchronization errors; biases in the management of the sound ray refraction reconstruction; horizontal inhomogeneities in the water column parameters. These systematic error sources confound one another: they interact and mask each others effect. Error correction methods must have permanence.

SUMMARY: This is a continuing project. The reconstruction of the sound ray from receiver to sound source was examined carefully. Error budgets were developed for the several choices that affect the refraction and position location algorithms. These choices include isospeed vd isogradient ray tracing; the thickness of the water layers; the extrapolation of the depth speed profile below the depth measured; approximate vd exact tilt correction methodology; initialization methods for starting the algorithm. The errors are periodic functions of the azimuth direction and they change with the sound speed vd depth profile. It appears that a third or more of the overlap bias can be removed by using exact tilt corrections. The extrapolation of the water column can, on occasion, lead to some rather large biases. The recommended policy is to measure speed all the way to the bottom. The initialization technique (the conversion of sound transit times to direction angles) has some unnecessarily large errors which can be reduced by an order of magnitude.

PUBLICATIONS: R.R. Read, "An Investigation of Timing Synchronization Errors for Tracking Underwater Vehicles," Naval Postgraduate School Technical Report, NPS55-90-15, July 1990, 74pp.

R.R. Read, "A Study of Underwater Sound Ray Tracing Methodology," Naval Postgraduate School *Technical Report*, NPS55-90-21, September 1990, 97pp.

OPERATIONS RESEARCH MODELING OF ANTI-SATELLITE ARCHITECTURES

R.E. Rosenthal, Professor of Operations Research
Sponsor: Naval Space Command
Funding: Naval Space Command

OBJECTIVE: The goal of this project was to analyze the design and operation of various anti-satellite (ASAT) architectures using optimization modeling techniques.

SUMMARY: The primary problem addressed in this research was ASAT targeting. We developed models which work in conjunction with U.S. SPACECOM's existing software for orbital calculations, and are sufficiently flexible to be used not only for analyzing U.S. battle management negation needs, but also for predicting approaches that might be taken by a hostile force against U.S. space assets. Our models were unified in one portable GAMS and Pascal package called **STOMP**, for Space Targeting Optimization Modeling Program.

THESIS DIRECTED: Gregory T. Wallick, MAJ, USMC, "Space Targeting Optimization Modeling Program," Masters Thesis in Operations Research, September, 1990.

OTHER: 1.) **STOMP** was adopted for use at US SPACECOM on orders of VADE William A. Dougherty, Jr., Director of Operations (J-3), and was used heavily during the Apollo-Griffin exercise in October, 1990. **2.)** Dr. Rosenthal and Major Wallick gave command briefings on **STOMP** at US SPACECOM and Naval SPACECOM, and a senior staff briefing at the National Space Council in the Office of the President of the United States.

OPTIMIZATION MODELING RESEARCH FOR THE MARINE CORPS' MANPOWER AND RESERVE AFFAIRS DEPARTMENT

R.E. Rosenthal, Professor of Operations Research
Sponsor: Headquarters, United States Marine Corps
Funding: Headquarters, United States Marine Corps

OBJECTIVE: The goal of this project is to apply recent advances in mathematical programming algorithms and computer implementation technology to demonstrate the feasibility of microcomputer-based manpower planning systems.

SUMMARY: We have had success in the past in building optimization models that run on small computers yet solve large-scale Marine Corps manpower planning problems. The problem of optimally assigning officers to billets during a mobilization was initially modelled conceptually as a network optimization problem with about a billion variables. Such problems are too large to solve using today's largest supercomputers, but after devising several computational refinements, we were able to solve it in under 10 minutes on a 386-based personal computer. This work, which subsequently won the Koopman prize, is the basis for a current project to assign new recruits to training schools. The new problem has the complicating feature of several non-network constraints, brought on by minority and other equity considerations. We will have a new program ready for Marine Corps testing early in 1991.

THESIS DIRECTED: Wolfgang Maskos, MAJ, German Army, "A Recruit Distribution Model for the U.S. Marine Corps," Masters Thesis in Operations Research, in progress.

BATTLE GROUP LOGISTICS COORDINATOR SUPPORT SYSTEM

D.A. Schrady, Professor of Operations Research
D.B. Wadsworth, CDR, SC, USN
Sponsor: Commander Second Fleet (C2F)
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this research was to develop a micro-processor based system of data, planning factors, and models to plan, track, and predict the usage and replenishment of fuels and ordnance in carrier battle group operations in support of the logistics coordinator and the commander.

SUMMARY: Development of models, planning factors and data were documented earlier (Technical Report NPS-55-90-02PR, October 1989, SECRET) and incorporated in a user friendly, menu driven program of over 10,000 lines of code. The program, Battle Group Logistics Coordinator Support System (BGLCSS) was evaluated by the investigators in C2F fleet exercise 3-90 in June 1990 with very good results obtained. In C2F fleet exercise 1-91/2-91 in November 1990, the investigators supported the Fleet Logistics Coordinator, COMLOGRON TWO, in his use of the system throughout the exercise. As the 1-91/2-91 exercise involved two battle groups, it was verified that BGLCSS could handle a battle force as well as a battle group. Commander Second Fleet, VADM Kalleres, noted that "a new standard had been set in logistic support planning and execution that has enhanced not only Fleet exercises but also battle group planning." A draft BGLCSS User's Guide has been written and, when evaluated, will be offered for inclusion in the C2F Fleet/Force/Battle Group Logistic Coordinator TACMEMO.

PUBLICATIONS: D.A. Schrady, "Running Out Of Ordnance Is An Absolute Combat Stopper," Navy Underway Replenishment Journal, Spring 1990. Also published in the OP-04 Navy Operational Logistics NEWSLETTER, July 1990.

D.A. Schrady, D.B. Wadsworth, R.G. Laverty and W.S. Bednarski, "Predicting Ship Fuel Consumption," Naval Postgraduate School Technical Report NPS-OR-91-3, October 1990.

CONFERENCE PRESENTATIONS: D.A. Schrady and D.B. Wadsworth, "Amateurs Discuss Tactics: Professionals Study Logistics," Seventh International Symposium on Military Operational Research (Combat Logistics and Support), Royal Military College of Science, 4 September 1990. Also presented at the SACLANT NATO Naval Operations Research Symposium, Norfolk, 11 October 1990.

THESES DIRECTED: K.R. Cheezum, LCDR, USN, "Defensive Screen Degradation versus CLF Vulnerability During Underway Replenishment," Masters Thesis, September 1990.

W.S. Bednarski, LT, USN, "Amphibious Logistic Planning Factors and Fuel Curve Smoothing," Masters Thesis, September 1990.

R.G. Laverty, LT, USN, "F-76 Consumption Function Inputs To and Recommendations for Further Development of the Battle Group Logistics Coordinator Support System," Masters Thesis, September 1990.

OTHER: A draft BGLCSS User's Guide (230+ pages) has been completed and will be evaluated by users during Winter Quarter FY91. Publication in April 1991 is scheduled.

IMPROVED SUPPORT TO C^{3}I REQUIREMENTS DECISIONS

J. Sternberg, Chairman EW Academic Group
C.R. Jones, Chairman C3 Academic Group
M.G. Sovereign, Professor of Operations Research
Sponsor: OP94 and OP76
Funding: Naval Postgraduate School

OBJECTIVE: Design and development of a prototype war game to permit DON decision makers to relate the products of C^{3}I systems to warfare effectiveness. Such information will provide needed performance data for C^{3}I system selection decisions.

SUMMARY: The initial specifications for the war game have been completed and contractor support obtained. Software development is ongoing focusing on the AAW Warfare area. Initial play of the war game is anticipated in the Spring of 1991.

The work during 1990 focused on development of the game and supporting analyses and so did not result in any professional reports or papers. Following is a summary of documentation that was produced during 1990.

1. Statement of Work (SOW) and "Request for Proposals" package for Software Procurement now in progress. SOW completed 30 Jan 1990.

2. Working Paper No. 6. The approach to the analysis of war game results to make them useful in supporting requirements decisions.

3. C^{3}ICM Project Working Paper No. 7. "Calculations of Expected Bomber Detection Range Using the Basic Chainsaw Tactic."

This describes a scheme of Numerical Integration and an analytic approximation for precisely estimating expected detection ranges as a function of chainsaw configuration and bomber approach axis. Provides inputs to the war game.

PRESENTATIONS: Briefings in Wash, D.C. The concept for the unique approach of this project was briefed at OPNAV, SPAWAR and CNA to those people concerned with the assessment of non-organic C^{3}I systems. Part of our objective was to lay the groundwork for future funding support for the project.

•OP-942 E. CPT Paul Fraser, head of Space and Electronic Warfare.

•OP-76 CPT Tom Ford and staff, head of Electronic Warfare Division.

•SPAWAR 30 CPT (and RADM (SEL)) Wisely, head of Warfare Sys Architecture & Eng. Directorate.

RADM (SEL) George Wagner, Warfare Systems Engineering.

C3 ANALYSIS METHODOLOGY

M.P. Bailey, Assistant Professor of Operations Research
M.G. Sovereign, Professor of Operations Research
W. Kemple, Assistant Professor of Operations Research
Sponsor: MCCDC Warfighting Center, USMC
Funding: MCCDC Warfighting Center, USMC

OBJECTIVE: The objective of this study is to support the USMC in allocating frequency hopping radios within the MAGTF organization.

SUMMARY: The USMC is in the process of upgrading its tactical communications equipment by purchasing new frequency hopping radios SINCGARS, PRC-117) which are intended to replace the currently deployed single-channel radio (PRC-77). Due to fiscal constraints, the USMC is unable to replace radios on a one-for-one basis. Furthermore, the networking and collocation of radios becomes rather complex if the radios are SINCGARS. The SINCGARS is believed to afford higher security, and greater MTBF. Our study will attempt to produce: 1) optimal allocation of SINCGARS within MAGTF organizational structures; 2) optimal networking of radios in the mixed SINCGARS/single-channel environment.

To achieve this end, the system of radios, messages, and tasks will be modeled using discrete event simulation. The simulation system will be produced in MODSIM, an object oriented simulation language. It is hoped that the resulting simulation model will be reusable in the analysis of other USMC C3 problems.

The model for this project has been used in the P.I.'s OA4333 course as an example. The MODSIM language is taught in this course, as well as advanced simulation output analysis.

CONFERENCE PRESENTATIONS: Modeling Opportunities in MAGTF C3, MCCDC-Warfighting Center, Quantico, VA, June 1990 and September 1990.

Object Oriented Simulation Programming, CACI, Inc., LaJolla, CA, June 1990.

OTHER: This project began in November 1990. Two Theses are being supported by this project.

MODELLING SOVIET MILITARY UNITS IN FORCE-ON-FORCE COMBAT

J.G. Taylor, Professor of Operations Research
Sponsor: U.S. Army TRADOC Analysis Center (TRAC),
White Sands Missile Range
Funding: U.S. Army

OBJECTIVE: Support the modelling of Soviet/Soviet-prototype ground-force combat units in the EAGLE model, a new model under development by TRAC-Los Alamos and TRAC FLVN. The specific goal of this research was not to generate any computer code, but to provide a "phenomenological basis" for the modelling of Soviet ground-force combat units in force-on force combat.

SUMMARY: Because of the relatively low level of research effort and the fact that this was an initial effort, the research strategy was to cover a number of topics of interest to the sponsor (using past research results of the principal investigator wherever possible), rather than treat only one topic in greater depth at this time. Considering open-source Russian-language Soviet military materials (mainly books), this research investigated Soviet troop control, correlation of forces and means, and tactical/staff calculations, with emphasis on the correlation of forces and means (sootnosheniye sil i sredstv). Substantive new results concerning the meanings of these important Soviet military concepts and corresponding details were developed.

PUBLICATION: J.G. Taylor, "Some Initial Considerations for Modelling Soviet Military Units in Force-on-Force Combat at the Operational-Tactical Level," NPS Letter Report, September 1990 (152 pages).

MODELLING SOVIET MILITARY UNITS IN FORCE-ON-FORCE COMBAT

J.G. Taylor, Professor of Operations Research
Sponsor: U.S. Army TRADOC Analysis Center (TRAC),
White Sands Missile Range
Funding: U.S. Army

OBJECTIVE: This research was part of a continuing project, whose long term goal is to investigate topics of interest to the Sponsor concerning Soviet control of forces and means. The short term goal of the work at hand was to investigate the Soviet conceptualization of the interconnection and interaction of control of combat means with troop control at various command levels.

SUMMARY: Considering open source Russian language Soviet military materials (mainly books), this research was to investigate a number of topics including the Soviet conceptualization of the interconnections and interactions of control of combat means with troop control at various command levels, with consideration given to the automatic and automated systems that comprise the resultant, single, unified control system. This latter goal was too ambitious and consequently research was focused on the Soviet hierarchy of military control concepts, troop control system, and its automation. The latter topics were essential for investigating the Soviet conceptualization of interconnections and interactions. New important results concerning Soviet military control concepts were obtained with the above focus. In particular, this work further refined the Soviet hierarchy of military control concepts and identified the basic elements of Soviet automated troop control systems. Key for understanding this control hierarchy was investigating the various meanings and nuances in meaning of the Russian word for "control" (upravleniye) and its various synonyms. New important results were also obtained concerning Soviet "linguistic maskirovka."

PUBLICATIONS: J.G. Taylor, "A Tutorial on Soviet Military Operations Research," Proceedings of the 57th Military Operations Research Symposium, forthcoming.

J.G. Taylor, "The Soviet System of Control Posts: Initial Results of Research," NPS Letter Report, March 1990 (25 pages).

J.G. Taylor, "Soviet Control of Combat Means and Troop Control, Phase II: Interconnections and Interactions (Identification of Basic Elements of Automated Systems," NPS Letter Report, December 1990 (303 pages).

J.G. Taylor, "Soviet Troop Control and Maskirovka," American Intelligence Journal, Invited Paper, submitted.

CONFERENCE PRESENTATIONS: J.G. Taylor, "Understanding Soviet Naval Writings," Naval War College, October 18, 1989.

J.G. Taylor, "Developing Reliable Knowledge concerning Soviet Control of Naval Forces," Naval War College, October 18, 1989.

J.G. Taylor, "Soviet Control of Naval Forces: A Simulated View of the Soviet Perspective," Naval War College, October 19, 1989.

THE MINIMUM TOTAL CONFUSION PROBLEM: APPLICATIONS AND ALGORITHMS

E.S. Theise, Assistant Professor of Operations Research and Human Factors
Sponsor: Research Initiation Project, Naval Postgraduate School
Funding: Research Initiation Project, Naval Postgraduate School

OBJECTIVE: To develop and use tools for the analysis of visual, acoustic, and tactile stimulus-response compatibility in human-system interfaces.

SUMMARY: This research is directed towards a systematic study of the confusion matrix, a data construct arising in human factors engineering and applied psychology. The 'applications' portion of the project focuses on the analysis and interpretation of empirically derived confusion matrices, some from the literature and some from experiments to be run in our Human Factors Laboratory. A taxonomy of confusion matrices will also be developed. The 'algorithms' portion of the project focuses on finding exact and approximate solutions to the problem of selecting subsets of stimulus-response pairs having desirable properties, e.g., minimum confusion, maximum recognition, minimum variability, etc. This problem can be formulated as a quadratic binary integer programming problem, but its large size often prevents effective solution using off-the-shelf software. Special purpose optimization algorithms and heuristics are being explored. Platforms for implementation range from personal computers to parallel computers. Results from the project can be applied to console and work station design, voice and handwriting recognition systems, graphical displays, human-computer interface design, coding systems, etc.

PUBLICATIONS: E.S. Theise, "Tabu Search and Subset Selection," in progress.

E.S. Theise, "On the Optimal Selection of Graphic Symbols for Line Graphs," in progress.

E.S. Theise, "Finding a Subset of Stimulus-Response Pairs with Minimum Total Confusion: A Binary Integer Programming Approach," Human Factors 31, 291-305 (June 1989).

CONFERENCE PRESENTATIONS: E.S. Theise, "Tabu Search and Subset Selection," Journes de l'Optimisation 1991, Montreal, Quebec, May 8, 1991.

E.S. Theise, "More with the Minimum Total Confusion Problem," Joint TIMS/ORSA National Meeting, Las Vegas, NV, May 7, 1990.

E.S. Theise, "The Minimum Total Confusion Problem: Application and Solution," Journes de l'Optimisation 1990, Montreal, Quebec, May 4, 1990.

E.S. Theise and E.C. Rosenthal, "The Minimum Total Confusion Problem and Other Models of Stimulus-Response Selection," Joint ORSA/TIMS National Meeting, New York City, NY, October 16, 1989.

E.S. Theise, "Finding a Subset of Stimulus-Response Pairs with Minimum Total Confusion," Joint TIMS/ORSA National Meeting, Washington, DC, April 27, 1988.

AUTOROUTER DEVELOPMENT

A.R. Washburn, Professor of Operations Research
Sponsor: Chief of Naval Operations
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project was to produce a prototype decision aid for finding the optimal route from A to B in two dimensions. Such aids exist, but they are invariably based on using discrete Dynamic Programming to find a global optimum to a rough approximation of the problem. The idea here was to find a local optimum to a more precise approximation.

SUMMARY: The technique employed is essentially the Theory of Optimal Control, except that two point boundary value problems are avoided at the expense of introducing a first order hill climbing technique. Thus the user of the decision aid sees a route from A to B that is always feasible and that gradually warps itself into (local) optimality. The technique is applied to a submarine navigation problem in a MS-DOS diskette distributed with the technical report.

PUBLICATIONS: A.R. Washburn, "Continuous Autorouters, with an Application to Submarines, NPSOR-91-05, October 1990.

FREQUENCY PLANNING

A.R. Washburn, Professor of Operations Research
G.G. Brown, Professor of Operations Research
Sponsor: National Security Agency
Funding: National Security Agency

OBJECTIVE: There are 30 stations, each of which has about 6 receivers that can be assigned to any of 31 frequencies. The goal of this research is to find the allocation of receivers to frequencies (the tasking) that maximizes S, the average number of signals detected.

SUMMARY: There are far too many taskings to permit a solution by exhaustion, and anyway S is such a complicated function of tasking that even evaluating S for a given tasking requires a large amount of computer time. Thus the first object was to find an approximation to S that is both accurate and more amenable to analysis. Several such approximations have been investigated. Given the approximation, two optimization methods have been pursued. The first is local optimization, the idea being to move receivers from one frequency to another until no such swap produces an increase in the objective function. The second utilizes the idea of a "tactic," a tactic being an assignment of receivers to a given frequency (thus a tasking is a collection of 31 tactics, one for each frequency). For any given collection of tactics, the optimization problem can be viewed as an integer programming problem with 0-1 variables. Problems with thousands of tactics are solvable, but even so the set of tactics must necessarily be a sparse subset of the billions of tactics that are feasible. Therefore, the quality of the integer programming solution will be very much dependent on the tactic generator. We have yet to find a tactic generator that will permit the integer programming approach to dominate local optimization, but work will continue in 1991.

SEQUENTIAL ESTIMATION IN RELIABILITY

L.R. Whitaker, Assistant Professor of Operations Research
Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: The primary goal of research was to continue studying both the parametric and nonparametric sequential estimates of age replacement policies. The secondary goal was to extend this research to a broader class of sequential decision problems in particular those that are of interest to the Navy and DOD in general.

SUMMARY: We continued to study both the large and small sample properties of both the nonparametric and parametric sequential estimators of optimal age replacement policies. At the end of FY89 we had not established the weak convergence properties of the nonparametric estimation procedure. This has now been completed. This problem is technically very difficult and it's solution involves considering two dimensional counting processes rather than the usual one dimensional approach. The small sample properties of parametric and nonparametric procedures were studies using very extensive Monte Carlo simulations. Many of the ideas encompassed in this work were then applied to depot level maintenance policies for the M1 tank.

Research is this area took an unexpected turn. Collaboration with Professors Glazebrook and Bailey has lead to a substantially different approach to sequential decision problems that are much more general than the age replacement problem. The approach is Baysian and uses a cost-rate heuristic dynamic program to minimize total discounted costs rather than long run expected costs per unit time.

PUBLICATIONS: K.D. Glazebrook and L.R. Whitaker, "Single Machine Scheduling with Dependent Processing Times," Naval Postgraduate School Technical Report. (1990) (submitted)

K.D. Glazebrook, M. Bailey and L.R. Whitaker, "Cost-Rate Heuristic for Semi-Markov Decision Processes," Naval Postgraduate School Technical Report. (1990)

CONFERENCE PRESENTATIONS: L.R. Whitaker, "Nonparametric Sequential Estimation of Age Replacement Policies," conference invited paper at the Western Regional IMS/WNAR, Bozeman, MT, June 1990.

OTHER: The investigator organized an invited paper session concerning research related to this project entitled "Sequential Decisions" at the Western Regional ISM/WNAR conference.

THESIS DIRECTED: Y.H. Wu, Major, Korean Army, "Sequential Estimation of Age Replacement Policies," Master Thesis, March 1990.

J. Wilhelm, Capt, USA, "An Analysis of NIC Field Exercise Data to Determine an Optimal Depot Level Repair Policy," Master Thesis, September 1990.

V. Oclay, Lt, Turkish Navy, "Sequential Estimation of Age Replacement Policies: Parametric Case," Master Thesis, September 1990.

CONFIDENCE INTERVALS FOR MECHANICAL RELIABILITY

W.M. Woods, Professor of Operations Research
Sponsor: NAVAIRSYSCOM, NAVAIR (5165)
Funding: Naval Postgraduate School

OBJECTIVE: Develop closed form expressions for approximate lower confidence limits for mechanical reliability of the type P(X>y) and P(X>Y) and perform computer simulations to demonstrate their accuracy. Both X and Y are assumed to have normal probability distributions with unknown means and variances and are statistically independent.

SUMMARY: Closed form expressions for approximate lower confidence limits for P(X>y) and P(X>Y) were developed and their accuracies determined by simulation. The accuracy of the expression for P(X>y) was compared with some existing tables known to be accurate and the accuracy of the approximate closed form expressions were found to be very accurate. Two expressions were developed for P(X>Y) corresponding to the two cases: equal variances and unequal variances. Simulations demonstrate that all three closed form expressions are very accurate.

THESES DIRECTED: H. Lee, " Approximate Interval Estimation Methods for the Reliability of Systems Using Component Data with Exponential and Weibull Distributions," September 1989.

W. Yang, "Approximate Interval Methods for Mechanical Reliability," September 1990.

OTHER: The investigator submitted the following two papers for publication:

W.M. Woods and W. Yang, "Lower Confidence Limit Expressions for P(X>y) and P(X>Y) Under Normality," submitted to Technometrics, December 1990.

W.M. Woods, "Equations for Approximate Lower Confidence Limits on Process Capability Indices," submitted to Journal of Quality Technology, December 1990.

CONFIDENCE INTERVALS FOR SYSTEM RELIABILITY

W.M. Woods, Professor of Operations Research
Sponsor: NAVAIRSYSCOM, NAVAIR (5165)
Funding: Naval Postgraduate School

OBJECTIVE: Develop closed form expressions for approximate lower confidence limits for the reliability of complex coherent systems using only attribute test data on the components with the constraint that the expressions developed must be reasonably accurate and amenable to combined use with similar expressions previously developed for coherent systems with continuously operating components whose failure times are exponentially distributed.

SUMMARY: Closed form expressions were developed for the reliability of complex coherent systems that have cyclic (discrete) components using discrete test data only. These expressions use ratios of failure rate estimates and properties of the Poisson distribution and the chi-square distribution in a manner similar to procedures previously developed for complex coherent systems with components that have exponentially distributed failure times. These two procedures can be combined to obtain lower confidence limit procedures for the reliability of complex coherent systems with mixtures of cyclic and continuously operating components using component test data. The discrete interval expressions were evaluated for accuracy using computer simulations and determined to be at least as accurate as other classical procedures when the total number of failures across all components was one or less and much more accurate as the total number of failures increases to 5. The procedures appear to be quite accurate when the total number of failures is 5 or more. The procedures account for differences in failure impact on system performance due to redundancy.

THESES DIRECTED: E. Bellini, "Approximate Interval Estimation Methods for the Reliability of Systems Using Discrete Data," September 1990.

V. Covington, "Lower Confidence Interval Bounds for the Reliability of Coherent Systems with Cyclic Components," September 1990.

OTHER: In the fall of 1990, equations were developed for lower confidence intervals for systems with components whose failure times have Weibull probability distributions. These equations use an improved estimate of the shape parameter in the Weibull distribution and a modified estimate of failure rate ratios which is the common feature of all three interval procedures. This common feature allows the formulation of one interval procedure for the reliability of systems with mixtures of discrete components and continuously operating components whose failure times have either the exponential or Weibull distribution.

RELIABILITY GROWTH MODELS

W.M. Woods, Professor of Operations Research
Sponsor: NAVAIRSYSCOM, NAVAIR (5165)
Funding: Naval Postgraduate School

OBJECTIVE: Determine the affect of failure discounting on the accuracy of a discrete reliability growth model and a modified version of the well known AMSAA reliability growth model. Also develop new expressions for improved estimates of a linear function of the parameters in the discrete model.

SUMMARY: Extensive computer programs were developed that compared reliability growth estimates obtained from randomly generated data using specific failure distributions with the actual (true) growth patterns determined from the input parameters to the specific failure distributions. Two parametric failure discounting methods were formulated and imbedded in the computer programs. The simulations were run with over 140 combinations of discounting and failure distribution parameters. The accuracy results were summarized in graphic form. A users summary was developed for those wanting to use the program to assess the accuracy of either model for hardware specific situations.

CONFERENCE PRESENTATIONS: W.M. Woods, "The Affect of Failure Discounting and Data Weighing on the Accuracy of Some Reliability Growth Models," Reliability and Maintainability Symposium Proceedings, January 1990.

DEPARTMENT
OF
PHYSICS

DEPARTMENT OF PHYSICS

During FY90, the research activities in the Physics department consisted of 29 identified individual projects.

The majority of these projects (75%) were funded through the Navy Direct Funding mechanism. The rest was externally funded as Reimbursable. The direct funded projects involved Navy sponsors in an advisory capacity. These sponsors were NAVSEA, ONR, NRL, NUSC, NRL-USRD, PMS 421 SSP 2340. Non-Navy sponsors of reimbursable funds were DARPA, DNA, NASA, AFSD, SDIO, AFWL.

The projects fall naturally into five groups. They are: 1) Physical Acoustics, 2) Electro-Optics/Infrared Technology, 3) Space and Plasma Physics, 4) Directed Energy and Radiation Physics, and 5) Environmental Physics.

Although broadly based, this research program is the result of a long term carefully orchestrated evolution, designed to explore the physics of areas where modern technology, particularly Naval weapons technology, interfaces and is limited by our understanding of the natural environments. As a group, the department specializes in the physics of the interface between weapon systems and environment. The nature and significance of the research in each area is outlined here. All projects are clearly identifiable in the DoD listing of 20 critical technologies.

PHYSICAL ACOUSTICS

The department has one of the strongest and largest group in physical acoustics in the nation, with 8 faculty members participating in FY90. The research in this area in the department falls into five categories. a) Ocean bubble dynamics, b) Acoustic sensor technology, c) Thermoacoustic energy processes, d) Transducer physics, and e) Wave Turbulence. The interaction of sound and Ocean Bubble swarms is investigated by Professor Atchley which led to the development of a dual frequency method of measuring size spectrum of bubble clouds and the damping constant of bubble oscillations. During FY90, the project continued unfunded at low level.

In the area of sensor technology, work continued on the development of the fiber optic sensor system (Garrett) and the design of the Space Shuttle Vibroacoustic Experiment. Work in the fiber optic sensor system concentrated on a flexural plate, fiber optic, interferometric, acceleration canceling, omnidirectional hydrophone which appears to have the highest sensitivity reported in the literature to date. This year a new ellipsoidal, flextensional interferometric hydrophone design development was continued. Measured sensitivity of both designs are consistent with theoretical predictions.

The work on the system to measure the airborne acoustic noise in the space shuttle cargo bay during the launch phase has been re-scheduled for a FY 1992 launch date.

The work on thermoacoustic energy transfer processes (Atchley, Garrett, Hofler, Larraza) has led to better understanding of the temperature gradient generated in thermoacoustic heat transport devices and experiments measuring the onset of thermally driven acoustics oscillations were made and seem to compare adequately with theory at low acoustic pressure amplitudes. At higher amplitudes an onset of irregularities has been observed. It was found that nonlinear effects are predominant in this region and that the waves show similarities to the earlier results on finite amplitude waves made in this department by Coppens and Sanders. Work has begun on a third generation thermoacoustic refrigerator that can reach a cold temperature of 100 degrees Kelvin.

The work on the development of a thermoacoustic refrigerator for a test on a Shuttle Get Away Special G337 which is now scheduled for sometime in 1991 has continued and the refrigerator is now completed and has been tested and shown to maintain a 72° C temperature difference. It is able to pump a 5.6 Watt heat load at a coefficient-of-performance relative to Carnot of 10% and it can operate autonomously for 300 hours.

The wave turbulence project is a new effort which will attempt to measure the spectral density of wind driven wave turbulence and the phase speed of the waves in order to test certain new theoretical models

of steady state non-linear dynamical systems which are driven far off-equilibrium exhibiting chaotic behavior, (Garrett, Larraza, Denardo). Good agreement has been found between theory and experiment for growth rates of wind driven gravity waves in a laboratory tank. Investigation of localized structures in parametrically driven lattices was carried out and showed these structures to correspond to breathers, kinks, and domain walls.

In the transducer physics area (Wilson, Baker) work continued on the investigation of the usefulness of the Delta-Z method for monitoring the sensitivity of in-service sonar transducers installed in domes which can be flooded and purged. The method has been developed into a state of the art computer-controlled measuring system and has been used on the AN/BQQ-6 sonar system on Trident submarines. The importance of this work lies in the ability to test large sonar system arrays on submarines in-situ avoiding the very costly dry-docking of the submarine for that purpose. The development of a compact apparatus to measure both the complex bulk modulus and the complex mass density of a fluid contained in rigid porous solid has proceeded and different ways of measuring and extracting the complex effective mass have been compared. The Delta-Z method has been used for in-situ reciprocity calibration of sonar transducers and the sensitivity of the results to air-water temperature differences has been investigated. The compact Complex Immittance Measurement System which had been developed in previous years has been adapted to monitor the DT-605 hydrophone and has been used to monitor the performance of the spherical array of DT-574 hydrophones aboard the USS Ohio. The work on the application of the finite element computer codes ATILA and CHIFF to performance modeling of sonar arrays has continued with the adaptation of the code to model the DT-276A hydrophone.

A cooperative program between Baker and Canright and Scandrett from the mathematic department is seeking to exploit the T-Matrix method for low frequency active sonar array performance prediction. In a new not funded project the use of sympathetic resonators in a transducer array to improve the sonar transducer performance was investigated. An increased gain of radiation resistance of almost a factor of two seems possible, which translates into directivity.

ELECTRO-OPTICS/INFRARED SENSOR TECHNOLOGY

The work in this area is concentrated in the Naval Center for Infrared Technology (NACIT) at NPS which is led by Professor A. Cooper. Work continued in four areas: The NACIT Infrared Search and Target Designation Research (Cooper, Cleary, Crittenden, Lentz, Walker) seeks to establish a program of measurement of target and background scenes for analysis, development and of validation of detection and background suppression algorithms and for evaluation of IRST technology. The program revolves around the NPS modified Advanced Demonstration Model IRSTD system supported by the Navy's AN/SAR-project office. The system has been augmented with a high speed TV digitization board and desk top computer for raster scan display. This year an interface was constructed that allows near real time scene display. Measurement exercises were carried out in which signature of calibration target, sky and land background scenes and aircraft targets at close range were analyzed and the detector channel compensation and Target enhancement features were shown to be effective for close targets. Measured ranges had been compared with predictions and had shown serious discrepancies. During FY90 two further D-3 overflight experiments were carried out with additional instrumentation to add to the data base of ship signatures, sea and sky radiance for evaluation of target-sea surface temperature contrast models.

The Off-Board Countermeasures Program (Cooper, Crittenden, Milne, Rodeback, Lentz) is to carry out simulation analyses of performance and tactics for off-board decoys, development of hardware components for off-board devices and evaluation of passive ship defense techniques. A laser altimeter has been developed and tested from the Golden Gate Bridge at various sea states. Reflection measurements from the sea surface for nearly ocean like waves have shown that the probability distribution of the returned intensity differs from reported distributions in the literature. During this year the dependence of the signal amplitude probability distribution and the periods of zero return signals on the sea surface state and the displacement from vertical incidence were investigated with encouraging results for the operational usefulness of the laser altimeter.

The Evaluation and Validation of FLIR Performance models (Cooper, Milne, Crittenden, Lentz, Walker) centered on the participation in experimental comparison observations involving overflights of FLIR carrying Naval aircraft, with code predictions. An evaluation has been made of the sensitivity of the UFLIR code to variations in input and environmental parameters of the variability of the predicted ranges to the

variation of radiosonde data in the operational area. These experiments were continued in FY90.

A new effort was started by Davis on Infrared Image spectroscopy and its applications. A new method of image encoding, based on encoding of spatially distributed irradiance patterns with orthogonal functions was developed in order to demonstrate the feasibility of a new approach to efficient multiplexed imaging and to develop a prototype imaging spectrometer for remote sensing problems, such as target infrared signature measurements.

SPACE AND PLASMA PHYSICS

Research in this area spans a wide array of phenomena where plasma processes at the interface between man made devices and their respective environments have detrimental effects on the devices and where a thorough understanding of these processes is necessary before hardening strategies can be developed. Investigation of Plasma Heating Processes near the Plasmapause of the earth's magnetosphere was carried out by Olsen and Gnanalingam to determine the total density and the contributions of hot and cold ion populations, using existing satellite data. Most recently data taken by the SCATHA satellite near geosynchronous orbit were analyzed. Of direct relevance to satellite survival is the investigation of methods for Satellite Charge Control with on board electron and ion sources (Olsen, Gnanalingam). Data from earlier satellite experiments were analyzed. Data analysis from SPEAR I, a space power rocket experiment to determine the response of the rocket body to high voltages applied to a deployed boom was completed. The vehicle potential was obtained for all bias operation sequences. A linear relation between sphere bias and current collected was found. The rocket body appears to be grounded to the external plasma by the neutral gas from the altitude control system.

Another effort is the investigation of data from the ISEE satellite which showed resonance plasma waves which were induced by an electron beam in the magnetospheric plasma which appear at the local plasma and upper hybrid resonance frequency. There also appears a feature which seems to result from interactions between the beam and the local photon-electron cloud.

Design and laboratory work for a hollow cathode charge control prototype device to be flown on the POLAR satellite in 1993 has been completed and tested. Laboratory work toward a solid state ion source was initiated.

More down to earth Professor Schwirzke is investigating the unipolar arcing as a basic, potentially dangerous laser damage mechanism for the vulnerability to Laser Directed Energy Weapon Systems. These basic phenomena are of equal importance in plasma opening switches which are considered for application in high power short pulse Directed Energy Systems. This year energy and momentum coupling to conducting target materials were investigated, and the basic phenomenon of unipolar arcing catering has now been seen on the cathode surface of the high power vacuum diode of the NPS Flash X-ray facility. Experiments have now confirmed that the high current density of the unipolar arc provides the explosive plasma formation of a cathode spot.

Finally, a new initiative begun in the previous year by Prof. Cleary has had significant success. The middle UV Spectrometer for the development of an eventually revolutionary technique for measuring global ionospheric electron densities from a space based platform has been built and was flown on a rocket in March 90. The experiment yielded about 8000 spectra at altitudes from 100 Km to 320 Km. Preliminary analysis has proven the feasibility of the concept.

DIRECTED ENERGY BEAMS/RADIATION PHYSICS

Our Directed Energy Beam and Radiation Physics Group consisting of Professors Buskirk (em.), Neighbors, Maruyama and Colson is now concentrated on two large experimental facilities, the Linear Accelerator, a high energy (120 MeV), low current machine which has been working and producing results since 1965 and the new Flash X-Ray Pulse Power Facility, a low energy (1.8 MeV) high current (35 KA) Pulserad 112A machine, which is now operational. The FXR was put into operation and characterization of its performance has been completed and the complete suite of instrumentation has been installed, tested, and calibrated. This year most of the effort has gone into noise suppression which has been achieved with 5 mV peak-to-peak background level. The facility is now capable of meaningful TREE experiments.

The LINAC facility has been used in cooperation with researchers from the Texas Center for Superconductivity to study the effects of electron radiation on one of the high temperature superconductors $YBa_2 Cu_3 O_{7-\tau}$ It was found that the defects responsible for degradation of the critical current must be macroscopic and that large anisotropic cluster defects induced by irradiation are more effective for flux pinning than small isotropic defects.

The work on optical transition radiation has continued with the development of practical compact instrumentation for determination of beam position, profile, intensity, angular divergence and energy. This technology has potential for wide application in directed energy systems and commercial applications.

Other measurements made this year with the LINAC were measurement of the absolute and relative cross section for elastic scattering of electrons from protons giving a rms proton charge radius of 0.865 ± 0.020 fm. Also measurements of intensity and polarization of RF radiation in the near and far field of the pulsed beam wave made and compared with theoretical models. A new activity in the department is our Free Electron Laser Simulation Laboratory led by Prof. Colson an internationally known expert in this field. Computational simulations were used to examine electron trajectories in the undulator of FEL's, the trapped particle instability, simple models of high power FEL's and evaluation of compact FEL's. The simulation of the trapped particle instability and limit cycle behavior showed good agreement with recent experimental observations at Stanford. Studies of limitations on compact FEL designs, the gain spectrum spikes of high power FEL amplifiers were done in collaboration with Los Alamos for space based FEL's.

ENVIRONMENTAL PHYSICS

The research in this area falls in three categories: characterization of atmospheric optical turbulence, remote sensing of the lower earth thermosphere and investigation of flow and dispersion of hazardous gas plumes. The Optical Atmospheric Turbulence work is carried out by Professor Walters. The program provides continuous support the Air Force by providing measurements and assessment of atmospheric distortions for the Strategic Defense Initiative program using instrumentation for measuring modulation transfer function, isoplantic angle, acoustics sounder and rawinsonde systems to characterize the entire troposphere. These instrumentations were used in particular to characterize the atmosphere above the Pacific coastal mountain range to find sites with very low optical turbulence degradation. NPS research in this field has made it the principal source of data for decision processes directed by SDIO together with NASA, ONR, and NRL. A continuous program of such measurements was carried out to aid the optimal site selection for the new western U.S. Naval Observatory. A significant result was the discovery that rawinsonde data are often contaminated by solar heating effects. A new sensor system for atmospheric characterization measurements in connection with the Air Force's relay mirror experiment was developed and built. The long existing program of investigation of airflow and dispersion patterns of hazardous gaseous plumes has continued (Schacher, Kamada, Skupniewicz). These investigations involving meteorological field measurements and computer models have now resulted in the completion of the Vandenberg AFB Meteorological Plume Dispersion Handbook. A mesoscale prognostic windflow model and models of slope flow and seabreeze physics have been added to the arsenal of models.

BASIC RESEARCH IN THERMOACOUSTIC HEAT TRANSPORT (FY 1990)

A.A. Atchley, Associate Professor of Physics
T.J. Hofler, Adjunct Research Professor of Physics
Sponsor: Office of Naval Research, Physics Division

OBJECTIVE: The main objective of this project is to conduct basic research in thermoacoustic heat transport.

SUMMARY: Our primary emphasis in FY 1990 was the investigation of thermoacoustic prime movers. Extensive measurements were made below the onset of self oscillation. The results were analyzed in two different ways. The first way uses an energy approach discussed by Swift. The second way is a wave propagation approach which treats the prime mover as a porous medium. We also made measurements above the onset of self oscillation, finding that nonlinear effects are prominent. We began to investigate ways to separate apparent inadequacies of the theory of thermoacoustics from phenomena caused by nonlinear acoustic affects. In addition, we began to study the performance of thermoacoustic heat engines that operate with an acoustic sound field that is not a perfect standing wave. Finally, we extended our previous measurements of thermoacoustic phenomena using thermoacoustic couples (TACs).

PUBLICATIONS: A. A. Atchley, T. J. Hofler, M. L. Muzzerall, M. D. Kite, and C. Ao, "Acoustically generated temperature gradients in short plates," J. Acoust. Soc. Am. 88, 251-263, (1990). A. A. Atchley, H. E. Bass and T. J. Hofler, "Development of nonlinear waves in a thermoacoustic prime mover," Frontiers of Nonlinear Acoustics 12th ISNA, edited M. F. Hamilton and D. T. Blackstock (Elsevier Applied Science, New York, 1990), pp. 603-608. A. A. Atchley and T. J. Hofler, "Annual summary of basic research in thermoacoustic heat transport: 1990," Naval Postgraduate School Report Number NPS PH-91-002PR, 30 pages, October 1990.

CONFERENCE PRESENTATIONS: H. E. Bass, A. A. Atchley and T. J. Hofler, "Study of a parallel plate thermoacoustic prime mover," J. Acoust. Soc. Am. 88, Suppl. 1, S95(A) (1990). A. A. Atchley, H. E. Bass and T. J. Hofler, "Development of nonlinear waves in a thermoacoustic prime mover," Frontiers of Nonlinear Acoustics 12th ISNA, edited M. F. Hamilton and D. T. Blackstock (Elsevier Applied Science, New York, 1990), pp. 603-608. A. A. Atchley and T. J. Hofler, "Thermoacoustic heat pumps," J. Acoust. Soc. Am. 87, Suppl. 1, S32(A) (1990). A. A. Atchley, S. L. Garrett and T. J. Hofler, "Thermoacoustic Heat Transport: Explanations, Demonstrations and Applications," Abstracts of Papers for the 156th National Meeting of the American Association for the Advancement of Science, 45 (1990).

THESIS DIRECTED: W. Liu, LCDR, Taiwan Navy, "Investigation of Edge Effects in Thermoacoustic Couples." MS Engineering Acoustics, Dec. 1990. P. Fisher, LT, USN, "Numerical Investigation of a Thermoacoustic Generator" MS Physics, June 1990.

APPLICATION OF THE T-MATRIX METHOD TO LOW FREQUENCY ACTIVE ARRAY PERFORMANCE PREDICTION

S. R. Baker, Assistant Professor of Physics
D. R. Canright, Assistant Professor of Mathematics
C. L. Scandrett, Assistant Professor of Mathematics
Sponsor: Naval Underwater Systems Center
Funding: Naval Postgraduate School

OBJECTIVE: The objective is to produce an economical yet complete description of sonar array performance, with specific application to dense, low frequency active arrays. This is a new project.

SUMMARY: The method employed is an extension of the T-matrix method, which has been previously applied to scattering problems, but has not heretofore been applied to the problem of coupled electroacoustic transducers. The T-matrix method is used to obtain the mutual radiation impedance matrix of an array of interacting elements. Multiple scattering to all orders is rigorously included, so that arbitrarily dense arrays may be described. Each element may be represented analytically in the simplest cases, or may be described more generally by a finite-element model.

Professors Canright and Scandrett have successfully derived the analytical representation of the mutual radiation impedance matrix for an array of spheres, and have validated this model for an array composed of three closely-spaced, identical spherical shell radiators.

Professor Baker has developed a procedure whereby an assembled finite-element matrix, which describes the structure in terms of nodal degrees of freedom, can be reduced to a dynamical matrix describing the structure in terms of the normal velocity and pressure on its (spherical) bounding surface, with the coefficients of the spherical harmonics as degrees of freedom.

For her Masters degree thesis research, LT Kathleen McLean applied the procedure to an axisymmetric finite-element model of a hollow piezoelectric spherical shell. Plans for FY91 include applying the procedure to a full three-dimensional finite-element model.

PUBLICATIONS: D. R. Canright and C. L. Scandrett, "Acoustical Interactions in Arrays of Spherical Elastic Shells", submitted for publication.

CONFERENCE PRESENTATIONS: K. A. McLean, S. R. Baker, C. L. Scandrett, D. R. Canright, and E. Kuntsal, "Numerical modeling of arbitrarily dense active sonar arrays", presented at the Second International Workshop on Power Transducers for Sonics and Ultrasonics, 12-13 June, 1990, Toulon, France.

THESIS DIRECTED: LT Kathleen McLean, USN, "Transformation of a finite-element model of a piezoelectric spherical shell transducer from a nodal to a spherical harmonic function representation", MS Physics (Nucl. Weaps. Effects), June 1990.

CONTINUED DEVELOPMENT OF AUTOMATED METHODS FOR IN-SERVICE SONAR TRANSDUCER PERFORMANCE MONITORING

S. R. Baker, Assistant Professor of Physics
O. B. Wilson, Professor of Physics
Sponsor: NAVSEA
Funding: NAVSEA and NPS

OBJECTIVE: The objective of this research program is to develop and apply automated methods for in-service sonar transducer performance monitoring. This is a continuing project.

SUMMARY: Projects were completed in FY90 in the continued development of the Complex Immittance Measurement (CIM) System and the Delta-Z Reciprocity Calibration Method.

Under the direction of Professors Baker and Wilson, for his Masters degree research LT Charles Piersall completed the construction and testing of a new automated switchbox for use with the CIM System. The switchbox is built into an aluminum attache case the same size as the CIM test unit, and now communicates with it exclusively via an IEEE-488 interface, eliminating the multiple connections of the previous switchbox.

For his Masters degree research, LT David Waugh adapted an efficient pole-zero curve-fitting algorithm to model the input electrical impedance of the DT-605 hydrophone, from which are found the values of the elements in an equivalent circuit model of the transducer. The goal of this project is to monitor the values of the elements representing the internal mechanical structure to detect degradation caused by oil seepage into the compliant vibration isolation material.

For his Masters degree research, LT Ted Janacek successfully applied the Delta-Z Reciprocity Calibration procedure to a small flextensional transducer.

PUBLICATIONS: S. R. Baker, R. Bedard, M. D. Patton, and O. B. Wilson, "Reciprocity calibration of a sonar transducer from electrical impedance measurements in water and in air: the Delta-Z reciprocity calibration method", Proceedings of the First French Conference on Acoustics, 10-13 April 1990, Lyon, France, published in Colloque de Physique, Colloque C2, 51-S2, C2-1291 (1990).
Theodore K. Janacek and Steven R. Baker, "Reciprocity calibration of a flextensional transducer by the Delta-Z Method", Journal of the Acoustical Society of America, Volume 88, Supplement S1, p. S136 (1990).

CONFERENCE PRESENTATIONS: S. R. Baker, R. Bedard, M. D. Patton, and O. B. Wilson, "Reciprocity calibration of a sonar transducer from electrical impedance measurements in water and in air: the Delta-Z reciprocity calibration method", Presented at the First French Conference on Acoustics, 10-13 April 1990, Lyon, France.

T. K. Janacek and S. R. Baker, "Reciprocity calibration of a flextensional transducer from electrical impedance measurements in water and in air: the Delta-Z Reciprocity Calibration Method", presented at the Second International Workshop on Power Transducers for Sonics and Ultrasonics, 12-13 June, 1990, Toulon, France.

Theodore K. Janacek and Steven R. Baker, "Reciprocity calibration of a flextensional transducer by the Delta-Z Method", presented at the 120th Meeting of the Acoustical Society of America, San Diego, CA, Nov 1990.

THESES DIRECTED: LT Dave Waugh, USN, "Application of the Complex Immittance Measurement System to the DT-605 hydrophone", MS Sys. Tech. (ASW), Mar 1990.

LT Ted Janacek, USN, "Reciprocity calibration of a flextensional transducer by the Delta-Z Method", MS Physics (Weap. Science), Jun 1990.

LT Chuck Piersall, USN, "A computer-controlled multiple-transducer switchbox for the Complex Immittance Measurement System", MS Sys. Tech. (ASW), Sept 1990.

INVESTIGATION OF THE USE OF SYMPATHETIC RESONATORS TO IMPROVE SONAR TRANSDUCER PERFORMANCE

S. R. Baker, Assistant Professor of Physics

Sponsor: Unsponsored in FY90

OBJECTIVE: The objective of this project is to establish the feasibility of using an array of sympathetic resonators in the vicinity of a sonar transducer to improve its performance. This is a new project.

SUMMARY: Under the direction of Professor Baker, for his Masters thesis research LT John Ellsworth performed an analysis of the achievable gain in the radiation resistance and directivity of a low frequency underwater transducer due to the nearby presence of an array of sympathetic resonators. The resonators were all taken to be air bubbles of radius a ($<<1$), equally spaced around a circle of radius R. The transducer was taken to be of radius a_0 ($<<1$), located on the axis of the circle. The gain was calculated for various numbers of resonators as a function of ka_0 ka, and kR, for the transducer in the plane of the resonators and out of the plane a distance of one-quarter wavelength. It was found that for the transducer in the plane, a gain in radiation resistance of almost a factor of two is possible with approximately six or more resonators. It was found that for the transducer out of the plane, some directivity can be achieved at the expense of a slight amount of radiation resistance.

Plans for FY91 include calculating the gain in performance for a linear array of sympathetic resonators, and to initiate an experiment to verify the calculations.

PUBLICATIONS: John M. Ellsworth and Steven R. Baker, "On the use of sympathetic resonators to improve the performance of a low frequency underwater projector", Journal of the Acoustical Society of America, Volume **88**, Supplement **S1**, p. S137 (1990).

CONFERENCE PRESENTATIONS: John M. Ellsworth and Steven R. Baker, "On the use of sympathetic resonators to improve the performance of a low frequency underwater projector", presented at the 120th Meeting of the Acoustical Society of America, San Diego, CA, November 1990.

THESIS DIRECTED: LT John Ellsworth, USN, "On the use of sympathetic resonators to improve low frequency transducer performance", MS Engr. Acoust. and MS Sys. Tech. (ASW), September 1990.

MODELING OF SONAR TRANSDUCERS AND ACOUSTIC FIELDS USING FINITE-ELEMENT METHODS

S. R. Baker, Assistant Professor of Physics
O. B. Wilson, Professor of Physics
Sponsor: NRL-USRD
Funding: Naval Postgraduate School

OBJECTIVE: The objective of this project is to apply finite-element computer codes, primarily ATILA and CHIEF, to model transducers, arrays, and acoustic fields. This is a continuing project.

SUMMARY: Two projects were completed in FY90. Under the direction of Professors Baker and Wilson, for his Masters degree research, LT Ralph Ward conducted a finite-element analysis of the redesigned DT-276 hydrophone using the ATILA code to determine whether to expect any of its properties which are measured by the Complex Immittance Measurement System to be substantially changed, and for what physical reason. He found some slight differences in the calculated vibration patterns owing to the difference in the construction of the cable feedthrough. He validated the models of the old and new design against experimental electrical impedance measurements. For his Masters degree research, LT Mike Brown applied the ATILA finite-element code to compute the two-port reciprocal network parameters, the radiation impedance, and the diffraction constant of the DT-574 hydrophone.

PUBLICATIONS: M. W. Brown, K.A. McLean, E. Kuntsal, S. R.Baker, and O. B. Wilson, "Computation of the reciprocal network parameters of a piezoelectric transducer using the ATILA finite-element code", Journal of the Acoustical Society of America, Volume 87, Supplement S1, p. S127 (1990).

CONFERENCE PRESENTATIONS: M. W. Brown, K. A. McLean, E. Kuntsal, S. R. Baker, and O. B. Wilson, "Computation of the reciprocal network parameters of a piezoelectric transducer using the ATILA finite-element code", presented at the 119th Meeting of the Acoustical Society of America, State College, PA, May 1990.

M. W. Brown, E. Kuntsal, S. R. Baker, and O. B. Wilson, "Computation of the reciprocal network parameters of a piezoelectric transducer using the ATILA finite-element code", presented at the companion conference on the use of the ATILA finite-element code, 14 June, 1990, Toulon, France.

THESES DIRECTED: LT Mike Brown, USN, "Calculation of the two-port network parameters for the DT-574 using the ATILA finite-element computer code", MS Physics (Weap. Science), December 1989.

LT Ralph Ward, USN, "Finite-element analysis of the DT-276A hydrophone", MS Physics (Weap. Science), December 1989.

A SOUNDING ROCKET EXPERIMENT FOR REMOTE SENSING THE IONOSPHERE

David D. Cleary, Assistant Professor of Physics
S. Gnanalingam, Adjunct Professor of Physics
Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: This is an ongoing research project with the objective of developing a simple technique for measuring global ionospheric electron densities from a space based platform. The short term goal of this project was to obtain ultraviolet spectra of the Earth's ionospheric dayglow. The long term objective is to identify ultraviolet atmospheric emissions that can be used to infer electron density profiles with the aid of photochemical and radiative transfer models.

SUMMARY: A middle ultraviolet spectrometer was developed and calibrated in the NPS Physics laboratory, and launched on a NASA sounding rocket on March 30, 1990, at the White Sands Missile Range, NM. The rocket experiment yielded approximately 8000 spectra between the altitudes 100 km and 320 km. A preliminary analysis of these spectra has produced the density profile of nitric oxide, and the emission profiles of the OI 2972-Å and OII 2470-Å multiplets. Further analysis of these and other emission features will be used to infer the electron density profile of the ionosphere.

CONFERENCE PRESENTATIONS: S. Gnanalingam and D. D. Cleary, "The Middle Ultraviolet Spectrograph of the HIRAAS/MUSTANG Rocket Experiment", Fall Meeting of the American Geophysical Union, December 3, 1990.

D. D. Cleary, S. Gnanalingam, C. K. Anderson, J.J. Clayton, R. P. McCoy, K. F. Dymond, "Preliminary Results from the Middle Ultraviolet Spectrograph of the HIRAAS/MUSTANG Sounding Rocket Experiment", Fall Meeting of the American Geophysical Union, 4 December, 1990.

THESES DIRECTED: James L. Bosserman, LT USN, "Analysis of Thermospheric Dayglow Spectra from the Spacelab 1 Shuttle Mission", Master Thesis, December 1989.

Gary M. Danczyk, CPT, USA, "Identification of Thermospheric Dayglow Emissions for the MUSTANG Experiment", Master Thesis, December 1989.

Richard Campbell, LT, USN, "Development and Integration of the NPS Middle Ultraviolet Spectrograph with an Extreme Ultraviolet Spectrograph", Master Thesis, December 1989.

Michael J. Clayton, LT, USN, "Analysis of the Ultraviolet Emissions of Nitric Oxide from Mid-Latitude Rocket Observations", Master Thesis, June 1990.

Carl K. Andersen, LT, USCG, "Calibration of the Naval Postgraduate School Middle Ultraviolet Spectrograph and an Analysis of the OII 2470 Å and OI 2972 Å Emissions Obtained from Mid-Latitude Rocket Observations", Master Thesis, September 1990.

James W. Nichols, MAJ, USA, "The Design of a New Far Ultraviolet Interferometer for Ionospheric Spectroscopy", Master Thesis, December 1990.

FREE ELECTRON LASER RESEARCH

W.B. Colson, Professor of Physics
J. Blau, Adjunct Professor of Physics
Sponsor: Research Administration Office
Funding: Naval Postgraduate School

OBJECTIVE: Research was proposed that established a free electron laser program at the Naval Postgraduate School.

SUMMARY: Computer simulations were used to examine electron trajectories in the undulator of free electron lasers (FELs), the trapped-particle instability, simple models of high power FELs, and evaluation of compact FELs. This research helped establish an ongoing collaboration with the Tactical FEL Program at Los Alamos National Laboratory.

PUBLICATIONS: W. B. Colson, C. Pellegrini and A. Renieri, editors, "Free Electron Laser Handbook," North-Holland Physics, Elsevier Science Publishing Co. Inc., The Netherlands, December 1990.

D. Oepts and W. B. Colson, "Phase Locking in a Infrared Short-Pulse Free-Electron Laser", IEEE Journal of Quantum Electronics QE-26, 723-730 (1990).

CONFERENCE PRESENTATIONS: J. Blau, "The Effects of Electron Beam Quality on the Free Electron Laser Mechanism," Twelfth International Free Electron Laser Conference, Paris, France, September 16-21, 1990.

D. E. Craun, "Undulator Fields and Electron Trajectories at the End of a Helical Undulator," Twelfth International Free Electron Laser Conference, Paris, France, September 16-21, 1990.

D. Gillingham, "Electron Phase-Space Trajectories in a Linearly-Polarized Undulator," Twelfth International Free Electron Laser Conference, Paris, France, September 16-21, 1990.

G. Cord, "Comparing Simulations and Experimental Observations of the Trapped-Particle Instability and Limit-Cycle Behavior in the Stanford Free Electron Laser," Twelfth International Free Electron Laser Conference, Paris, France, September 16-21, 1990.

THESES DIRECTED: LT D. E. Craun, "Magnetic Fields and Electron Trajectories at the End of a Helical Undulator," December, 1990.

LT D. Gillingham, "Free Electron Laser Single-Particle Dynamics Theory," December, 1990.

SIMULATIONS OF THE STANFORD FREE ELECTRON LASER

W.B. Colson, Professor of Physics
J. Blau, Adjunct Professor of Physics
Sponsor: Stanford University
Funding: High-Energy Physics Laboratory, Stanford University

OBJECTIVE: Several research topics have been proposed in support of the Stanford University free electron lasers (FEL) experiment.

SUMMARY: Recent experiments at Stanford have clearly observed the sidebands of the well-known trapped-particle instability, and have possibly seen limit-cycle behavior for the first time. Simulations at the Naval Postgraduate School have been used to help understand these results. The simulations showed good agreement with the observed optical spectrum evolution and the observed electron spectrum. The total optical power, the sidebands in the optical power spectrum, and the electron spectrum all had periodic oscillating components.

CONFERENCE PRESENTATIONS: G. Cord, "Comparing Simulations and Experimental Observations of the Trapped-Particle Instability and Limit-Cycle Behavior in the Stanford Free Electron Laser," Twelfth International Free Electron Laser Conference, Paris, France, September 16-21, 1990.

RESEARCH ON SPACE-BASED FREE ELECTRON LASERS

W.B. Colson, Professor of Physics, Department of Physics
J. Blau, Adjunct Professor of Physics, Department of Physics
Sponsor: Office of Naval Research
Funding: SDIO

OBJECTIVE: Several research topics supported the SDIO space-based FEL program.

SUMMARY: The topics included the study of quantum limitations to compact FEL designs, gain spectrum spikes in high-power FEL amplifiers, general trends in the development of compact FELs, simple FEL simulations that run on small computers, and FEL optical coherence. The research helped establish an ongoing collaboration with the group developing the Compact FEL at Los Alamos National Laboratory. This FEL technology has long term interest to the Navy.

PUBLICATIONS: W.B. Colson, "A Limitation on the Startup of Compact Free Electron Lasers", Nuclear Instruments and Methods in Physics Research A296, 348-350 (1990).

W.B. Colson, "Gain Spectrum Spikes in FEL Amplifiers", Nuclear Instruments and Methods in Physics Research A296, 400-402 (1990).

W.B. Colson, C. Pellegrini, A. Renieri, and J.M. J. Madey, "Introduction", Chapter 1, pages 1-7, in "Free Electron Laser Handbook", W.B. Colson , C. Pellegrini and A. Renieri (editors), North-Holland Physics, Elsevier Science Publishing Co. Inc., The Netherlands (1990).

W.B. Colson, "Classical Free Electron Laser Theory", Chapter 5, pages 115-194, in "Free Electron Laser Handbook", W.B. Colson, C. Pellegrini and A. Renieri (editors), North-Holland Physics, Elsevier Science Publishing Co. Inc., The Netherlands (1990).

CONFERENCE PRESENTATIONS: W.B. Colson, "A Look at Free Electron Lasers," Keynote Address to the Twelfth International Free Electron Laser Conference, Paris, France, September 16-21, 1990.

D.H. Kiel, "A Simple Macroparticle Model of the High-Current, Strong-Field Free Electron Laser," Twelfth International Free Electron Laser Conference, Paris, France, September 16-21, 1990.

J.H. Park, "A Simple Model of the LLNL ELF FEL Amplifier," Twelfth International Free Electron Laser Conference, Paris, France, September 16-21, 1990.
Randy Souza, "Evaluation of a Compact FEL at 0.4 Wavelength," Twelfth International Free Electron Laser Conference, Paris, France, September 16-21, 1990.

W.B. Colson, "Panel Summary on the Ultimate Free Electron Laser Bandwidth," Twelfth International Free Electron Laser Conference, Paris, France, September 16-21, 1990.

THESES DIRECTED: LT D. H. Kiel, "Two Simple, Nonlinear Models of the Free Electron Laser," December, 1990.

LT Randy Souza, "Evaluation of a Compact FEL at 0.4 Wavelength," December, 1990.

ENVIRONMENTAL EFFECTS ON IR SENSOR SYSTEM

A.W. Cooper, Professor of Physics
E.A. Milne, Associate Professor of Physics
E.C. Crittenden, Jr., Distinguished Professor of Physics
W.J. Lentz, Research Associate of Physics
P.L Walker, Research Physicist of Physics
Sponsor: Naval Oceanographic and Atmospheric Research Laboratory, Atmospheric Directorate
Funding: NOARL - Atmospheric Directorate and NPS

OBJECTIVE: To validate and improve current Tactical Decision Aid (TDA) codes for prediction of performance of operational FLIR devices by comparison of experimental observations with code predictions. To develop and evaluate improvements to existing codes.

SUMMARY: This is a continuing multi-year program, coordinated with NOARL, for evaluation of the operational performance of the Tactical Decision Aids used in aircraft mission planning in the fleet. For several years airborne measurements of detection and recognition range have been made in conjunction with student cruises of the R/V Point Sur. These have been coordinated with experimental measurement of local meteorological parameters and target ship signature. Measured ranges have been compared with predictions using standard fleet TDAs and inputs, and modified codes using locally measured inputs. These comparisons have shown serious discrepancies. In FY90 two further series of P-3 over-flights of the R/V Point Sur were made for FLIR range measurements in conjunction with two meteorology/oceanography student cruises, for which the ship was additionally fitted with an array of thermal sensors. Related infrared images were also taken with an AGEMA Thermovision sensor to add to the data base of ship signatures and sea and sky radiance for evaluation of target-sea surface temperature contrast models. Conversion programs were developed to present ship and background AGEMA thermal images in ASCII and PC Image format for general access. Ship image files were provided to the MKIII TDA program for development of new target ship signature models for inclusion in the TDA. An evaluation was made of the sensitivity of the UFLIR code to variations in input and environmental parameters, and to the time and space variations of radiosonde data within the operational area. This indicated that potential for code improvement exists in the treatment of transference of temperature contrast.

PUBLICATIONS: A.W. Cooper, M.G. Ridgeway, W.J. Lentz, P.L.Walker: "Experimental Validation of
Proceedings of the 1990 IRIS Specialty Group on Passive Sensors; Johns Hopkins Applied Physics Laboratory, Laurel, MD, March 13 - 15, 1990.

A.W. Cooper, M.G. Ridgeway, W.J. Lentz, P.L. Walker; "Modeling of Sea Surface Effects in FLIR Performance Codes"; SPIE Conference Proceedings Vol. 1311, Pages 200-211, 1990.

A.W.Cooper, E.A. Milne, P.L.Walker," Summary Report on FLIR Test Program" ; Technical Report NPS-61-90-002.

CONFERENCE PRESENTATIONS: A.W. Cooper, M.G. Ridgeway, W.J. Lentz, P.L. Walker: "Experimental Validation of FLIR Tactical Decision Aid Programs": 1990 IRIS Specialty Group on Passive Sensors; Applied Physics Laboratory/JHU, March 13 - 15, 1990.

A.W. Cooper, M.G. Ridgeway, W.J.Lentz, P.L.Walker; "Modeling of Sea Surface Effects in FLIR Performance Codes"; SPIE Conference 1311, Characterization, Propagation and Simulation of Infrared Scenes, Orlando, April 16-20, 1990.

THESES DIRECTED: Gregory M. Lawler, LT, USN, "Validation of the Schwartz and Hon Algorithm at Low Grazing Angles"; Master's Thesis, September 1990.

Paul Randall Doyle, LCDR, USN, "An Analysis of the UFLR Prediction Model for Naval Helicopters"; Master's Thesis, September 1990.

NACIT INFRARED SEARCH AND TARGET DESIGNATION RESEARCH

A.W. Cooper, Professor of Physics
W.J. Lentz, Research Associate of Physics
E.C. Crittenden, Jr., Distinguished Professor of Physics
Sponsor: Naval Sea Systems Command PMS-421
Funding: NAVSEA PMS-421 and NPS

OBJECTIVE: To apply the NPS-Infrared Search and Target Designation system to record and analyze background scenes and target signatures for evaluation of target detection and background suppression algorithms, and for evaluation of IRST technology. This is a continuing multi-year project, supported by the Surface Electro-Optics Project Office.

SUMMARY: An IRST system is designed to detect unresolved targets at the greatest feasible range, in the presence of clutter, using background suppression and thresholding. The NPS-IRST has been modified from the SAR-8 Advance Demonstration Model to allow recording of background scene data directly from the detectors, followed by reduced speed play back for permanent storage, display, and computer analysis. Such a system can benefit greatly from real time image display for feature recognition and operator response. The system has been augmented with an adaptation of a commercial high speed TV digitization board and desk-top computer for raster scan display in false color of a selected sector of the rotation. During the year an interface was constructed to bypass the computer bus and allow near real time scene display. Recorded background data from selected regions were also analyzed statistically for irradiance probability density, pulse width probability density (i.e. the spatial frequency spectrum) and autocorrelation function.

PUBLICATIONS: A.W. Cooper, W.J. Lentz, E.D. Bloedel, L. Yee, R.R. Keever, M.A. Polehn, B.E. Northon, R.N. Murata; "Surface IRST Target and Background Measurements at Monterey", Proceedings of 1990 Meeting of IRIS Specialty Group on Targets, Backgrounds and Discrimination, 1990.

A.W. Cooper, W.J. Lentz, R.C. Engel; "Background Measurements using the NPS IRST System"; SPIE Conference Proceedings, Vol 1311, Characterization Propagation and Simulation of Infrared Scenes, pp 200 - 211, 1990.

W.J. Lentz, "Continued Fraction Calculation of Spherical Bessel Functions": Computers in Physics, Jul/Aug 403-407, 1990.

Lentz,W.J., "High Speed Photon Counting Lidar", Optical Remote Sensing of the Atmosphere, 1990 Technical Digest Series Vol. 4, pp. 519-522.

CONFERENCE PRESENTATIONS: A.W. Cooper, W.J.Lentz, E.D.Bloedel, L.Yee, R.R.Keever, M.A.Polehn, B.E.Northen, R.N.Murata; "Surface IRST Target and Background Measurements at Monterey"; IRIS Specialty Group on Targets, Backgrounds and Discrimination, Monterey, CA, 23 - 25 January 1990.

A.W. Cooper, W.J. Lentz, R.C. Engel; "Background Measurements using the NPS IRST System"; SPIE Conference 1311, Characterization propagation and Simulation of Infrared Scenes, Paper 23, Orlando, FA, 16-20 April 1990.

W.J. Lentz, High Speed Photon Counting Lidar" presented at the Optical Society of America Topical Conference on Optical Remote Sensing of the Atmosphere, Incline Village, Nevada, February 12, 1990.

THESES DIRECTED: P.T. Fernan, LT, USN, "Evaluation of a Potential Wave Division Multiplexer (WDM) for use in the IRSTD"; Master's Thesis, December, 1989.

Michael J. Baca, LT, US Coast Guard, "Real Time Imaging of InfraRed Scene Data Generated by the Naval Postgraduate School InfraRed Search and Target Designation (NPS-IRSTD) System" Master's Thesis, September 1990.

SEA SURFACE REFLECTIVITY AND LASER ALTIMETER TESTING

A.W. Cooper, Professor of Physics
E.C. Crittenden, Jr., Distinguished Professor of Physics
E.A. Milne, Associate Professor of Physics
G.W. Rodeback, Associate Professor of Physics
Sponsor: Naval Sea Systems Command
Funding: Naval Postgraduate School

OBJECTIVE: To investigate the reflection of a narrow beam laser altimeter output from the sea surface at normal incidence as a function of sea surface characteristics, and to evaluate the behavior as it affects the performance of disposable laser altimeters.

SUMMARY: In this continuing program a disposable laser altimeter developed earlier was used to measure the reflected signal from the sea surface as represented by the waters beneath the Golden Gate Bridge. This site allowed precise measurements not possible from flying platforms. For short wavelength water waves superimposed on swell the signal amplitude probability distribution showed periods of zero return signal, even for vertical incidence, apparently due to tipping of the average slope. The non-zero signals show an antilog normal probability distribution, skewed toward higher signal than that provided by a normal (Gaussian) distribution. With incidence angle displaced from the vertical, the distribution shape is retained but with more frequent zero reflections. The decrease with angle of the average signal, including the zeroes, is well fitted with a Gram-Charlier distribution, as seen by earlier observers using photographic techniques which masked these details of the structure. For the simpler wave pattern due to a long sustained wind direction, the signal amplitude probability distribution is log-normal with no zero signal periods. At large angles from the vertical the distribution shifts toward exponential. For surface states intermediate between the above two extremes the distribution is often normal. The larger return signals resulting from the skew toward larger amplitudes from lognormal are more favorable for disposable laser altimeters than previously believed. Also for an altimeter which may be swinging from a parachute or balloon, the return at angles from the vertical remains high. The presence of occasional zero return signal does degrade the accuracy of altitude somewhat for a descending altimeter, but the signal available assures performance at larger altitudes than previously expected.

INFRARED IMAGING SPECTROSCOPY AND ITS APPLICATIONS

D.S. Davis, Associate Professor of Physics
Sponsor: NPS Research Initiation Program
Funding: Naval Postgraduate School

OBJECTIVE: This is a continuing project, whose goals are twofold: (1) to demonstrate the feasibility of a new approach to efficient multiplexed imaging, and (2) to develop a prototype imaging spectrometer that will be capable of applying this new technique to remote sensing problems, such as target infrared signature measurements.

SUMMARY: A new method of image encoding, based on encoding of spatially-distributed irradiance patterns with orthogonal functions, is being developed. Unlike other encoding techniques, such as Hadamard or cyclic-redundancy mask approaches, the method under development should prove to be superior in several respects. First, it should be exceedingly sensitive, thereby permitting the imaging of weak sources. Second, it will be very versatile; a wide range of resolutions will be available, and the resolutions in orthogonal directions will be completely independent of one another. Third, the technique should provide excellent thermal background compensation for the extraction of target images that are immersed in a field of ambient thermal radiation. The first objective stated above, that of a feasibility demonstration, has been achieved. The second goal, the development of a working prototype instrument, is now being pursued.

THESIS DIRECTED: R. H. McKenzie III, CPT, USMC, "Image Encoding and Resynthesis with Coupled Walsh Functions", M.S. Thesis, December 1990.

FIBER-OPTIC HYDROPHONE DEVELOPMENT

S.L. Garrett, Professor of Physics

Sponsor: Naval Sea Systems Command - Advanced Technology
Funding: NAVSEA and Naval Postgraduate School

OBJECTIVE: To design, fabricate, and test, a fiber-optic interferometric hydrophone system suitable for hull-mounted submarine sonar applications.

SUMMARY: During this period,two new fiber-optic, push-pull, interferometric omni directional hydrophone designs, fabricated out of castable epoxy, were constructed and calibrated, both at NPS and at the Naval Research Laboratory - Sound Reference Detachment. One of the designs used a four-coil, dual plate design and demonstrated both high acoustical sensitivity and excellent rejection of acceleration. The other design was based on an oblate spheroidal shell with interferometer legs wound around the equatorial and meridional circumferences. The measured sensitivity of both designs were consistent with our theoretical predictions based on solid mechanics and the measured properties of the epoxies. A new method for acoustical measurement of elastic moduli was developed and extended to test the performance of optical fibers in characterizing strain in simple mechanical structures.

PUBLICATIONS: D. A. Brown, T.J. Hofler, and S. L. Garrett, "High-sensitivity, Fiber-optic, Flexural Disk Hydrophone with Reduced Acceleration Response", Fiber and Integrated Optics, Vol. 8, pp. 169-191, October 1989.

D. A. Danielson and S. L. Garrett, "Fiber-optic Ellipsoidal Flextensional Hydrophones", Journal of Lightwave Technology, Vol.7(12), pp. 1995-2002, December 1989.

T. Hofler and S. L. Garrett, "Reply to Comment on "Thermal noise in a fiber optic sensor", [J. Acoust. Soc. Am. 84, 471-475 (1988)], Journal of the Acoustical Society of America, Vol. 87(3), pp. 1363-1364, March 1990.

S.L. Garrett and D. A. Brown, "Fiber-optic Push-pull Hydrophones", in proceedings of DOD Fiber Optics Conference '90, pp. 110-114, March 1990.

S. L. Garrett, "Resonant Acoustic Determination of Elastic Moduli", Journal of the Acoustical Society of America, Vol. 89(1), pp. 210-221, July 1990.

D. A. Brown, and S. L. Garrett, "Fiber Optic Interferometric Flex Disk Accelerometer", in Fiber Optic and Laser Sensors VIII, Proceedings of the Society of Photo-Optical Instrumentation Engineering, Vol. 1367, 7 pages, September 1990, in press.

S. L. Garrett, D. A. Brown, B.L. Beaton, K. Wetterskog, and J. Serocki, "A General Purpose Fiber-optic Interferometric Hydrophone made of Castable Epoxy", in Fiber Optic and Laser Sensors VIII, Proceedings of the Society of Photo-Optical Instrumentation Engineering, Vol. 1367, 17 pages, September 1990, in press.

D. A. Brown, S. L. Garrett, D. V. Conte, R. C. Smith, E. Rothenberg, M. Young and E. Rissberger, "A Fiber Optic Interferometric Ellipsoidal Shell Hydrophone", in Fiber Optic Systems for Mobile Platforms, Proceedings of the Society of Photo-Optical Instrumentation Engineering, Vol. 1369, 7 pages, September 1990, in press.

D. A. Brown and S. L. Garrett, "An Interferometric Differential Strain Sensor: the Smart Strut", in Fiber Optic Smart Structures and Skins III, Proceedings of the Society of Photo-Optical Instrumentation Engineering, Vol. 1370, pp. 262-270, September 1990.

D. A. Brown and S. L. Garrett, "Nondestructive Dynamic Complex Moduli Measurement using a Michelson Fiber Interferometer and a Resonant Bar Technique", in Fiber Optic Smart Structures and Skins III, Proceedings of the Society of Photo-Optical Instrumentation Engineering, Vol. 1370, pp. 238-247, September 1990.

S. L. Garrett, D. A. Brown, K.Wetterskog, B. L. Beaton, and J. Serocki, " A Fiber-optic Acceleration Canceling Hydrophone made of Castable Epoxy (U)", U. S. Navy Journal of Underwater Acoustics, forthcoming.

S. L. Garrett, D. A. Brown, J. Serocki, K. Wetterskog, B. L. Beaton, B. J. Flaskerud, and J.B. Kreijger, "Elastic Moduli of Castable Epoxies for use in Fiber-optic Hydrophones (U)", U. S. Navy Journal of Underwater Acoustics, forthcoming.

CONFERENCE PRESENTATIONS: D.A. Brown and S. L. Garrett, "Fiber-optic Interferometric Differential Strain Sensor: the Smart Strut", in 119th Meeting of the Acoustical Society of America in State College, PA, Journal of the Acoustical Society of America, Vol. 87, p. S45, May 1990.

D. A. Brown, J. E. Olcott, and S. L. Garrett, "A Fiber-optic Interferometric Flex Disk Accelerometer", 119th Meeting of the Acoustical Society of America in State College, PA, Journal of the Acoustical Society of America, Vol. 87, p. S128, May 1990.

J. Serocki, K. Wetterskog, B.L. Beaton, D. A. Brown, and S.L. Garrett, "Static and Dynamic Moduli Measurement and Temperature Dependence for Elastomers and Composites", 119th Meeting of the Acoustical Society of America in State College, PA, Journal of the Acoustical Society of America, Vol. 87, p. S147, p. S32, May 1990.

S. L. Garrett and I. Rudnick, "Modes of a Bar", 119th Meeting of the Acoustical Society of America in State College, PA, Journal of the Acoustical Society of America, Vol. 87, p. S32, May 1990.

S. L. Garrett, "Thermal Noise in Simple Electrical and Mechanical Devices", 120th Meeting of the Acoustical Society of America in San Diego, CA, Journal of the Acoustical Society of America, Vol. 88, pp. S159-S160, November 1990.

S. L. Garrett and D. A. Brown, "Fiber-optic Push-pull Hydrophones", 120th Meeting of the Acoustical Society of America in San Diego, CA, Journal of the Acoustical Society of America, Vol. 88, pp. S64-S65, November 1990.

PATENTS: S. L. Garrett and D.L. Gardner, "Multiple Axis Fiber Optic Interferometric Seismic Sensor", U. S. Pat. No. 4,893,930 (January 16, 1990).

S. L. Garrett and D. A. Danielson, "Flextensional Hydrophone", U. S. Pat. No. 4,951,271 (August 21, 1990).

M. R. Brininstool, T. Hofler, J. T. Newmaster, and S. L. Garrett, "Remote Fiber-optic Angular-orientation Sensor using Phase Detection of two Orthogonal Oscillating Polarization Vectors", U. S. Pat. No. 4,958,072 (September 18, 1990).

T. Hofler and S. L. Garrett, "Flexural Disk Fiber Optic Hydrophone", U. S. Pat. No. 4,959,539 (September 25, 1990).

M. R. Brininstool, J. T. Newmaster, and S. L. Garrett, "Remote Angular Position Sensor Using Four Channel Intensity Summation", Navy Case No. 71,824 application submitted 17 September 1990.

THESES DIRECTED: K. Wetterskog, B. L. Beaton, and J. Serocki "A Fiber-optic Hydrophone made of Castable Epoxy", Masters Thesis, June 1990.

B. J. Flaskerud and J. B. Kreijger, "Calibration and Environmental Testing of a Fiber-optic Hydrophone System", Masters Thesis, December 1990.

NONLINEAR DYNAMICS OF COUPLED OSCILLATORS AND CONTINUA

S.L. Garrett, Professor of Physics
A. Larraza, Adjunct Professor of Physics
B. Denardo, ONT Postdoctoral Student
Sponsor: Office of Naval Research, Physics Division
Funding: Naval Postgraduate School

OBJECTIVE: This is a continuation of the previous year's project. It is intended for experimental and theoretical investigations of nonlinear wave interactions applied to surface gravity waves and to the self focusing mechanisms of localized nonlinear modes, like breathers, kinks, and domain walls.

SUMMARY: Theoretical investigations of nonlinearly interacting random waves driven far off equilibrium led to a two fluid model and to the prediction of a new propagating mode (analogous to second sound in superfluid helium). The design and initial calibration of a dual channel capacitive probe was completed. This probe will be used for phase velocity and energy spectrum measurements in order to test the theory for the case of deep water surface gravity waves. Further theoretical developments have yielded preliminary results of growth rates for wind driven gravity waves that are in qualitative agreement with laboratory tank measurements. Experimental and numerical investigations of localized structures in parametrically driven nonlinear lattices were also conducted. These structures correspond to breathers, kinks, and domain walls between modes of a lattice.

PUBLICATIONS: A. Larraza, S.L. Garrett, and S. Putterman, "Dispersion relations for gravity waves in a deep fluid: Second sound in a stormy sea," Physics Review B, Vol. 41, pp. 3144-3155, March 1990.

B. Denardo, W. Wright, S. Putterman, and A. Larraza, "Observation of a kink soliton on the surface of a liquid," Physics Review Letters, Vol. 64, pp. 1518-1521, March 1990.

CONFERENCE PRESENTATIONS: A. Larraza, S. L. Garrett, and S. Putterman, " Dispersion relations for gravity waves in a deep fluid: Second sound in a stormy sea," 42th annual APS Fluid Dynamics meeting, Bulletin of the American Physical Society, Vol. 34(10), pp. 2276, November 1989.

Andres Larraza and Bruce Denardo, "On nonlinear equations for fields with a level repulsion spectrum," Proceedings of the WASDA IV (Waves and Soliton Days, Antwerp) Conference, August 1990.

A. Larraza, R.K. Yarber, S.L. Garrett and S.J. Putterman, "An experimental search for classical second sound in a system of nonlinear random waves," 119th meeting of the Acoustical Society of America, Journal of the Acoustical Society of America Supplement 1, Vol. 87, pp. S55, V7, May 1990.

Charles McClelland, Bruce Denardo, Andrews Larraza, Alan Greenfield, and Seth Putterman, "Observations of standing solitons in a parametrically driven lattice," 120th meeting of the Acoustical Society of America, Journal of the Acoustical Society of America Supplement 1, Vol. 88, pp. S75, 4PA6, November 1990.

Brian Galvin, Bruce Denardo, and Andres Larraza, "Numerical studies of standing solitons in a nonlinear lattice," 120th meeting of the Acoustical Society of America, Journal of the Acoustical Society of America Supplement 1, Vol. 88, pp. S76, 4PA7 November 1990.

Andrews Larraza and Bruce Denardo, "Nonlinear evolution equations for fields with a level repulsion spectrum," 120th meeting of the Acoustical Society of America, Journal of the Acoustical Society of America Supplement 1, Vol. 88, pp. S76, 4PA9 November 1990.

SPACE THERMO-ACOUSTIC REFRIGERATOR

S.L. Garrett, Professor of Physics
Sponsor: Naval Research Laboratory - Spacecraft Engineering
Funding: Naval Research Laboratory and Naval Postgraduate School

OBJECTIVE: To design, and test, a cryocooler suitable for flight as a Get Away Special on the Space Shuttle which uses sound to pump heat.

SUMMARY: The Space Thermo-Acoustic Refrigerator (STAR) is an experiment which will "fly" on the Space Shuttle as a Get Away Special (NASA G-337) sometime in 1991. It is an entirely self-contained system including the thermoacoustic refrigerator (electrodynamic driver, acoustic resonator, thermodynamic "stack", gas handling and vacuum can) and its support electronics (processor, bubble memory data recorder, resonance frequency and amplitude feedback controller, multiplexed measurement systems and A-to-D converters for 21 different sensors, batteries and power distribution system, and pulse width modulated heat load).

During this period the entire refrigerator and control system was completed and produced a temperature difference of 72°C (117 F) with a 10 bar He/Ar working fluid and at a pressure amplitude of Pm/Po = 3%, was able to pump a 5.6 Watts heat load at Tc/Th = 0.76, and a coefficient-of-performance, relative to Carnot of 10%. The entire system operated autonomously for 300 hours.

PUBLICATIONS: S.L. Garrett and T. Gabrielson, "Magnetohydrodynamic and Thermoacoustics Mechanisms for Generation of Low Frequency Sound in Sea Water", Proceedings of the Second International Workshop on Power Transducers for Sonics and Ultrasonics, Toulon, France, June 1990, (18 pages), *in press.*

CONFERENCE PRESENTATIONS: A.A. Atchley, S.L. Garrett, and T.J. Hofler, "Thermoacoustic Heat Transport: Explanations, Demonstrations, and Applications", Am. Assn. Adv. Sci., New Orleans, LA, February 1990.

THESES DIRECTED: J.A. Adeff, "Measurement of the Space Thermoacoustic Refrigerator Performance", Masters Thesis, September 1990.

THIRD GENERATION THERMOACOUSTIC REFRIGERATION

T.J. Hofler, Adjunct Research Professor of Physics
Sponsor: Naval Research Laboratory - Spacecraft Engineering

OBJECTIVE: The primary long term objective is to develop the next generation Thermo Acoustic Refrigerator (TAR), or cryocooler, prototype. The secondary short term goal is study numerical solutions of the thermo acoustic theory in order improve the general understanding, and to optimize solutions for prototype development.

SUMMARY: The second generation thermo-acoustic refrigerator is a high reliability device that can achieve a cold temperature of 200 degrees Kelvin temperature span with modest efficiency. We believe this kind of refrigerator is suitable for spacecraft and we hope to demonstrate this when the STAR project flies on the space shuttle sometime in late 1991 or 1992.

The third generation TAR should double the temperature span and achieve a cold temperature of 100 degrees Kelvin, and thereby approach true cryocooler performance. Some improvement in the engine's efficiency may be possible. The long term goal is to build, instrument, and test such a prototype device. The experimentally oriented work achieved has been to acquire the necessary instrumentation, vacuum equipment, and fabrication equipment and materials. Also, a set of specifications was drawn up and an open contract (RFP) from NRL was let, for the design and fabrication of several high intensity acoustic drivers for incorporation into the prototype TAR III. Design details have been discussed with the awardee of the contract. The short term goal is to study numerical solutions of the thermo acoustic theory. One area of interest is to study contour plots of engine performance with respect to two parameters in order to learn which areas in a large parameter space are best for TAR III. One of the parameters of interest is one that describes the mixture of traveling waves and standing waves in the sound field. This work was mostly completed. The second area of interest is a detailed numerical model of the possible prototype geometries for the purpose of optimization and the eventual comparison to experimental results. A small portion of this work has been completed.

PUBLICATIONS: A. A. Atchley and T. J. Hofler, "Annual summary of basic research in thermo-acoustic heat transport: 1990," Naval Postgraduate School Report Number NPS-PH-91-002PR, 30 pages, October 1990.

CONFERENCE PRESENTATIONS: T. J. Hofler, "Performance of a short parallel-plate thermo-acoustic stack with arbitrary plate separation," J. Acoust. Soc. Am. 88, Suppl. 1, S94 (1990).

BASE SUPPORT FOR RADIATION SOURCES

X.K. Maruyama, Professor of Physics
Sponsor: Naval Surface Warfare Laboratory
Funding: Naval Postgraduate School

OBJECTIVE: The radiation sources at NPS, the RF electron linear accelerator and the pulsed flash x-ray machine are required for a number of projects at NPS, including the unipolar arcing plasma physics experiment led by Professor Schwirzke; radiation signature and optical transition radiation project of the Radiation Physics Group, and the radiation tolerant electronics project of Professor Michael in ECE. This project provides part of the funding to operate the facilities. Experiment specific support is provided by other project funding.

SUMMARY: The Naval Postgraduate School Electron Linear Accelerator commemorated its 25th year of continuous operation. This facility has outlasted many other similar capability linacs at major institutions worldwide. The latest two linacs with similar electron energy capabilities to be closed are at the University of Illinois and the National Institute of Standards and Technology (NIST). The success of the NPS linac is due to its lean and efficient operation and its flexibility to explore novel avenues of research. The NPS linac was made operational in 1965 with a direct expenditure of approximately $250,000. Today's replacement cost for the laboratory capability would exceed several million dollars. Over 125 students theses have been associated with the NPS accelerator laboratory. Such diverse topic as neutron charge distribution, nuclear giant resonances, detector characterization, microwave Cerenkov radiation, optical transition radiation, x-ray generation, x-ray optics, HgCdTe IR detector radiation hardness, high temperature superconductor radiation effects, and radiation tolerant amplifier circuits have been investigated. The flash x-ray machine is a complementary machine to the linac. It has been used in plasma physics study of unipolar arcing and measurement of transient radiation effects in electronics (TREE). In addition, this program also maintains NPS capabilities to measure rf signatures arising from charge particle beams. This is a support program, so the experimental accomplishments are listed under the individual programs. Publications, presentations, and theses directed are presented under other project summaries associated with Prof. X.K. Maruyama, F.R. Schwirzke, S. Michael, and J.R. Neighbours.

OTHER: Current collaborators, institutions and topics include: R. Fiorito and D. Rule, Naval Surface Warfare Center, optical transition radiation, parametric x-rays; M.A. Piestrup et al., Adelphi Technology and C. Gary, Stanford Univ., X-ray transition radiation and x-ray optics, parametric x-rays; H. Backe, U. Mainz, high T superconductors and optical transition radiation; S. Michael et al., NPS, radiation tolerant electronics; J.R. Neighbours, NPS, EM radiation from charged particle beams; F.R. Buskirk, NPS, high temperature superconductors and optical transition radiation; F. Schwirzke, NPS, unipolar arcing; and J. Bechtold, Paul Chu et al., Texas Center for Superconductivity, high temperature superconductors.

OPTICAL TRANSITION RADIATION

X.K. Maruyama, Professor of Physics
Sponsor: Naval Postgraduate School
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project is to develop optical transition radiation measurement techniques so that they may be useful for diagnostic of relativistic electron beams. In addition, since the frequency range chosen for the detection of OTR is somewhat arbitrary, we extend this investigation to the generation and detection of x-ray transition radiation.

SUMMARY: Optical transition radiation (OTR) can be exploited as a charged particle beam diagnostic. OTR is capable of determining beam position, profile, intensity, angular divergence and energy. Simultaneous measurement of beam profile and angular divergence constitutes a measurement of emittance. This technology has potentially wide application for DOD accelerator technology such as used in directed energy weapons programs and as radiation sources for space and nuclear radiation effect studies. For civilian research applications, this beam diagnostic capability can be used to profile the electron beam for nuclear physics experiments and to measure beam emittance for free electron lasers, high energy and nuclear physics accelerators. We are continuing development of practical techniques so that OTR can be exploited as a useable tool by non-experts with regards to transition radiation and optic detection.

X-rays are also generated as transition radiation. By exploiting the photo-absorption edge of transition radiation foils, quasi-monochromatic x-rays are also generated. The use of high density transition radiators allows for generation of hard x-rays with moderate energy electrons.

PUBLICATIONS: M.A. Piestrup, D.G. Boyers, C.I. Pincus, J.L. Harris, X.K. Maruyama, J.C. Bergstrom, H.S. Caplan, R.M. Silzer, D.M. Skopik, "Quasi-monochromatic x-ray sources using photo absorption edge transition radiation", submitted to Physical Review A.

M.A. Piestrup, M.J. Moran, D.G. Boyers, C.I. Pincus, J.O. Kephart, R.A. Gearhart, X.K. Maruyama, "Generation of Hard X-rays from Transition Radiation Using High Density foils and Moderate-Energy Electrons", submitted to Physical Review A.

CONFERENCE PRESENTATIONS: X.K. Maruyama, C. Reid, F.R. Buskirk, H. Backe, "A Novel Optical Transition Beam Profile Monitor Using a Diffuse Screen", submitted to the 1991 Particle Accelerator Conference, San Francisco, 6-9 May, 1991.

D.W. Rule, R.B. Fiorito, M.A. Piestrup, C.K. Gary, X.K. Maruyama, "Production of X-rays by the Interaction of Charged Particle Beams with Periodic Structures and Crystalline Materials", Submitted to SPIE 1991 International Conference on Optical Applied Science and Engineering, San Diego, 21 -26 July 1991.

X.K. Maruyama, "Optical Transition Radiation, Photons from a Classical Relativistic Source", Summer Research in Physics for Upper Level Undergraduates Seminar, U. Virginia, 13 June 1990.

X.K. Maruyama, "Optical Transition Radiation for Application in Nuclear Physics", Joint Accelerator/ Physics Division Seminar, Continuous Electron Beam Accelerator Facility, CEBAF, 31 August 1990.

X.K. Maruyama, " Optical Transition Radiation for Application in Nuclear Physics Experiments", Physics Department Colloquium, Catholic University, 27 August 1990.

X.K. Maruyama, "Transition Radiation", Physics Department Colloquium, James Madison University, 28 September 1990.

X.K. Maruyama, "Optical Transition Radiation", Physics Department Colloquium, Naval Postgraduate School, 20 July 1990.

THESIS DIRECTED: C.B. Reid, CPT, USA, "Measurement of Electron Beam Emittance Using Optical Transition Radiation and Development of a Diffuse Screen Electron Beam Monitor, Masters Thesis, December 1990.

TOTAL DOSE EFFECTS ON NOVEL MATERIALS

X.K. Maruyama, Professor of Physics
Sponsor: Theater Nuclear Warfare Program, PMS 423
Funding: Naval Postgraduate School

OBJECTIVE: This project is to investigate properties of novel materials under the influence of ionizing radiation. At present, the concentration of effort is in studying the radiation effects on the properties of high temperature superconductors.

SUMMARY: The effects of electron irradiation on $YBa3O_{7-d}$ have been studied in collaboration with researchers from the Texas Center for Superconductivity, University of Houston, TCSUH. With the solid state physics expertise and capabilities of TCSUH, we have been able to go beyond the earlier measurements of the critical temperature dependence on irradiation. Measurements of magnetization -J ab and transport -J ab indicate that the defects responsible for degradation of the critical current are macroscopic. Furthermore, there is an orientation dependence of the radiation effects indicating that large anisotropic cluster defects induced by irradiation are more effective for flux pinning than small isotropic defects.

CONFERENCE PRESENTATIONS: J. Bechtold, R.L. Meng, L. Gao, Y.Y. Xue, E. Hungerford, P.H. Hor, C.W. Chu, X.K. Maruyama, H. Backe, F.R. Buskirk, S.M. Connors, D.D. Snyder, "Degradation of Transport J_c in Melt-Textured Y123 by e-Irradiation", submitted to the American Physical Society Meeting, Cincinnati, 18-22 March 1991.

R.L. Meng, J. Bechtold, Y.Y. Xue, E. Hungerford, P.H. Hor, C.W. Chu, S.M. Connors, H. Backe, F.R. Buskirk, X.K. Maruyama, H. Rietdyk, "Observation of Defect-Shape Dependence in Fluxon-Defect Interactions", submitted to the American Physical Society Meeting, Cincinnati, 18-22 March 1991.

OTHER: This investigation is continuing. A student thesis on the dosimetry and activation g-ray spectrum to determine the electron fluence on target will be completed in December 1991.

TRANSIENT RADIATION EFFECTS

X.K. Maruyama, Professor of Physics
Sponsor: Strategic Systems Program, SP-2340
Funding: Naval Postgraduate School

OBJECTIVE: This project is to investigate transient radiation effects in electronics and circuit components. The flash x-ray machine at the Naval Postgraduate School is to be instrumented to measure TREE effects.

SUMMARY: The collection of photon-induced transient radiation effects on electronics (TREE) data in a pulsed x-ray facility is hampered by severe electrical noise created by the pulse generation process. Suitable techniques for data collection and evaluation have been developed for the Pulserad Model 112A pulsed x-ray generator (FXR).

The Pulserad 112A radiation capabilities include the following: beam energy 1.75 MeV; beam current 35 kiloampere; pulse structure 35 nanoseconds, 10 nanosecond risetime. The radiation on target is 100 rad/pulse at 10 cm, x-ray mode, 10^{10} rads/sec during pulse rise time. The dosimetry capability include a Victoreen 2800 and 2800M TLD reader, CaF_2 thermoluminescent dosimeters. Tektronix 7104 gigahertz oscilloscope, with TEK 7A13 differential comparator plug-in, TEK7B92A horizontal line base plug in, TEK C50 oscilloscope camera, and Digital camera system constitute the basic TREE measurement capability. A Tektronix 7912 transient digitizer is also available. Noise suppression has been achieved to reduce the background level to 5 mV peak to peak. The thesis accomplished under this task describes fully the operational procedure so that the FXR is now capable of making meaningful TREE phenomena. The system has also been used for the classroom demonstration of IEMP effects.

THESIS DIRECTED: D. Galarowicz, "Instrumentation Requirements for TREE Effects Data Collection at the Naval Postgraduate School Flash X-Ray Facility", Masters Thesis in Electrical Engineering, June 1990.

W.A. Conklin, LT, USN, A Comparison of Single and Composite Operational Amplifier Performance During Irradiation by 30 MeV electrons from a Linear Accelerator", Electrical Engineer Thesis, September 1990.

OTHER: The flash x-ray facility is available for TREE effects investigation with collaborators both internal and external to NPS. The linac and the FXR represents complementary radiation sources for radiation effects research.

MEASUREMENT OF E.M. RADIATION FROM HIGH CURRENT ELECTRON BEAMS

J. R. Neighbours, Professor of Physics, Department of Physics
Sponsor: Research Administration Office
Funding: Naval Postgraduate School

OBJECTIVE: The measurement and characterization of radio frequency electromagnetic radiation from intense electron beams.

SUMMARY: This is a continuing project which has been concerned with the collection and analysis of the radio frequency signals that are emitted from an intense charged particle beam propagating in air. All of the data collected and the theoretical analysis and calculations have been for electron beams. Past experimental work has been carried out at NPS, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, and Sandia National Laboratory. Recently, we participated in a related (classified) experiment at the Nevada Test Site. At present, there are no experiments scheduled so that the concentration is on the analysis of data taken in previous experiments.

PUBLICATIONS: J.R. Neighbours, F.R. Buskirk, and X.K. Maruyama, "Wide Band R. F. Measurements of the Signals from an Electron Beam Meeting.

THESES DIRECTED: R. Lally, CPT, USA, "Analysis of Radio Frequency Radiation from Propagating Electron Beam", June 1990.

H. Nye, LCDR, USN, "Experimental Analysis of B-Dot Sensors", June 1990.

PLASMA HEATING AT THE PLASMA PAUSE

R.C. Olsen, Associate Professor of Physics
Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: Analyze particle, field, and wave data from satellites orbiting the earth near the magnetic equator, near the plasmapause. The thrust of the analysis is to determine the characteristics of the cold and hot plasmas which lead to interchange of energy, e.g. heating.

SUMMARY: This work has been part of an ongoing study. Data analysis during the past year has been focused on data taken near geosynchronous orbit, from the SCATHA satellite.

CONFERENCE PRESENTATIONS: R. C. Olsen, "Electron Heating at the Plasmasphere/plasma sheet boundary", presented at the Fall meeting of the American Geophysical Union, San Francisco, CA, December 3, 1990.

SPACE POWER EXPERIMENT ABOARD ROCKET (SPEAR)

R.C. Olsen, Associate Professor of Physics
Sponsor: Defense Nuclear Agency
Funding: Defense Nuclear Agency

OBJECTIVE: Analyze data taken by SPEAR 1 to determine the potential response of the rocket body to high voltage patterns applied to a deployed boom set. A secondary objective has been to support the pre-flight tests and launch of SPEAR II.

SUMMARY: Analysis of the SPEAR 1 data was completed during this period. The vehicle potential was obtained for all the bias operation sequences. The major result was a startlingly linear relationship between sphere bias voltage and current collected. A new results was the conclusion that the rocket body was grounded to the external plasma by the emission of the neutral gas (by the attitude control system). The gas was apparently ionized by the 50-100 eV ions and electrons around the vehicle.

CONFERENCE PRESENTATIONS: R. C. Olsen, T. Van Horn, R. B. Torbert, W. J. Raitt, "SPEAR-1 Charging Behavior", presented at the ESA Space Environment Analysis Workshop, Noordwijk, The Netherlands, October 10, 1990.

THESIS DIRECTED: Determination of SPEAR-1 rocket body potential during high-voltage experiments, Thurston Van Horn, June 1990.

ELECTRON BEAM GENERATED PLASMA WAVES

R.C. Olsen, Associate Professor of Physics
Sponsor: National Aeronautics and Space Administration
Funding: National Aeronautics and Space Administration

OBJECTIVE: Analyze plasma wave data taken during electron gun experiments on the ISEE 1 satellite in June-July 1987. Search for features in the data which indicate beam-plasma interactions induced by the electron beam.

SUMMARY: Analysis of the plasma wave data showed that resonant interactions were induced when the 40 eV electron beam was emitted into the hot, tenuous magnetosphere plasma. Strong features were seen at the local plasma frequency (or upper hybrid resonance frequency). There was a persistent feature which appears to result from interactions between the beam and the local photo-electron cloud.

CONFERENCE PRESENTATIONS: R.R. Anderson, R. C. Olsen and F.S. Mozer, "Plasma wave observations during electron gun operations on ISEE 1", presented at the American Geophysical Union Meeting in San Francisco, CA, December 1989. R. C. Olsen, R. R. Anderson and F. S. Mozer, "Plasma wave observations during electron gun experiments on ISEE-1", presented at the XXVII Plenary Meeting and associated activities of the Committee on Space Research (COSPAR), The Hague, The Netherlands, 8 July 1990.

SATELLITE CHARGE CONTROL

R.C. Olsen, Associate Professor of Physics
Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: Design charge control technology for high altitude satellites. Analyze charging data from existing satellites. Work towards future flight experiments.

SUMMARY: Laboratory work with hollow cathodes was completed at the end of 1989. The flight prototype for the POLAR satellite has been completed, and has been tested at Hughes Research Laboratory. The flight model is being built, and will be launched in 1993. Laboratory work towards a solid state ion source was initiated. A compact, lightweight, and electromagnetically quiet source appears practical. Analysis of electrostatic charging of dielectric materials on satellites indicates that it may have a catalytic effect on the development of satellite charging.

THESES DIRECTED: Hollow Cathode Plasma source characteristics, Young-chul Park, Physics, December 1989.

Physical Processes in hollow cathode discharge, Hwang-Jin Han, Physics December 1989.

Dielectric charging as a catalyst of the formation of potential barriers on synchronous orbit satellites, M. E. Young, March 1990.

Lithium ion source for satellite charge control, Tae Ik Song, June 1990.

Satellite charge control with lithium ion source and electron emission, Chong Soo Ryu, December 1990.

EXTENDED DOMAIN, 3-DIMENSIONAL HAZARD ASSESSMENT OF ROCKET PLUMES AND GROUND SOURCES, VANDENBERG APPLICATIONS

G.E. Schacher, Dean of Faculty and Graduate Studies
R.F. Kamada, Adjunct Research Professor of Physics
C.E. Skupniewicz, Physical Scientist
Sponsor: Air Force Space Division
Funding: Air Force Space Division

OBJECTIVE: To improve Vandenberg AFB launch exhaust and ground source plume release dispersion prediction ability.

SUMMARY: The Lompoc Valley Diffusion study showed that plumes from Vandenberg's fuel storage facilities can impact Lompoc, CA. Details are being confirmed with the Colorado State U. RAMS 3-D prognostic windflow model. We compared two diagnostic wind flow models, WOCSS and LINCOM to results from the Vandenberg Mt. Iron study. Slope flow and multi-tower input are being added to the LINCOM diagnostic flow model. Our Vandenberg Boundary Layer Survey showed that fumigation can occur via a "cloud breeze" residing within the regular seabreeze flow, endemic to Vandenberg. We found that daytime inversion heights largely paralleled the hilly terrain found at Vandenberg.

PUBLICATIONS: C.E. Skupniewicz, R.F. Kamada, S.A. Drake, and L. McKay R.N., Abernathy, K.C. Herr, and G.J. Scherer A. Guenther, "Lompoc Valley Diffusion Experiment Data Report", Naval Postgraduate School Technical Report, NPS61-90-017, 123 pps., November 1990.

C. E. Skupniewicz, R. F. Kamada, and L. McKay, "Vandenberg Boundary Layer Survey (VBLS) Final Report - Results", Naval Postgraduate School Technical Report, NPS61-90-004, 341 pps., April 1990.

CONFERENCE PRESENTATIONS: R. F. Kamada, C. E. Skupniewicz, L. McKay, and S.A. Drake, "An Inversion Height Study in Complex Coastal Terrain", Proc. 5th JANNAF Symp., Livermore, CA, June 18-20, 1990.

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T. Mikkelsen, S. Thykier-Nielsen, R. F. Kamada, and S. A. Drake, "Windflow Model Evaluation Study for Complex Terrain", Proc. 9th Symp. on Turb. and Diff., Roskilde, Denmark, April 30 - May 3, 1990.

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OTHER: C. E. Skupniewicz, J. W. Glendening, and R. F. Kamada, "Atmospheric Boundary Layer Transition Across a Stratocumulus Edge, Mon. Wea. Review, in review.

DISCHARGE PHYSICS AND UNIPOLAR ARCING

F. Schwirzke, Professor of Physics
X. K. Maruyama, Professor of Physics
Sponsor: Naval Research Laboratory
Funding: Naval Postgraduate School

OBJECTIVE: To understand the breakdown process and formation of plasma on electrodes. Breakdown and plasma formation on electrodes is a fundamental process in pulsed power technology. The initial plasma formation on the surface of a cathode is very non-uniform. Micron-sized cathode spots form within nanoseconds. Unipolar arcing represents a discharge form which can explain the explosive like formation of cathode spots. Power dissipation for an unipolar arc is considerably higher than for field emitted or space charge limited current flow.

SUMMARY: Breakdown and "explosive" plasma formation on electrodes are basic processes in pulsed of cathode spot formation have not been well understood. Breakdown in a vacuum diode is initiated by field emitted electrons. Besides joule heating of the emitting spot, the electrons also ionize desorbed gas layers. These ions fall back to the cathode, heating the surface of the electron emitting spot. Ion surface heating is initially orders of magnitude larger than joule heating. Surface heating and the build-up of positive space charge rapidly lead to further enhanced field emission and, finally, thermionic electron emission. The localized build-up of plasma above the electron emitting spot naturally leads to pressure and electric field distributions which ignite unipolar arcs. The high current density of the unipolar arc then provides the "explosive" plasma formation of a cathode spot. This was confirmed by experimental results using the flash x-ray facility.

PUBLICATIONS: F. Schwirzke, "Laser Induced Breakdown and High Voltage Induced Breakdown on Metal surfaces", to be published as a chapter in a book: Laser Interaction and Related Plasma Phenomena, H. Hora and G.H. Miley, eds., Plenum Publishing Corporation, forthcoming in 1991.

F. Schwirzke, X.K. Maruyama, and S.A. Minnick, "Onset of Breakdown in a Vacuum Diode", to be published in a book BEAMS 90, forthcoming in 1991.

F. Schwirzke, "Vacuum Breakdown on Metal Surfaces", published in a book XIVth International Symposium on Discharges and Electrical Insulation in Vacuum, Santa Fe, New Mexico, September 17-20, 1990, Editor R.W. Stinnett, p. 19-25.

F. Schwirzke, "Formation of Cathode Spots by Unipolar Arcing", to be published in the proceedings of the SIXTH INTERNATIONAL SYMPOSIUM ON GASEOUS DIELECTRICS, Knoxville, Tennessee, September 23-27, 1990, forthcoming 1991.

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F. Schwirzke, "Laser Induced Breakdown and High Voltage Induced Vacuum Breakdown on Metal Surfaces", Naval Postgraduate School Technical Report NPS-61-90-003, March 21, 1990.

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F. Schwirzke, "Formation of Cathode Spots by Unipolar Arcing", Sixth International Symposium on Gaseous Dielectrics, Knoxville, TN, September 23-27, 1990.

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F. Schwirzke, "Formation of Cathode Spots by Unipolar Arcing", Forty-Second Annual Gaseous Electronics Conference, Palo Alto, CA, October 1989. Long paper.

F. Schwirzke, "Laser Induced Breakdown and High Voltage Induced Vacuum Breakdown on Metal Surfaces", Seminar given at the Institute for Applied Physics, University of Frankfurt, August 2, 1990.

F. Schwirzke, "Laser Induced Breakdown and High Voltage Induced Vacuum Breakdown", Seminar given at the University Bochum, Germany, August 9, 1990.

F. Schwirzke, "Laser Induced Breakdown and High Voltage Induced Vacuum Breakdown", Seminar given at the Institute for Neutron Physics and Reactor Technology, Kernforschungszentrum Karlsruhe, Germany, September 3, 1990.

F. Schwirzke, Electrical Breakdown on Metal Surfaces", Colloquium, Dept. of Physics, NPS, October 26, 1990.

THESES DIRECTED: R. K. Downs, LT, USN, "Surface Dynamics of Unipolar Arcing", Master's Thesis, December 1989.

D. S. Youn, LCDR, Korean Navy, "Measurements on Laser Produced Plasma Using Faraday Cups", Master's Thesis, December 1989.

S. A. Minnick, LT, USN, "Unipolar Arcing on the Cathode Surface of a High Voltage Diode", Master's Thesis, December 1989.

OTHER: Paper submitted to Eighth IEEE International Pulsed Power Conference to be held in San Diego, CA, 17-19 June 1991: F. Schwirzke M. P. Hallal, Jr., X. K. Maruyama, and G. V. Station, "Explosive Plasma Formation on Electrodes".

ATMOSPHERIC OPTICAL TURBULENCE MEASUREMENTS AND DEVELOPMENTS FOR ADAPTIVE OPTICS

D.L. Walters, Associate Professor of Physics
Sponsor: Kirtland Air Force Base
Funding: U.S. Air Force

OBJECTIVE: To determine the magnitude and thickness of the turbulent boundary layer surrounding a 3.5 m aperture Optical Facility before construction.

SUMMARY: Optical turbulence envelopes a hill and declines with altitude. The design of the instrument pedestal required knowledge of the altitude distribution of this turbulence. This project developed a high resolution acoustic sounder to measure the thickness of the layers as well as the wind velocity distribution.

PUBLICATIONS: J. Krause-Polstroff and D. L. Walters. "Refractive turbulence profiling using an orbiting light source", Applied Optics, Vol. 29, No. 13, pp. 1877-1885, March 1990.

THESES DIRECTED: James K. McCrary, LT, USN, "High Resolution C_{T2} and Radial Wind Velocity Measurements Using a High Frequency Monostotic Acoustic Echosounder", Master Thesis June 1990.

James M. Lackemacher, LT, USN, "Reconstruction of Computer Simulated Atmospheric Turbulence-Degraded Astronomical Objects by Application of the Knox-Thompson and Triple-Correlation Phase Recovery Techniques", Master Thesis, December 1990.

OTHER: These measurements were critical to design and placement of the 3.5 m aperture for the US Air Force STARFIRE optical facility, Kirtland Air Force Base.

ATMOSPHERIC OPTICAL TURBULENCE MEASUREMENTS FOR THE RELAY MIRROR EXPERIMENT

D.L. Walters, Associate Professor of Physics
Sponsor: Kirtland Air Force Base
Funding: U.S. Air Force

OBJECTIVE: To develop and field two optical sensors and perform measurements for the Relay Mirror experiment.

SUMMARY: The relay mirror experiment, involves a ground-satellite-ground optical link. During the experiment measurements of the optical turbulence were essential to quantify the atmospheric contribution to systems performance. The US Air Force requested that NPS provide atmospheric characterization measurements for this program. A fifth generation, dual mode isoplanatic angle and coherence length sensor was developed and delivered to the Kihei, Hawaii site.

THESES DIRECTED: Mark R. Weitekamp, CPT, USA, "Investigation of the Source of Thermosonde Measured Diurnal Variation of Optical Turbulence, Master Thesis, December 1990.

PACIFIC COASTAL MOUNTAIN ATMOSPHERIC CHARACTERIZATION

D.L. Walters, Associate Professor of Physics
Sponsor: Andrews Air Force Base
Funding: U.S. Air Force

OBJECTIVE: Long term atmospheric measurements and support for a target acquisition and surveillance program.

SUMMARY: NPS has been providing long term atmospheric characterization measurements, equipment and long term support. This project evolved the point where data requirements exceeded the ability of NPS personnel to provide support. A fifth generation system was fabricated and delivered for use by a contractor. Since that time data has been collected for a 24 hour period once a week. During development of a single point probe, optical turbulence rawinsonde we discovered solar contamination of our data. We showed that solar heating was contaminating data collected previously by others producing a factor of ten error.

CONFERENCE PRESENTATION: D. L. Walters, M. R. Weitekamp, C. A. Vaucher, "Single Point Optical Turbulence Profile Measurement System", Optical Society of America Annual Meeting, Boston, Mass., November 9, 1990.

THESES DIRECTED: Dea Kieffer, CPT, USA, "Development of a Single Point Temperature Probe to Measure the Temperature Structure Parameter", Thesis, June 1990.

Mark R. Weitekamp, CPT, USA, "Investigation of the Source of Thermosonde Measured Diurnal Variation of Optical Turbulence, Thesis, December 1990.

OTHER: During this program we developed a low cost Rawinsonde system for measuring atmospheric turbulence that is patentable. The VIZ company wants to develop this system commercially.

OPTIMAL SITE CHARACTERIZATION AND MEASUREMENTS FOR GROUND BASED SYNTHETIC APERTURE SYSTEMS

D.L. Walters, Associate Professor of Physics
Sponsor: J. Hughes, Naval Observatory
Funding: Naval Postgraduate School

OBJECTIVE: To collect atmospheric characterization measurements for large optical interferometers.

SUMMARY: The US Naval Observatory and Naval Research Laboratory are both planning 15 m to 100 m baseline optical interferometers. The performance of these systems depends on selecting an optimal site. Previous NPS measurements showed that both the Flagstaff, AZ and the Anderson Peak, CA, areas provided superior conditions. Measurements at both of these sites were collected to allow selection of the best site.

CONFERENCE PRESENTATION: D. L. Walters, G. Tirrell-Vaucher, and C. A. Vaucher, "Optimal Sites for Optical Interferometry", Proceedings of the International Society for Optical Engineering, Amplitude and Intensity Spatial Interferometry, February 14,1990, Tucson, AZ.

OTHER: The Flagstaff, AZ site has been selected for the 100 m baseline (NRL) system because of long baseline requirements. The Naval Observatory has selected the Anderson Peak, CA, site since it provides darker skies and superior observing conditions.

SPACE SYSTEMS ACADEMIC GROUP

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 Administrative Sciences, Aeronautical and Astronautical Engineering, Computer Science, Electrical and Computer Engineering, Mathematics, Mechanical Engineering, Meteorology, Oceanography, Operations Research, and Physics.

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) Computer Memory Technology in Space (3) Space Environment Effects, (4) Control and Dynamics, and (5) Spacecraft and Flight Hardware Laboratories/Facilities.

SPACECRAFT TECHNOLOGY

Professor Steve Garrett continued the "Acoustics in Space" research projects. The first project, the design of the Space Shuttle Vibroacoustic Experiment (NASA G-313) had to be rescheduled for a FY92 flight opportunity. Work on the second project, the Space Thermoacoustic Refrigerator ("STAR," NASA G-337), rescheduled for an early FY92 flight, continued and the refrigerator is now completed and has been tested (see Department of Physics.)

Professors Tri Ha and Glen Myers investigated performance characteristics of frequency hop spread spectrum receivers for use with tactical low-altitude satellites (see Department of Electrical and Computer Engineering.)

Professors Herschel Loomis and Chyan Yang investigated computer aided design (CAD) techniques of complex VLSI chips to achieve high performance or special functionality for Navy Space applications (see Department of Electrical and Computer Engineering.)

Professor Rudolf Panholzer continued his research program on Small Satellite Design Studies with the Petite Amateur Satellite Project--PANSAT. The small satellites design program originated with the ORION Mini-Satellite Project--a prototype general purpose satellite. PANSAT is a simplified version of ORION--smaller and with no attitude control. PANSAT is being designed to function as a small pocket radio communications satellite using spread spectrum techniques.

COMPUTER MEMORY TECHNOLOGY IN SPACE

Professor Panholzer's research program on Computer Memory Technology in Space addressed the feasibility of developing a Solid State Bubble Memory Data Recorder (SSDR) to record acoustic data board the space shuttle during lift-off. A number of students contributed to the Bubble Memory Project with design and analysis for thesis topics. This included the design and development of flight test hardware (recorder housing, space qualified P.C. Boards, components assembly, and microprocessor based controller card); design and fabrication of thermal and structural models; thermal analysis of the recorder, and development of software routines. This research project ended with a "Proof of Concept" first generation 8-bit microprocessor based SSDR. A subsequent attempt to develop a Space Qualified Magnetic Bubble Memory Data Recorder was discontinued in favor of a new research initiative.

Professor Panholzer's new research initiative on Computer Memory Technology in Space was to evaluate ferroelectric technology to determine its suitability in military and space applications. In November 89, SSAG designed a Ferroelectric Experiment that was later incorporated into Orbital Science Corporation's (OSC) Datasat-X Satellite (now OrbComm-X, scheduled for a July 12th 1991 launch aboard an Ariane rocket from French Guiana). Within a few months, this experiment was designed, built, tested, and delivered to OSC for integration into their satellite, demonstrating SSAG's capacity for a prompt response. In March 1990 the experiment was presented to the Space Test Program board (STP), and received a favorable ranking.

SPACE ENVIRONMENT EFFECTS

Professors R. Christopher Olsen and S. Gnanalingam investigated methods for Satellite Charge Control with onboard electron and ion sources (Liquid Metal Ion Gun Flight Experiment). Laboratory work towards a solid state ion source was initiated: a compact, lightweight, and electromagnetically quiet source appears practical (see Department of Physics.)

Later in the year, Professor S. Gnanalingam joined Professor David Cleary in the continuing research on the development of an eventually revolutionary technique for measuring global ionospheric electron densities from a space based platform. The Middle UV Spectrometer (MUStang) Experiment was built and flown on a rocket in March 90. Preliminary analysis of experimental results proved the feasibility of the concept (see Department of Physics.)

Professor Sherif Michael continued research on photovoltaic power technology by investigating the possibility to anneal a satellite's InP and GaAs solar cells while in orbit using new minority carriers annealing techniques. (See Department of Electrical and Computer Engineering.)

Professor Michael also investigated the advantage of applying new composite operational amplifier techniques for radiation hardening of analog networks, using the NPS Linear Accelerator. (See Department of Electrical and Computer Engineering.)

SPACE CONTROL AND DYNAMICS

Professor Jeffrey Burl continued to advance the theory, practice, and application of estimation and control of distributed parameter systems and large scale space systems. Methods of refining model parameters on orbit were studied and developed. The LACE spacecraft was modelled and was used as a testbed. (See Department of Electrical and Computer Engineering.)

Professor Donald Danielson and several students obtained analytical solutions to the equations of motion of a satellite orbiting an oblate planet. The theoretical results were compared with a numerical solution of the differential equations and with actual satellite data. (See Mathematics Department.)

SPACECRAFT AND FLIGHT HARDWARE LABORATORIES/FACILITIES

Under the direction of Professor Panholzer (SSAG), and participating departments, a considerable amount of resources were dedicated to the development of four existing and four new laboratories/facilities:

(1) Spacecraft Integration & Environment Simulation Test (SSAG
(2) Open Site EMI/EMC Environmental Simulation Test (SSAG)
(3) Mobile Satellite Ground Station (SSAG)
(4) Space Systems AIS Computing (SSAG)
(5) Precision Fabrication Facility (SSAG)
(6) FLTSATCOM Satellite Operation, Simulation & Test (SSAG/AA)
(7) Spacecraft Environmental Simulation & Test (SSAG/AA)
(8) Spacecraft Attitude Dynamics & Control Lab (SSAG/AA)
(9) Radiation Effects & Solar Simulation (SSAG/EC)
(10) Space Systems Sensitive Compart. Inf. Computing (SSAG/EC)
(11) Low-Altitude Satellite Communications & Network (SSAG/EC)

SMALL SATELLITE DESIGN STUDIES (PANSAT)

R. Panholzer, Chairman of Space Systems Academic Group
Sponsor: SSAG, NRL, NASA/USRA
Funding: NPS, NRL, NASA/USRA

OBJECTIVE: The goals of the Continuing Small Satellite Design Studies program are to design, fabricate, test, and ultimately launch a small satellite for operation by NPS enhancing the education of officer students through a systems engineering approach; and to provide a valuable space asset to augment existing space defense systems. The continuing project is the Petite Amateur Navy Satellite (PANSAT) which is being designed to investigate spread spectrum communication with store-and-dump capability for relaying information digitally.

SUMMARY: A breadboard of the satellite's main computer was built. Initial test plans were developed for programming commands and to implement modifications. The communication and electric power subsystems initial designs were completed. An application for frequency allocation was submitted to the Federal Communications Commission.

CONFERENCE PRESENTATION: Daniel Sakoda, Mike Noble, and Steve Paluszek, "Preliminary Design of the Naval Postgraduate School Petite Amateur Navy Satellite (PANSAT) Electric Power and Communication Subsystems," 4th Annual AIAA/Utah State University Conference on Small Satellites, 28-31 August, 1990.

THESES DIRECTED: M.L. Noble, LCDR, USN, "Preliminary Design of the Pansat Electrical Power Subsystem," Master Thesis, June 1990.

S.S. Paluszek, LCDR, USN, "Spread-Spectrum Communications for the Petite Amateur Navy Satellite (PANSAT)," Master Thesis, June 1990.

R.R. Rowsey, CAPT, USMC, "Design Restrictions and Licensing for Petite Amateur Navy Satellite (PANSAT)," Master Thesis, September 1990.

OTHER: Provided support and direction for S.M. Tobin, CAPT, USA, "Construction and Testing of an 80C86 Based Communications Controller for the Petite Amateur Navy Satellite (PANSAT)," Master Thesis, December 1990.

SOLID STATE BUBBLE MEMORY DATA RECORDER (SSDR)

R. Panholzer, Chairman, Space Systems Academic Group
Sponsors: SSAG, NRL
Funding: NPS, NRL

OBJECTIVE: The goals of the Solid State Bubble Memory Data Recorder (SSDR) research project were to develop a Space Qualified Magnetic Bubble Memory Data Recorder as an alternative to the analog models; and to record acoustic data aboard the space shuttle during lift-off.

SUMMARY: This project ended with a "Proof of Concept" first generation 8-bit microprocessor based SSDR. Changes in flight opportunity for the Space Shuttle Vibroacoustic Experiment (see Professor Garrett), and promising developments in ferroelectric memory technology redirected development efforts away from a potentially cost ineffective, second generation, radiation hardened, space qualified Magnetic Bubble Memory SSDR.

THESIS DIRECTED: P.P. Ayotte, LCDR, USN, "The Operation and Circuit Analysis of the NPS Bubble Memory Data Recorder," Master Thesis, December 1989.

THIN-FILM FERROELECTRIC EXPERIMENT (FERRO NPS-001)

R. Panholzer, Chairman, Space Systems Academic Group
Sponsors: SSAG, NRL
Funding: NPS, NRL

OBJECTIVE: The goal of the ferroelectric memory research program is to evaluate ferroelectric technology to determine its suitability in military and space memory applications.

SUMMARY: In November 89, SSAG designed a Ferroelectric Experiment that was later incorporated into Orbital Science Corporation's (OSC) Datasat-X Satellite (now OrbComm-X). This satellite will be launched May 4th 1991 aboard an Ariane rocket from the French Guiana. Devices under test include one 8 bit octal latch and 8 256x1 bit static RAMS. This initial research effort was further developed into a Ferroelectric Memory Program. A new Thin-Film Ferroelectric Experiment was designed to test the effects of space environment on ferroelectric capacitors. On-ground and on-orbit fatigue, aging and radiation testing procedures were established using: (a) irradiated materials and devices for on-ground tests; and (b) high radiation orbits for space environment tests. A radiation-fatigue test board was designed to allow accurate and simultaneous testing of multiple ferroelectric devices.

CONFERENCE PRESENTATION:
Professor Panholzer, Co-Chairman and organizer, "The 2nd International Symposium on Integrated Ferroelectrics," held for the 1rst time at the Naval Postgraduate School.

THESIS DIRECTED: C.E. Josefson, CDR, USN, "Evaluation of Ferroelectric Materials for Memory Applications," June 1990.

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AIAA Paper No. 89-0023, Journal of Aircraft, Vol. 27, No. 6, pp 516-522, June 1990.

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AIAA Paper 91-0431, (Forthcoming).

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Journal of Aircraft, Vol. 27, No., pp. 468-470, May 1990.

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Journal of Spacecraft and Rockets, (Forthcoming).

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