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Monterey, California 93943-5019

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SUMMARY OF RESEARCH 1992

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NAVAL POSTGRADUATE SCHOOL
Monterey, California 93943-5019

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THE NAVAL POSTGRADUATE SCHOOL MISSION

The mission of the Naval Postgraduate School is to provide advanced professional studies at the graduate level for military officers and defense officials from all services and other nations. The school's focus is to increase the combat effectiveness of the armed forces of the United States by providing quality education which supports the unique needs of the defense establishment.

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PREFACE

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

To develop, on an ongoing basis, an overall research investment strategy that ensures a high quality creative and relavent learning experience for our graduate students, that encourages pursuit of new discoveries and applications in areas critical to DOD and that actively enhances the long term combat effectiveness of the Navy and other services.

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

In 1992, the faculty executed 124 research work-years. Of this total, 62% were reimbursable and 38% were direct funded. The work was 70% Navy and 30% non-Navy. The reimbursable research totaled $21M and was equally divided between Navy and non-Navy sponsors. The research work resulted in 838 theses, 361 journal papers, 272 conference papers, 612 conference presentations, 160 technical reports, 54 books and chapters, and 8 patents. In addition, NPS faculty received various national and international awards in recognition of their research accomplishments.

Research at NPS is carried out by faculty in the School's 11 Academic Departments and 4 Academic Groups. In the pages that follow, Research Summaries are provided for projects conducted by the faculty during FY 1992. They are grouped by Department and Academic Group with an overview provided by the Department or Group Chair. A List of Publications for each Academic Department is also included. Questions about particular projects may be directed to the principal investigator or to the Research Office. General questions about the NPS Research Program should be directed to the Research Office (408) 656-2098.

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

November 1993

Jeffrey B. Knorr
Associate Dean
of Research

NAVAL POSTGRADUATE SCHOOL
Monterey, California 93943

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DEPARTMENT OF ADMINISTRATIVE SCIENCES

Professor D.R. Whipple
Chairman



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) progrms. 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** contined 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 COMMUNICATIONS

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.

SOFTWARE PROJECT MANAGEMENT

Tarek K. Abdel-Hamid, Assistant Professor of Information Systems
Kishore Sengupta, Assistant Professor of Information Systems
Department of Administrative Sciences
Sponsor and Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project is to examine the processes by which software projects are managed and to investigate methods by which the management of software projects can be improved.

SUMMARY: The research project entailed conducting laboratory experiments on the decision processes underlying the management of software projects. The research finds that individuals have difficulty in making decisions in complex, dynamic environments. The quality of the decisions can be improved by delivering information on the task environment and altering reward structures.

THESES DIRECTED: Costello, T., "Anchoring and Adjustment in Software Project Management: An Experimental Investigation," Master's Thesis, September 1992.

Baker, D., " An Experimental Investigation of the Effects of Software Size Increase on Software Project Management Behavior," Master's Thesis, March 1992.

OTHER: Abdel-Hamid, T.K, K. Sengupta, and M. Hardebeck have submitted "The Impact of Reward Structures on Staff Allocations in a Multi-Project Software Development Environment," to IEEE Transactions on *Engineering Management*.

Sengupta, K. and Abdel-Hamid, T., have submitted "Anchoring and Adjustment: a Dynamic Perspective" to Information Systems Research.

DATA AND METHODS FOR ESTIMATING COSTS OF AIRCRAFT MODIFICATIONS AND DERIVATES

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

OBJECTIVE: The goal of this project iss to develop databases for eventual development of parametric cost estimating models for aircraft modification and derivative programs.

SUMMARY: In prior reporting period of this multi-year project, a survey of data availability, the formulation of a cost element structure, and acquisition were completed. Final database development was completed.

PUBLICATIONS: Boger, D.C. and Liao, S.S., "Aircraft Modifications Cost Analysis, Volume 10: The KC-135R

Engine Modification, " NPS Technical Report, NPS-AS-009PR, October 1992.

CASE STUDIES OF THE IMPLEMENTATION PRACTICES OF MANAGEMENT INFORMATION SYSTEMS IN DOD

Tung Bui, Associate Professor
Department of Administrative Sciences
Sponsor and Funding: Mr. Paul A. Strassmann,
Director of Defense Information, OASD (C3I)

OBJECTIVE: The objective of the research was to conduct a series of case studies that focus on important issues in the implementation of management information systems within the DoD. A case study may unfold either food or unsound practices, or possibly a mixture of both. Critical analyses of these findings will help formulate future implementation policies of DoD MIS.

SUMMARY: With four NPS faculty members and nine students, we conducted extensive field studies at DoD agencies that have played pioneering role in using information technology to enhance DoD combat effectiveness. Visited sites included the US Army Corps of Engineers, the Sata Management Center at Fort Belvoir, the RAPID center, Fort Lewis, Naval Logistics Command, OASD-C3I, and contractors involved in the projects initiated by these commands. Personal interviews, site visits, follow-on data gathering using questionnaires were conducted. We examined and evaluated research publications in the MIS literature, and paid visit to civilian institutions that engaged in similar use of information technology. Lessons learned were derived from these studies.

PUBLICATIONS: Bui, Tung, Dolk, Hayes, and Donohue. "Data Management: Implementation and Lessons Learned from the DOA Data Management Program, Technical Report, NPS-AS-93-04.

Bui, T., Blake, and Emery, "Prototyping with Application Generators: Lessons Learned from the Naval Aviation Logistics Command Management Information System Case," Technical Report, NPS-AS-93-005.

Bui, T., Emery, Suh, Harms, and VanHook, "A Clearinghouse for Reuse: Lessons Learned from the US Army RAPID Project, Technical Report, NPS-AS-93-06.

Bui, T., Emery, Duvall, and Elliot, "Business Re-Engineering: Lessons Learned from the US Army Corps of Engineers Modernization Program," Technical Report, NPS-AS-93-07.

THESES DIRECTED: Elliot, Maryjo, LT, USN, and Gilliann Duvall, LCDR., USN "Business Re-Engineering: Lessons Learned from the USA Army Corps of Engineers," Master's Thesis, September 1992.

Blake, Cheryl, LT, USN,"Software Development with Application Generators: The Naval Aviation Logistics Command Management Information Systems (NALCOMIS) Case", Master's Thesis, September 1992.

VanHook, Tina, LT, USN and Gerard Harms, LCDR. USN, "A Clearinghouse for Software Re-use: Lessons Learned from the RAPID/DSRS Initiatives", Master's Thesis, September 1992.

Donohue, Christine, LT, USN, and Hayes, Gregory, LT, USN,"Data

Management: Implementation and Lessons Learned for de DOA Data Management Program," Master's Thesis September 1992.

Harkleroad, Joseph, LT, USN, "A Case Study of Information Resource Management In DoD", Master's Thesis In Electronics and Communications, March 1992.

Jennings, Charles, LT, USN, "Re-Engineering Software Systems in DoD using Integrated CASE," Master's Thesis, September 1992.

IMPLEMENTATION OF A SINGLE EXERCISE ANALYSIS WORKSTATION (SEAS) PROTOTYPE

Tung Bui, Associate Professor
Department of Administrative Sciences
Sponsor and Funding: USA TRADOC Command

OBJECTIVE: The purpose of this two-year research has been to conduct a feasibility study and implementation of the Single Exercise Analysis System (SEAS). The system is intended to (i) provide Army analysts with an integrated computer system to analyze and evaluate battle exercises, and (ii) serve as a front-end of Janus(A). The research adopts a modular and prototyping approach to build the proposed prototype.

SUMMARY: During FY92, most of the efforts were devoted to the conceptual design of the system, specifically on the modeling aspects of the battle scenario generation process. A substantial amount of time was spent on the knowledge acquisition of the (i) data qualification process for tasked organized unites, and (ii) the tank route determination process. This first year of the research has led to the following modules of the prototype: an expert system module to compare OPFOR and BLUEFOR data from various data sources (i.e. INGRES database, video tape, NTC home package).

an expert system module for combat system totals comparison

an expert system module for combat system reallocation.

A neural net system that suggests routes based on qualified data a multimedia interface.

PUBLICATIONS: Bui, T., Davis Dryer, and Matthew Laskoski, "A neural-Network Based Behavioral Theory of Tank Commanders," NPS Technical Report, NPS-AS-92-015, published in the Conference Proceedings, Neural Network Conference, Navy Personnel Research and Development, San Diego, February 1993.

CONFERENCE PRESENTATION: Bui, T., "A Cognitive Model of Tank Commanders, Military Operations Research Society (MORS) conference, Monterey, May 1992.

THESES DIRECTED: Bryant, Lance, Jr.,CPT, USMC, Richard White Jr., LT, USN, "Automating the NTC-Janus(A) Conversion Process with Rule-Based Systems," Master's Thesis, March 1992.

Thur, Julia Ann, LCDR, USN, "Multimedia: The Case with Army's Single Exercise Analysis Prototype," Master's Thesis, September 1992.

Elridge, Dwayne, LT., USN, "Using Neural Network for Determining Battle Vehicle Routing in War Games," Master's Thesis, September 1992.

DEFENSE AND DESCENSUS: THE IMPACT OF CONGRESSIONAL BUDGET STALEMATE ON DEFENSE RESOURCES

Richard Doyle, Associate Professor of Public Budgeting,
Department of Administrative Sciences
Sponsor: Research Council
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this investigation was to extend an assessment of the impact of the Budget Enforcement Act of 1990 on the congressional budget process during the second full year of its implementation and the final year during which walls were in effect between the major categories of discretion spending.

SUMMARY: All of the major events associated with the development of the FY 1993 budget were recorded and analyzed. Spending conflict focus on an intense but unsuccessful efforts to remove the discretionary spending walls in order to shift resources from defense to domestic programs. Other controversies surrounded similarly unsuccessful efforts to amend the constitution to require a balanced budget and to cap entitlement spending. Because of the recession, increased spending for entitlements and the limited mandate of the Budget Enforcement Act, Congress was unable to prevent the deficit from reaching another record high.

CONFERENCE PRESENTATIONS: "The Impact of the Budget Enforcement Act of 1990 on Defense Budgets," presented at the annual meeting of the International Security Studies Section and the International Studies Association-West, Fall 1992.

"Reconciliation Revisited: A Decade of Practice and Policy," presented at the annual meeting of the Section on Budgeting and Financial Management of the American Society for Public Administration, October 1992.

Colloquium, "U.S. Defense Spending After the Cold War," presented to the Pacific Northwest Colloquium on International Security, Jackson School of International Studies, Seattle, WA, 3 Apri, 1992.

THESES DIRECTED: Knowles, Win, LCDR, USN, "The Budget Enforcement Act of 1990: Supplemental Appropriation Spending Control Effectiveness," Master's Thesis, December 1992.

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

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

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. To examine selected aspects of population representation in the military. This is part of a continuing project at NPS.

SUMMARY: The second 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 results of a pilot project in pre-enlistment skill training that was undertaken by the University of Mississippi; a case study of recruits from Florida who entered the military with a juvenile arrest record; a study of the Montgomery GI Bill (enrollment patterns and usage rates since its introduction in July 1985); and new research on the transfer of military skills to the civilian sector. A second report was prepared for Congress on "population representation" in Operations Desert Shield and Desert Storm, following an extensive effort to develop and refine a data base on personnel deployed to the Persian Gulf. Concluding work on the project resulted in two conference presentations in 1992 and preparation for follow-up activities in the years ahead.

CONFERENCE PRESENTATIONS: Mark J. Eitelberg, "Military Manpower Policy and the Defense Department's Reduction-in-Force," Annual Meeting of The Military Testing Association,San Diego, California, October 1992.

Eitelberg, Mark J., "Human Resource Development Issues in the U.S. Department of Defense," Annual Meeting of UTP-3, The Technical Cooperation Program, Kingston, Ontario, Canada, July 1992.

Eitelberg, Mark J. and Stephen L. Mehay, "Demographics and the American Military at the end of the 20th Century," paper presented at a "Workshop on U.S. Domestic and National Security Agendas: Into the 21st Century,: Cantigny, Illinois, September 1992. Sponsored by the U.S. Army War College, the National Strategy Forum, and the Robert R. McCormick Tribune Foundation.

Eitelberg, Mark J. and Stephen L. Mehay, "The Shape of Things to Come: Trends and Projections Affecting Military Recruiting and Manpower in the 21st Century," paper presented at a "Workshop on Sociocultural Designs for the Future Army." University of Maryland, March 1992.

Eitelberg, Mark J. and Stephen L. Mehay, "The Shape of Things to Come," in David R. Segal, Sociocultural Dimension of the Future Army.

Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences, 1992.

PUBLICATIONS: Eitelberg, Mark J. and Stephen L. Mehay. "The Shape of Things to Come: Trends and Projections Affecting Military Recruiting and Manpower in the 21st Century," NPS Technical Report, NPS-AS-92023, 1992.

ANALYSIS OF THE MANAGEMENT CONTROL IMPLICATIONS OF RAMP

K. J. Euske, Associate Professor
Department of Administrative Sciences
Sponsor: Commander, Naval Supply Systems Command

OBJECTIVE: This is a continuation of part of a previous research project. The specific Objective of this research project is:

1) Analyze the current management control system currently in place to support the RAMP project.

2) Recommend adjustments to that system such that the output of the system will provide information that accurately appraises the RAMP project.

3) Ensure that the system provides valid and reliable information regarding the cost, effectiveness, and efficiency of the RAMP project. The RAMP Project within the Navy is concerned with developing highly automated manufacturing facilities using advanced robotics.

Release time: One Quarter.

THESES DIRECTED: Douglas, Robert C., "An Assessment of the FCIM Decision Support System for the Effects of Lead Time on Procurement Decisions," Master's Thesis, December 1992.

IMPROVING THE PROCESS IMPROVEMENT PROCESS

K. J. Euske, Associate Professor
W. J. Haga, Associate Professor
Department of Administrative Sciences
Sponsor: Office of the Director of Defense Information

OBJECTIVE: The objective of the project is to design a process help the functional manager understand how to accomplish process improvement. The researchers will develop:

1). a model of how to effect process redesign,

2). an inventory of alternative resources and inputs that can be used by process redesign teams to accomplish their goal,

3). a case study demonstrating the application of the model and inventory.

THESES DIRECTED: Kotheimer, William C., Jr., "Development of a prototype Database to Support Business Reengineering in the Department of Defense," Master's Thesis, September 1992.

White, Scott A., "Modeling Process Redesign," Master's Thesis, September 1992.

IDENTIFICATION OF PERFORMANCE MEASUREMENT PROCEDURES

K. J. Euske, Associate Professor
Department of Administrative Sciences
Michel J. Lebas, Professor, Hautes Etudes Commericales
C. J. McNair, Associate Professor, Bason College
Sponsor: CAM-I International

OBJECTIVE: The purpose of the project is to identify how private sector organizations develop and use performance measures. The Objective of the study is to identify existing performance measurement practices, detail the linkages to and divergence form "accepted" theory and identify areas where performance management systems can be improved. The Project directly supports DoD efforts to support and improve the stability and competitiveness of the U.S. defense industrial base.

THESIS DIRECTED: Chacule, Sandra Kay, "Performance Measurement Systems: A Best Practices Study," Master's Thesis, December 1992.

CONFERENCE PRESENTATION: Euske, K.J., M. J. Lebas, and C. J. McNair, "Management Performance in an Industrial Setting: A Survey of Current Practice," The Second European Management Control Symposium, Hautes Études Commerciales, France, 9-11 July 1992.

INCENTIVES FOR NAVY RECRUITERS: LESSONS LEARNED FROM THE PRIVATE SECTOR

David R. Henderson, Associate Professor of Economics
Department of Administrative Sciences
Sponsor/Funding: Under MPTA Faculty Research to Support BUFERS and OP-01

OBJECTIVE: The goal of this project was to investigate how the private sector meets the challenge of giving incentives to recruiters, with the idea of drawing lessons from the private sector for use by the Navy.

SUMMARY: A thorough literature review was done and a questionnaire was sent to recruiters at various large companies in a wide range of industries. The literature was summarized and the data from the questionnaire were reported. There were three main findings. First, firms in the private sector often reward employees for referring other potential employees if those potential employees become actual employees. This way, many members of the employer's labor force, not just those who specialize in recruiting, are recruiters. Second, variety in incentives may be important to keep recruiters insensitive. Third, increasing incentives at the margin are sometimes used. This makes sense, if as seem likely, additional recruits are harder and harder to find.

THESIS DIRECTED: Skidmore, Mark, LT, USN, "Incentives for Navy Recruiters: Lessons from the Private Sector," Master's Thesis, September 1992.

CONFERENCE PRESENTATIONS: Henderson, David R., "A Humane

Economist's Case for Drug Legalization," presentation at the Cato Institute-CISLE Conference, "Liberating the Hemisphere: Free Trade and Beyond", Mexico City, May 22, 1992.

PUBLICATIONS: Henderson, David R., "Adultery's Legal; Why not Marijuana?," Los Angeles Times, 13 February, 1992.

Henderson, David R, "Incentives for Navy Recruiters: Lessons from the Private Sector," report prepared for Bureau of Naval Personnel (pers-2). David R. Henderson, "Capitalism: An Olympic Winner," The Freeman, July 1992.

Henderson, David R., "The Economics of Privatization," Speech given at Harvard University's John F. Kennedy School of Government, 28 August 1992.

Henderson, David R., "Academic Frauds" review of Impostors in the Temple by Martin Anderson, Fortune, November 16, 1992.

Henderson, David R., "What Should the President Read?", Reason, December 1992.

POTENTIAL MILITARY RIVALS

G.G. Hildebrandt, Visiting Associate Professor
Department of Administrative Sciences
Sponsor and Funding: Office of the Secretary of Defense

OBJECTIVE: The analysis will investigate issues associated with the maintenance of U.S. military-technological superiority into the twenty first century.

SUMMARY: The project was initiated on 28 September 1992. Work will begin during the Summer 1993 term. Final report is due 30 September 93.

STUDY OF QUALITY OF WORK LIFE AND ORGANIZATIONAL CULTURE AT THE NAVAL AIR WARFARE CENTER, AIRCRAFT DIVISION, INDIANAPOLIS

S. P. Hocivar, Adjunct professor
Department of Administrative Sciences
Sponsor/Funding: Naval Air Warfare Center
Aircraft Division, Indianapolis

OBJECTIVE: The goal of this project was to assist the sponsor with the design, analysis and interpretation of internal employee attitude surveys used as mechanisms for continuous improvement.

SUMMARY: Two employee surveys were conducted during 1992. First, the culture Gap survey was administered, data were analyzed, and results on the status of 1992 as well as comparison with 1990 data were provided. The second component involved the Quality of Work Life (QWL) survey, an instrument developed by the Center that has been used on a regular basis over the past 3 years. Analyses were done using data from prior administrations to enhance the

measurement characteristics of this instrument and recommendations were made to enhance the reliability of reported findings.

This revised instrument was then administered and analyzed at the end of 1992. A final report will summarize survey item results and longitudinal trends as well as qualitative comments.

PUBLICATION: Hocivar, S.P., "Culture Gap Study, 1990-1992," NPS Technical Report, NPS-AS-92-024PR, August, 1992.

OTHER: A briefing of the results of the Culture Gap Survey results was made to the Board of Directors of the NAWC-AD, Indianapolis and implications were discussed. The report on the QWL survey was completed and briefed in March 1993.

A COMPARISON OF THE FINANCIAL MANAGEMENT CURRICULUM WITH F.M. CURRICULA OFFERED AT OTHER INSTITUTIONS

L.R. Jones, Professor
J.L. McCaffery, Professor
Department of Administrative Sciences
Sponsor: Office of the Comptroller,
Office of Budget and Reports,
Department of the Navy
Funding: Naval Postgraduate School and the
Office of the Comptroller, COMNAVAIRPAC

OBJECTIVE: The goal of this project was to examine the structure of the financial management curricula offered at civilian institutions in the U.S., and with the programs offered by the Department of the Army and the Department of the Air Force and compare them to the financial management curriculum offered at NPS.

SUMMARY: The NPS curriculum was compared in detail to 54 other curricula accredited by the National Association of Schools of Public Affairs and Administration, including several prominent business schools and management schools with public sector programs. It was found that the NPS program offered a unique combination of MPA and MBA subjects tailored to the needs of the Navy. No other school had such a program. The NPS program was judged superior to MPA curricula in accounting, economics, and public sector budgeting and financial management. The NPS curricula programs in public sector budgeting, management, and public policy study. Relative to other DoD programs, the Navy educates public managers, while the Army is oriented toward business and the Air Force toward cost analysis. The possibility was raised that Navy students studying at civilian universities and seeking a financial management subspecialty code might not be adequately prepared in public sector emphasis, since most study in business curricula. The study also makes recommendations for improving NPS education, focusing on more financial management and more computer instruction and reasonable class sizes.

PUBLICATION: Jones, L.R., J.L. McCaffery, and R. Jackson. "A

Comparison Graduate Financial Management Programs Offered in U.S. institutions of Higher Learning." NPS Technical Report, August 1992.

THESIS DIRECTED: Jackson, R., LDCR, USN, "Comparison of the Financial Management Curriculum at the Naval Postgraduate School and other Graduate Public Financial Management Curricula in the United States." June 1992.

NAVY SHIP MAINTENANCE AND REPAIR AND IMPACT OF BUDGET REDUCTION

L.R. Jones, Professor
Department of Administrative Sciences
Sponsor and Funding: Naval Sea Systems Command

OBJECTIVE: The goal of this project was to assess the roles, participants and relationships in the Navy system for Ship Maintenance and Repair and to analyze methods for improving the efficiency and cost-effectiveness of this system. Selected issues in programming and budgeting for ship maintenance and repair also were examined. The goals and funding for this project were provided late in FY 1991 and continued in FY 1992.

SUMMARY: Research was performed in PACFLT and LANTFLT to assess the characteristics of the Navy ship maintenance and repair systems. This system was analyzed in terms of the roles of the participants and their relationships in the work preparation and documentation process for Navy ship repair and maintenance. The work preparation system as described and analyzed for methods and alternatives to improve efficiency and cost-effectiveness. Preliminary results were presented to the sponsor and feedback was obtained on further approaches to analysis. The climate and characteristics of the POM and budget preparation were assessed to assist in the design of further research.

PUBLICATIONS: Jones, L.R. and G. Bixler, "Mission Budgeting to Realign National Defense," (Greenwich, CT:JAI Press, 1992).

Jones, L.R., "Public Budget Execution Control," in J. Rabin, ed., Handbook of Public Budgeting and Financial Management, (New York, NY: marcel Dekker, 1992).

Jones, L. R., J. M. McCaffery, and J. Shields, "Financial Management Reform in the Federal Government, Technical Report, NPS-AS-92-04, August 1992.

CONFERENCE PRESENTATION: Presented a paper on Corporate Environmental Policy at International Conference on Public Service Ethics in Siena, Italy, June 1992.

THESES DIRECTED: Radice, M., "Analysis of the Defense Enterprise Program," Master's Thesis, June 1992 (Primary Advisor: Conrad Scholar).

Perkins, J., "Post-Availability Evaluation Systems in Ship Maintenance and Repair," Master's Thesis, December 1992.

Haidvogel, R., "The Afloat Maintenance Command and Finding Alternatives," Master's Thesis, December 1992.

Marchbanks, K., "Ship Maintenance and Repair in the Deployed Environments and the Effectiveness of Ship Tenders," Master's Thesis, December 1992.

Shields, J.J., "The Chief Financial Officer Act of 1992," Master's Thesis, December 1992.

NAVY FLEET AND FLIGHT HOUR BUDGETING AND IMPACT OF DMR AND BUDGET REDUCTION

L.R. Jones, Professor
Department of Administrative Sciences
Sponsor and Funding: AIRPAC, Pacific Fleetr

OBJECTIVE: The goal of this project was to assess the budget and the impact of budget reductions in the AIRPAC, PACFLT command, to assess management control system and accounting changes to respond to budget austerity including those related to DMR process and analyze U.S.-Japan national defense resource burdensharing.

SUMMARY: Research was performed in the field in AIRPAC HQ and installations to assess the characteristics of budget and accounting systems. These systems were analyzed in terms of the roles of the participants and their relationships in budget preparation, analysis and justification. The budget preparation system was analyzed for methods and alternatives to improve efficiency and cost-effectiveness. Preliminary results were presented to the sponsor and feedback was obtained on approaches to further analysis. The climate land characteristics of the POM and budget preparation were assessed with the assistance of the sponsor to assist in the design of further research. Characteristics of U.S.-Japanese defense resource burdensharing also were examined from a budgetary, political and economic perspective.

PUBLICATION: Jones, L.R. and R. Doyle, "Public Policy and Management Issues in Budgeting for National Defense," Defense Analysis, 23 March 1993.

CONFERENCE PRESENTATION: Paper on U.S.-Japan economic, trade land security relations at the annual research conference of the Association for Public Policy and Management, Denver, CO, October 1992.

Speech on the DMR process delivered to the San Diego Chapter of the American Society of Military Comptrollers, San Diego, CA. February 1992.

THESES DIRECTED: Martin, E., "The Navy Flight Hour Program: An Analysis of Potential Improvements," Master's Thesis, June 1992

Edwards, M., "Issues in Budgeting the Navy Flight Hour Program," Master's Thesis, December 1992.

Jacksom, P., "Cost Recovery for Health Care in the Navy," (Co-Advisor) Master's Thesis, December 1992.

Jimenez, R., "Naval Hospital Care Costs: A Case Study." (Assoc. Advi.), Master's Thesis, December 1992.

Kunkel, K., "Budgeting for Environmental Programs in the

Congress, the DoD and the Navy." (Assoc.Advisor), Master's Thesis, December 1992.

IMPACT OF DMR AND BUDGET REDUCTION AND DOD FM EDUCATION ASSESSMENT

L.R. Jones, Professor
J.L. McCaffery, Professor
Department of Administrative Sciences
Sponsor: Office of the Comptroller, DoD
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project was to assess the impact of budget reductions in DoD including those related to the DMR process and to conduct a survey of quality assessment in DoD Financial Management Education and Training Institutions.

SUMMARY: Research was performed to assess budget and DMR processes and reductions. These were analyzed in terms of the roles of the participants and their relationships. The budget system was analyzed for methods and alternatives to improve efficiency and cost-effectiveness. Preliminary results were presented to the sponsor and feedback was obtained on approaches to further analysis. The climate and characteristics of the budget preparation were assessed with the assistance of the sponsor to assist in the design of further research. The impact of the DMR in DoD was assessed. A survey of quality assessment methods in DoD Financial Management Education and Training Institutions was conducted and reported to the DoD Comptroller and staff to follow up on a part of DMR 985.

PUBLICATIONS: Jones, L.R., "The Defense Squeeze," Government Executive, 24/2, February 1992.

Jones, L.R, "Minding the Pentagon's Business," Government Executive, 24/10, October 1992.

Doyle, R. and J.L. McCaffery, "The Budget Enforcement Act - One Year Later," Public Budgeting and Finance, 11/3, 1992.

Jones, L.R., J. McCaffery, and M. Cragen, "Quality Assessment in DoD Financial Management Education and Training Institutions," NPS Technical Report, NPS-AS-92-05, August 1992.

Jones, L.R., J. McCaffery, and R. Jackson, "A Survey of Graduate Financial Management Education," NPS Technical Report, NPS-AS-92-06, August 1992).

CONFERENCE AND INVITED PRESENTATIONS: (1) Presented paper on DoD Financial Management Education and Training at annual conference of the Comptroller, DoD in Monterey, September 1992.

THESES DIRECTED: Cragen, M., "A Survey of Quality Assessment in Financial Management in DoD", (CoAdvisor), Master's Thesis, June 1992.

Jackson, R., "Comparing Graduate Financial Management Curricula in the U.S. to the Program at the Naval Postgraduate School," (CoAdvisor), Master's Thesis, June 1992.

Gilat, E., "The Arab Oil Boycott of Israel." (Assoc.Advisor), Master's

Thesis, December 1992.

Gallrein, E., "Navy Special Warfare Graduate Education Assessment," (CoAdvisor), Master's Thesis, June 1992.

IMPLEMENTATION, VALIDATION, AND REFINEMENT OF A COMPARATIVE EVALUATION METHOD FOR RISK MANAGEMENT METHODOLOGIES AND TOOLS (CERTS)

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

OBJECTIVE: The objective of this research project is to implement, validate, and refine a comparative evaluation method for risk management methodologies and tools.

SUMMARY: A new approach was recently proposed to effectively and objectively evaluate risk management methodologies and tools for their suitability to a given organizational situation. The proposed approach, known as CERTS, is based on defining suitability in terms of criteria which in turn are described in terms of attributes and metrics, using the Analytic Hierarch Process, this project develops the CERTS approach into an automated Decision Support System (DSS). The developed DSS is applied to three case studies to gain insights into and refine proposed methodology.

THESIS DIRECTED: Crump, L.A., Jr., and J.G. Pound, "DE-CERTS: A Decision Support System for a Comparative Evaluation Method for Risk Management Methodologies and Tools," Master's Thesis, September 1991.

RELIABILITY GOAL DETERMINATION FOR MAJOR CALIBER AMMUNITION

Keebom Kang, Adjunct Professor
Department of Administrative Sciences
Michael Bailey, Assistant Professor
Lyn Whitaker, Associate Professor
So Young Sohn, Assistant Professor
Department Operations Research
Sponsor and Funding: Naval Surface Warfare Center, Crane, IN

OBJECTIVE: This is a continuing support from Naval Surface Warfare Center, Crane, IN. The primary objective of the research is to determine how the effectiveness of NGFS changes with changes in round component reliability. The secondary concerns the storage of the millions of dollars worth of major caliber ammunition purchased every year. The continuing goal of this research is to develop good models and methodologies of estimation to predict deterioration rates as a func ion of a variety of conditions, such as vendor information and storage characteristics. These estimated deterioration rates would then be used to determine the best time to reorder ammunition before the

quality had deteriorated below an acceptable level.

SUMMARY: (i) Continuation of the study of reliability performance of major caliber ammunition used in NGFS, (ii) Construction of a simulation model for NGFS exercises and qualification test. (iii) Development of a Measure of reliability and bonus system to reward contractors with products whose reliability exceeds a minimum acceptable level, (iv) Development of methods that provide depot managers with information regarding appropriate time for reorder of ammunition before the quality reaches an unacceptable level. The first and the last items will be continued in FY93-FY94.

PUBLICATIONS: Bailey, M.P., M. Bartoli, K. Kang, and A.J. Callahan, "Establishing Reliability Goals for Naval Major Caliber Ammunition," Naval Research Logistics, Vol 39, 1992, pp 877-892.

Whitaker, L. and M.P. Bailey, "Pyrotechnic Device Reliability," Technical Report NPS-OR-92-05, Naval Postgraduate School, 1992.

Sohn, S. Young, "An Application of Growth Curve Analysis to the Ammunition Deterioration Model," Technical Report NPS-OR-92-013, Naval Postgraduate School, 1992.

CONFERENCE PRESENTATION: Sohn, S.Y., "An Application of Growth Curve Analysis to the Ammunition Deterioration Model," ORSA/TIMS National Conference, San Francisco, CA, November 1992.

THESIS DIRECTED: Mazanac, W., Lt., USN, "A Real Time Training System for NGFS Qualification Testing." Master's Thesis, Advisor: Prof. M. Bailey, March 1992.

OTHER: Spreadsheet-based decision support model was developed and delivered to NWSC.

DEFINITIONS OF CONTRACTING TERMS

D.V. Lamm, Associate Professor
Department of Administrative Sciences
Sponsor: Naval Postgraduate School
Funding: Unfunded

OBJECTIVE: The objective of this project was, and continues to be, the development of a dictionary of contracting terms.

SUMMARY: The contracting profession has been criticized over the past several years for the lack of clear definitions for a number of its terms. Beginning in 1988, NPS and the Air Force Institute of Technology (AFIT) have collaborated on a project to develop a dictionary of contracting terms to be used by the profession. The work has been accomplished principally by graduate thesis students at both institutions in the contracting curricula. Approximately 500 terms have been earmarked for definition, and approximately 350 terms have been defined. The process involves a comprehensive review of the literature, including The Federal Acquisition Regulation (FAR), to determine how a term is currently defined and to develop a "working" definition. A survey questionnaire

is used with selected experienced contracting professionals to obtain feedback concerning the terms use in practice. Responses are synthesized and a new proposed definition is presented. Terms are then published in the Contract Management journal with an invitation to respond to the researcher regarding any recommended changes.

PUBLICATIONS: Pursch, W.C. and D.V. Lamm, "A Dictionary of Contracting Terms, Part II," *Contract Management*, Vol 31, Issue 11, pp 42-45, November 1991.

CONFERENCE PRESENTATION: Lamm, D.V., "Acquisition Research," Fifth Annual Academic Conference for Contract Management Educators, University of California, Pomona, CA, 13 August 1992.

THESES DIRECTED: Zarau, M.M., "A Dictionary of Acquisition and Contracting Terms," Master's Thesis, December 1992.

Omeechevarria, G.L., "A Dictionary of Acquisition and Contracting Terms," Master's Thesis, December 1992.

Furforo, M.S., "A Dictionary of Acquisition and Contracting Terms," Master's Thesis, December 1992.

Hayes, S.T., "A Dictionary of Acquisition and Contracting Terms," Master's Thesis, December 1992.

Brown, M.A., "A Dictionary of Acquisition and Contracting Terms," Master's Thesis, December 1992.

Roe, R.G., "A Dictionary of Acquisition and Contracting Terms," Master's Thesis, December 1991.

Cotters, J.F., "A Dictionary of Acquisition and Contracting Terms," Master's Thesis, December 1991.

OTHER: Future articles will be published in Contract Management during 1993.

CONTRACT NEGOTIATIONS

D. V. Lamm, Associate Professor
Department of Administrative Sciences
Sponsor: Naval Postgraduate School
Funding: Unfunded

OBJECTIVE: The focus of this research was to examine the key differences among inexperienced negotiators and experienced negotiators related to general considerations as well as specific negotiation situations.

SUMMARY: A series of survey questionnaires were used to examine several negotiation elements as perceived by experienced and inexperienced negotiators. The test group for this study included students (considered to be experienced) participating in the Contract Pricing and Negotiations Course (MN3304) at NPS and industry contract administrators (considered to be experienced) participating in the in a sequence of negotiations with the students. The factors centered around the strategy, tactics, and ethics of negotiations as perceived by the two groups. A series of four questionnaires was used during the study. The first questionnaire was of a general nature

and was completed approximately 30 days before the negotiation sessions. The second, third and fourth questionnaires were administered immediately before, during and after the actual negotiation sessions. An analysis of the results includes a comparison of the two groups in terms of ethical vs unethical actions that might be taken during negotiations, the strategies considered the most feasible, and the tactics each group as a whole are likely to consider employing throughout the negotiation process.

THESES DIRECTED: Besch, T.M., "Identification of Negotiation Tactics and Strategies of Army Negotiators," Master's Thesis, December 1992.

Bennett, R.J., "Simulated Negotiations: A Measure of Their Effectiveness on Negotiated Outcome," Master's Thesis, December 1991.

OTHER: Two papers accepted for presentation at the 1993 Acquisition Research Symposium, June 1993. The researcher continues to use the Contract Pricing and Negotiations course/students as data collection base.

CONTRACTING TAXONOMIES

D.V. Lamm, Associate Professor
Department of Administrative Sciences
Sponsor: Naval Postgraduate School
Funding: Unfunded

OBJECTIVE: This project is a continuing effort to identify and examine various characteristics of the contracting profession through the development and use of the taxonomical approach. Taxonomies were develop for goods and for services.

SUMMARY: In order to research the acquisition and contracting profession, rigorous classification of significant characteristics must be accomplished. The premise that Federal Government goods exhibit elements than can be sued from a strategic sense in the buying process led to an attempt to identify and classify these elements. Through a panel of experts a theoretical structure was established. Questionnaires were used to obtain data for classification purposes. A model classification scheme was developed as the basis for further investigation. A second study was undertaken to examine homogeneous goods with specific sets of buyers. The study has been undertaken to examine the practical applications and benefits that can be gained through use of the taxonomy.

CONFERENCE PRESENTATION: D.V. Lamm for J.J. Pendergast, "Application of a Taxonomic Structure for Classifying Federal Goods," 1992 National Purchasing and Materials Management Research Symposium, California State University, Fresno, 13 March 1992.

THESES DIRECTED: Sheehan, E.W., "A Taxonomy of Goods Procured by the Federal Government," Master's Thesis, December 1992.

Perdergast, J.J., "Application of a Taxonomical Structure for Classifying Goods Procured by the Federal

Government," Master's Thesis, December 1991.

Allen, S.T., "A Taxonomy of Services Procured by the Federal Government," Master's Thesis, December 1991.

OTHER: Paper accepted for presentation at the 1993 Acquisition Research Symposium, June 1993. This is a continuing project in an attempt to integrate several taxonomies within the contracting profession into theoretical body of knowledge.

NAVAL POSTGRADUATE SCHOOL MPTA FACULTY RESEARCH IN SUPPORT OF N1/BUPERS

Sthephen L. Mehay,Professor
Linda Gorman, Adjunct Professor
Mark Eitelberg, Associate Professor
David Henderson, Associate Professor
Department of Administrative Sciences
Sponsor and Funding: Deputy Chief of Naval Operations (MPT)
N1/BUPERS, Washington, D.C.

OBJECTIVE: The project provided an umbrella funding within which individual projects were proposed and carried out by individual researchers. Mehay coordinated the overall project and facilitated interactions between individual MPT faculty and N1/BUPERS. Also, Mehay was the principal investigator of several sub-projects: 1. Economic Returns to Naval Service," 2. "OP-01 Model Validation and Technical Review," 3. "Analysis of Naval Officer Performance," and 4. "Wage Growth in Civilian Technical and Non-Technical Occupations."

SUMMARY: This project involved exploring alternative data bases to statistically estimate earnings patterns of military veterans and to compare navy veterans with those of other services; Projects # 2, 3, and 4 are on-going.

OTHER: Mehay, S., "Post-Service Earnings of Draft- and Volunteer Era Veterans," working paper.

Hirsch, B. and S. Mehay, "A Decomposition Analysis of Veterans Earnings Using Alternative Data Sets."

THESIS DIRECTED: Haumer, Mike, "Occupational Trends in the Civilian and Navy Labor Markets," December 1991.

ARMY RECRUITING IN THE 21ST CENTURY

Stephen L. Mehay, Professor
Mark J. Eitelberg, Associate Professor
Department of Administrative Sciences
Sponsor and Funding: U. S. Army Recruiting Command
Program Analysis and Evaluation Directorate
Fort 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 compiled numerous demographic, social, economic and other trends and projections, developed the implications of these trends for both active Army and reserve military manpower and recruiting; (2) We 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 subjects areas. (3) We published 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.

PUBLICATION: Mehay, S., and G. Swibies, "USAR Recruiting and Manpower in the 21st Century," NPS Technical Report, U.S. Army Recruiting Command, Ft. Knox, KY, 1992.

Eitelberg, M. and S. Mehay, "The Shape of Things to Come: Trends and Projections Affecting Military Recruiting and Manpower in the 21st Century," NPS Technical Report, NPS-AS-92-023, 1992.

OTHER: Organized a major conference entitled "Marching Toward the 21st Century," held in Arlington, VA in July 1992. The Conference brought together experts from numerous fields and will result in the publication of a book.

RESYSTEMIZATION MODELING SUPPORT

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

OBJECTIVE: A continuing project 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 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).

A realistic simulation model of the Navy's repairable inventory management process was successfully developed this past year, with the help of an OR thesis student, which allowED determination of the empirical time-weighted distributions for the inventory position (IP) and the net inventory levels. This model reflects the time a carcass is in repair as the measured repair turn-around time (RTAT) and allows a batch to be phased into repair, one unit at a time. As each carcass is successfully repaired, both the IP value and the net inventory value are adjusted to reflect that fact. In addition, carcasses which fail to be repaired are discharged from repair as soon as they are inducted and the IP is updated at that time. Simulation results have provided two important results; a means for defining safety stock for repairable item inventories and a confirmation of a model for IP derived two years ago.

In addition to the repairable item replenishment model, work continued on the development, with the help of three thesis students, of a queuing model for the Navy's process of handling carcasses being returned from the customer (called the Advanced Traceability and Control (ATAC) system). A year's worth of ATAC data was analyzed in two different theses: the first looked at an average item and the second subdivided the items into the major cognizance groups.

THESES DIRECTED: Pritchard, J.W., LCDR, USN, "The Advanced Traceability and Control System Performance Data Analysis," Master's Thesis, June 1992.

Mahaffey, V.G., LT, USN and R.A. Walker, LT, USN, "An Analysis to Specific Cognizance Symbol Material in the Advanced Traceability and Control (ATAC) Program," Master's Thesis, December 1992.

COST/EFFECTIVENESS ANALYSIS OF THE COMPONENT IMPROVEMENT ANALYSIS

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

OBJECTIVE: A continuing project to develop models to predict the savings in life-cycle costs of proposed engineering changes intended to improve reliability, maintain-ability, and sustainability of engines for Naval aircraft.

SUMMARY: An important element of aircraft logistical support is the aircraft engine Component Improvement Program (CIP). The CIP is essential for the continuing evolution of these engines. This project is looking for ways to justify that program. The approach is two-prolonged. The first

phase is to examine the current life-cycle cost models used by Air Force and the Navy to show expected savings from a specific improvement. Consideration of the Air Force model is being done because that service has been more successful in obtaining support for its CIP than the Navy. In addition, a better model than either of these is being sought. The second phase is to validate the logistics effectiveness of the CIP by looking at historical data. That may also suggest ideas for an improved model.

This Year sensitivity analyses of the Navy and Air Force models were performed and a User's Manual for the GE version of the Air Force model was developed, These are important steps towards understanding the models' assumptions. Data analyses of the J-52 engine were conducted to determine what connection there could be made between failures due to fuel nozzle problems were also studied.

THESES DIRECTED: Crowder, G.L., LT, USN, "Evaluation of the Cost Effectiveness Analysis Model Being Developed for the Component Improvement Programs of the Air Force and the Navy," Master's Thesis, June 1992.

Baldwin, R.P., LCDR, USN, "Aircraft Engine Reliability Analysis Using Lower Confidence Limit Estimate Procedures," Master's Thesis, December 1992.

Butler, R.S., LCDR, USN, "Preliminary Analysis of the J-52 Aircraft Engine Component Improvement Program," Master's Thesis, December 1992.

Clague, D.G., LT, USN, "A User's Manual for the General Electric Aircraft Engines Cost Effectiveness Analysis Model, (GE CEAMOND)," Master's Thesis, December 1992.

Gordon, L.B., LCDR, USN, "An Analysis of the Correlation Between the J-52 Engine Component Improvement Program and Improved Maintenance Parameters," Master's Thesis, December 1992.

Martens, S.L., LT, USN, "Estimating Characteristic Life and Reliability of an Aircraft Engine Component Improvement in the Early Stages of the Implementation process," Master's Thesis, December 1992.

NAVY LOGISTICS RESEARCH ASSESSMENT AND TECHNICAL DEVELOPMENT PLAN

A.W. McMasters, Professor of Operations Research and Administrative Sciences
Department of Administrative Sciences
Sponsor and Funding: Carderock Division, Naval Surface Warfare Center

OBJECTIVE: To conduct a preliminary study to assess the estate-of-the-art of Navy-related Operations Research logistics models in an attempt to identify areas where further model developments is needed. The full spectrum of models from weapon system integrated logistics support to operational logistics is to be examined.

SUMMARY: Since World War II, logistics research has received considerable attention and has lead

to Operations Research methodologies for solving a wide variety of logistics problems. Much of the continuing evolution of logistics models is being documented in professional journals. However, most of this research is not focused on military and, in particular, Navy logistics issues. And not all military logistics research is reported in the open literature. There are several organizations within the military services and in the private sector which have worked on such problems. Meetings with these agencies were held during August and September. The conclusion reached was that, with the exception of the Naval Postgraduate School, only very minor Navy-related OR modeling efforts are being conducted.

Five years have been identified for which the need is most pressing for OR logistics models: reliability prediction of new and existing complex systems; readiness-based sparing models for repairables which allow batching for procurement and repair; inventory location and transportation models to help decide stock positioning under a reduced infrastructure; underway replenishment models for helping to reduce the time that battle group is not available for combat; and a logistics tasking order model for scheduling and coordinating logistics support for task force and joint operations.

These modeling efforts must consider the current constrains imposed by the Navy's new strategic plan ("..From the sea"), the Defense Management Review Decisions and the moves towards joint services logistics management.

INVESTIGATION AND EVALUATION OF COST PROGRESS MODELS AND COST ESTIMATION METHODS

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

OBJECTIVE: This project continues the investigator's program of research on the performance of various cost estimating methods and models. The goal of this year's project was to assess the degree to which particular statistics were indicative of the predictive ability (accuracy) of selected learning curve type cost models.

SUMMARY: A simulation approach was used to create data reflecting series of unit costs of weapon systems acquired under *varying conditions*. Alternative cost models were fit to the data and statistics indicating the closeness of fit were observed. Then the models were used to forecast future cost and the accuracy of the cost forecasts was measured. The central question was whether fit statistics were good indicators of the forecasting ability of a model. Finding revealed which fit statistics best signaled model accuracy, and under which conditions.

PUBLICATION: Moses, O.D., "On the Reliability of Indicator of Learning Curve Models Accuracy," Naval Postgraduate School Technical Report No. NPS-AS-92-16, July 1992.

CONFERENCE PRESENTATIONS: Moses, O.D., "An Investigation of Learning Curve and Rate Adjustment Model Bias," Decision Sciences Institute National Meeting, Miami, FLA, November 1991.

Moses, O.D., "Learning Curve and Rate Adjustment Models: Evidence on Accuracy and Bias," Society of Cost Estimating and Analysis National Conference, Washington, D.C., July 1992.

Moses, O.D., "An Investigation of Indicators of Cost Progress Model Accuracy," 26th Annual DoD Cost Analysis Symposium, Washington, D.C., September 1992.

Moses, O.D., "On the Reliability of Indicators of Learning Curve Model Accuracy," Decision Sciences Institute National Meeting, San Francisco, CA, November 1992.

THESIS DIRECTED: Tagg, D.A., CAPT, USMC, "Evaluating the Bias of Alternative Cost Progress Models," Master's Thesis, December 1992.

A.1 KNOWLEDGE-BASED SUPPORT FOR SYSTEMS DESIGN AND MAINTENANCE

B. Ramesh, Assistant Professor
Department of Administrative Sciences
Sponsor and Funding: Naval Postgraduate School

OBJECTIVE: The objective of this research is to develop an environment to support various stakeholders involved in systems development by reasoning with design rationale knowledge.

SUMMARY: Support for various stakeholders involved in software projects (designers, maintenance personnel, project managers and executives, end users) can be provided by capturing the history of about design decisions (or process knowledge) in the early stages of the systems development lifecycle. This research project builds on our earlier work in which a conceptual model characterizing the use of design rationale knowledge to objects that are created during the systems development process. We have developed a prototype system based on our model that can provide assistance to the various stakeholders involved in the design and management of large systems. Various activities for which support is provided include the following areas: capturing design rationale, reuse of design knowledge components, domain knowledge acquisition, design synthesis, design decision support, maintenance of changing requirements, process knowledge reuse, design replay, temporal reasoning in project management.

PUBLICATIONS: Ramesh, B. and V. Dhar, "Supporting Systems Development Using Knowledge Captured During Requirements Engineering," IEEE Transactions on Software Engineering, June 1992.

Ramesh, B. and V. Dhar, "Group Support and Change Propagation in Requirements Engineering," in Jarke M. (Ed.): Development Assistance for Interactive Database Applications", Springer-Verlag, Hidelberg. Fall 1992.

Ramesh, B. and V. Dhar, "Applying Artificial Intelligence to Software Problems in REMAP project," in

proceedings of the IEEE Conference on AI Applications workshop on Applying AI to Software Problems, Monterey, CA, January 1992.

Ramesh, B. and V. Dhar, "Process knowledge Based Modification in Systems Development," in proceedings of the American Association for Artificial Intelligence Spring Symposium on Computational Considerations in Modification and Reuse, Stanford, CA, March 1992.

THESIS DIRECTED: Stenzoski, J.J., LCDR USN, "X Windows Applications Extensions using the Andrew Toolkit," Master's Thesis, September 1992.

COMPLEX TRACEABILITY TECHNIQUES FOR LARGE SCALE SYSTEMS

B. Ramesh, Assistant Professor
Department of Administrative Sciences
Sponsor and Funding: Naval Surface Warfare Center, Dahlgren Division

OBJECTIVE: The objective of this research is to develop a model of requirements traceability to support various stakeholders in large scale systems development.

SUMMARY: Development of complex, mission critical systems involves modification, refinement and evolution of initial requirements that lead to design solutions. In order to provide intelligent and useful support to the process of design and maintenance, a formal representation of the linkages between the design solutions and the requirements is essential. A comprehensive traceability scheme should no only identify traceability linkages to be maintained, but also provide the mechanisms to support use such a model and mechanisms by studying the current practices and techniques for requirements traceability and by identifying desired features in an ideal requirements traceability model and tool.

PUBLICATIONS: Ramesh, B. and M. Edwards, "An Initial Model of Requirements Traceability," in proceedings of the Workshop on Complex Systems Design, Naval Surface Warfare Center, Silver Springs, MD, September 1991.

THESIS DIRECTED: Abbott, Ann, LT, USN and Mona Busch, LT, USN, "An Investigation of Requirements Traceability to Support Systems Development," Master's Thesis, September 1992.

MILITARY DECISION MAKING

N.C. Roberts, Associate Professor
K. Sengupta, Assistant Professor
Department of Administrative Sciences
Sponsor: Naval Oceans Systems Center, San Diego
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project was to investigate how individuals, groups and organizations make decisions in military and DoD related contexts at both the strategic and operational levels of analysis and to make recommendations for improvement.

SUMMARY: This research cautions against the transfer of "lessons learned" from business decision making research and practice to organizations like the DoD/DoN with their special missions and mandates. Decision making in strategic and operational settings, especially under combat conditions, requires a decision approach geared to these unique contexts and situations.

PUBLICATIONS: Entin, E., D. Serfaty, D. Kleinman, and K. Sengupta, "Identification Error Under Stress in Navy Teams," Proceedings of the Annual Conference of the American Psychological Association, Washington, D.C., August 1992.

Roberts, N.C. "Reconstructing Combat Decisions: Reflections on the Shootdown of Flight 655," NPS Technical Report, NPS-AS-93-008, October 1992.

Serfaty, D., Sengupta, K., Kleinman, D.L., Song, A., and Deckert, J., "Hierarchical Decision Making and Resource Allocation in Command Teams," Proceedings of the IEEE Conference on Systems, Man and Cybernetics, Chicago, IL, October 1992.

CONFERENCE PRESENTATIONS: Bradley, R.T., and N.C. Roberts, "Dynamics of Collective Organization," paper presented to the International Sunbelt Network Conference, San Diego, CA, 14-17 February.

N.C. Roberts, "Strategic Planning in Public Bureaus," presentation to the Navy TQL Executive Leaders Seminar, 9 January 1992.

N.C. Roberts, "Reflections on the Shutdown of Fight 655," presentation to the 9th Annual Conference on C2 Decision Aids. Luncheon Speaker with Captain Will Rogers, 8 June 1992.

THESES DIRECTED: Kinney, B.C., and Symunds, S.B., "Achieving Just-in-Time Inventory Management at Naval Hospital, Oakland," Master's Thesis, December 1992.

Herrera, E.A., "Central Factors Affecting Purchasing and Contracting at Marine Corps Air Stations: Historical, Doctrinal, and Regulatory," Master's Thesis, December 1992.

Dotterway, K., "Systematic Analysis of Complex Dynamic Systems: The Case of the USS Vincennes," Master's Thesis, June 1992.

Ford, J.P., "Voluntary Separation and Early Retirement Plans: A Survey of Naval Postgraduate School Lieutenant Commanders," Master's Thesis, June 1992.

Broadwater, D.G., "SMMA Development Case Study," Master's Thesis, June 1992.

Frew, J.L., "Method for Implementing Computer Aided Software Engineering (Case) Tools at Fleet Numerical Oceanography Center," Master's Thesis, March 1992.

Lane, C.J., and J.W. Monk, "Decision Making in Military Command Teams: An Experimental Study," Master's Thesis, March 1992.

Krotow, G., "The Impact of Cognitive Feedback on the Performance of Intelligence Analysts," Master's Thesis, March 1992.

OTHER: Sengupta, K., D. Klinman, and D. Serfaty have submitted the Impact of Uncertainty in Resource Allocation Decisions in Naval Command Teams: An experimental Investigation" to IEEE Transactions on Systems, Man, and Cybernetics.

COST MANAGEMENT, STANDARDS, AND ANALYSIS: CASE STUDIES

J.G. San Miguel, Professor
Department of Administrative Sciences
Sponsor and Funding: Naval Postgraduate School

OBJECTIVE: This field research examines numerous issues involving the Department of Defense's design and implementation of unit costing to provide resources to defense activities.

SUMMARY: The easing of tension between the Soviet Union and the U.S. coupled with the rising federal deficit and a change in administrations have brought about several Department of Defense initiatives to improve management planning and control across defense activities. Two of these initiatives are: the consolidation of similar activities across the armed services, and the use of total cost per unit of output to resource defense activities such as supply depots, recruiting, training, commissaries, etc. This field research examines the management issues involved in the design and implementation of unit costing for the prototype consolidation of the physical distribution or supply activities. Individual supply centers' managers and DoD officials will be contacted as well as performing data collection and analyses. This project was funded for one month, June 1992.

OTHER: Abrams Company and Seaside Naval Shipyard.

THESES DIRECTED: Bruhn, D.D., LT, USN, "The Costs/Benefits of Opening a Skilled Nursing Facility at Naval Hospital San Diego," Master's Thesis, June 1992.

Doyle, G., LT, USN, "Cost Estimation of Software Development and Implications for the Program Manager," Master's Thesis, June 1992.

Berchtold, D., LT, USN, and D. Danner, LT, USN, "Utilities Cost Comparison Analysis Between A Public Works Center and Non-DoD Sector," Master's Thesis, December 1992.

STRATEGIC PROFIT ANALYSIS

J. G. San Miguel, Professor
Department of Administrative Sciences
Sponsor: None
Funding: Unfunded

OBJECTIVE: 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.

OTHER: Bridgewater Castings, Inc., (Revised) December 1992; Emerson Electric Company, September 1992.

RESEARCH FOR THE DEVELOPMENT OF TEST STRATEGIES USING RELIABILITY MODELS, AND OPTIMAL SELECTION OF MODEL FAILURE DATA

Norman F. Schneidewind, Professor
Department of Administrative Sciences
Sponsor and Funding: Strategic Systems Department Naval Surface Warfare Center, Dahlgren, VA 22448

OBJECTIVE: 1) Investigate whether the Schneidewind software reliability model can be used to formulate test strategies; 2) Investigate whether criteria can be identified to optimally determine the starting point of using the failure data in order to provide the greatest prediction accuracy of future failures.

SUMMARY: 1) A strategy for testing was developed by allocating test execution time in a given test interval for a given module according to the proportion of failures predicted for the module to the total number of failures predicted across modules. 2) Four criteria were evaluated for determining the optimal staring interval for the use of failure data. It was found that the mean square error criterion was the most consistent of the criteria in identifying the optimal starting interval for both predicted cumulative failures and time to next failure.

PUBLICATIONS: Schneidewind, N.F., and T.W. Keller, "Application of Reliability Models to the Space Shuttle," IEEE Software, July 1992 pp. 28-33.

CONFERENCE PRESENTATIONS: Schneidewind, N.F., Panel: "Collection and Application of Software Quality Data," Third International Symposium of Software Reliability Engineering, Raleigh, NC, October 1992, pp. 283-284.

Schneidewind, N.S., "Application of

Assessment Techniques Throughout the System Development Process," 1992 Complex Systems Engineering Synthesis and Assessment Technology Workshop, Naval Surface Warfare Center, White Oak, MD, 21 July 1992.

Schneidewind, N.F., "A Software Reliability Model with Optimal Selection of Failure Data," Computer Science Symposium, University of Houston, TX, 5 November 1992.

Schneidewind, N.F., "A Software Reliability Model with Optimal Selection of Failure Data," IBM Federal Sector Services Corporation, Houston, TX, 4 November 1992.

Schneidewind, N.F., "Overview of the Schneidewind Software Reliability Model," NASA, Houston, TX, 4 November 1992.

Schneidewind, N.F., "Applying Reliability Models to the maintenance of Space System Software," Software Process Improvement Network, University of California, Irvine, CA, 31 July 1992.

Schneidewind, N., "Applying Reliability Models to the Maintenance of Space Shuttle Software," Proceedings of the NASA/Goddard Software Engineering Laboratory Seventeenth Annual Software Engineering Workshop, Greenbelt, MD, 2 December 1992.

N. Schneidewind, "Reliability Models and Metrics for Space Shuttle Maintenance," (Position Statement), Conference on Software Maintenance, 1992, Orlando, FLA, 12 November 1992, pp. 386.

Keller, T.W. and N.F. Schneidewind, "Applying Reliability Models to the Maintenance of Space Systems Software," Proceedings of the 1992 International Simulation Technology Conference, 4-6 November 1992, Clear Lake, TX., pp 273-278.

Schneidewind, N.F., Panel on American Institute of Aeronautics and Astronautics Recommended Practice for Software Reliability: Overview, Proceedings of the Third International Symposium on Software Reliability Engineering," Raleigh, NC, 3 October 1992, pp. 124-125.

Schneidewind N.F. and T. W. Keller, "Application of Software Reliability Models to Space Systems," Fourth Annual Laboratory Software Quality Workshop, 5 August 1992. This paper was also reported in the Data Analysis Center for Software Newsletter, Vol. XI, No. 1, Fall 1992.

Schneidewind, N.F., "Methodology for Validating Software Metrics," Proceedings of the 1992 Complex Systems Engineering Synthesis and Assessment Technology Workshop, Naval Surface Warfare Center, white Oak, MD, 21 July 1992, pp. 171-199.

Schneidewind, N.F., "Using Software Reliability Models for Developing Test Strategies," proceedings of the Fourth Annual Oregon Workshop on Software Metrics, Silver Falls, OR, 23 March 1992.

VALIDATION AND APPLICATION OF SOFTWARE QUALITY METRICS

Norman F. Schneidewind, Professor
Department of Administrative Sciences
Sponsor and Funding: U.S. Army Operational Test and Evaluation Command CSTE-POC Park Center IV, Room 1050
4501 Ford Avenue, Alexandria, VA 22302-1458

OBJECTIVE: Validate and Apply Software Quality Metrics for the STEP Program.

SUMMARY: A comprehensive metrics validation methodology was developed that has six criteria, which support the quality functions assessment, control and prediction, where quality functions are activities conducted by software organizations for the purpose of achieving project quality goals. Six criteria have been defined and illustrated: association, consistency, discriminative power, tracking, predictability and repeatability. It was shown that non-parametric statistical methods like the contingency tables play an important role in evaluating metrics against the validity criteria. A metrics validation process was defined that integrates quality factors, metrics and quality functions.

PUBLICATIONS: Schneidewind, N.F., "Methodology for Validating Software Metrics," IEEE Transactions on Software Engineering," May 1992, PP.410-422.

Schneidewind, N.F., Editor, IEEE Standard for a Software Quality Metrics Methodology, P1061,D24, May 1, 1992 (Technical Report).

Schneidewind, N.F., "Minimizing Risks in Applying Metrics on Multiple Projects," Proceedings of the Third International Symposium on Software Reliability Engineering, Raleigh, NC, 9 October 1992, pp.173-182.

Schneidewind, N.F., "Experimental Designs for Validating Metrics and Applying them across Multiple Projects," Proceedings of the Experimental Software Engineering Issues Seminar, Dagstuhl Castle, Germany, 14-16 September 1992, Springer-Verlag.

CONFERENCE PRESENTATIONS: Schneidewind, N.F., "Minimizing Risk in Applying Metrics on Multiple Projects," Florida Atlantic University, Department of Computer Science and Engineering, 13 November 1992.

Schneidewind, N.F., "Status of Software Metrics: Methodology and Validation," University of California at Berkeley, Department of Electrical Engineering and Computer Sciences, Computer Science Colloquium, 11 March 1992.

THE ARMY FUTURE PERSONNEL SYSTEM

George W. Thomas, Associate Professor
Daniel R. Dolk, Associate Professor
Department of Administrative Sciences
Sponsor and Funding: U. S. Army Research Institute

OBJECTIVE: To Assist the Deputy Chief of Staff of the Army for Personnel (DESPER) in defining the personnel system of the future. Database and analytical modeling requirements will be identified to support manpower policy analysis for the Army Future Personnel System.

SUMMARY: A new Global military balance coupled with domestic budgetary constrains is necessitating an evolution of the Army Personnel system. The Army Future Personnel System will require a more fluid and integrated use of data and modeling resources. Whereas current models (e.g. PCS model, company rotation model, and fill rate optimization models) have been developed by disparate organizations with a resultant loss of data uniformity and inter-operability, the personnel models of the future must be integrated to reflect the steady state Army of the future and to support personnel management from a total force and total systems perspective. Current models need to be assessed for their strengths and weaknesses. A requirement analysis is being conducted to ascertain existing and desired model and data resources, and to assist in planning a migration path from the current human resource policy analysis environment to the desired one. This project was instituted September 1992.

NAVAL POSTGRADUATE SCHOOL RESEARCH SUPPORT FOR ARPERCEN

George W. Thomas, Associate Professor
Daniel R. Dolk, Associate Professor
Department of Administrative Sciences
Sponsor and Funding: Army Reserve Personnel Center

OBJECTIVE: To establish and umbrella research effort on the part of a group of NPS faculty to support the on-going research needs of ARPERCEN.

SUMMARY: This relationship was initiated in September 1992. We currently are working with the sponsor to develop a plan. Some elements of the study plan will be funded under the current umbrella. Other elements will be the basis for a long term relationship to ARPERCEN. The purpose of the first pro-project under this umbrella relationship is to develop a study plan for quantitatively identifying segments of the prior service market for personnel who have left the active component within two years.

NAVAL POSTGRADUATE SCHOOL SUPPORT FOR SLA

George W. Thomas, Associate Professor
Daniel R. Dolk, Associate Professor
Department of Administrative Sciences
Sponsor and Funding: Strategic Logistics Agency

OBJECTIVE: To establish an umbrella research effort on the part of a group of NPS faculty to support the on-going research needs os SLA.

SUMMARY: The Strategic Logistics Agency is responsible for performing developmental design, analysis and testing to determine the most efficient methods for modernization of the supply, maintenance, transportation, provisioning, distribution and service functions of existing and emerging logistics automation systems. Opportunities exist for research in logistics, information systems, C3, and economics. This project was initiated in September 1992. Twenty two proposals were received in response to our internal solicitation of NPS faculty. They were reviewed by the sponsors and three integrated projects currently are in the process of being funded for faculty in the AS and OR Departments.

FACTORS AFFECTING SOFTWARE REUSE

Dani Zweig, Assistant Professor
Department of Administrative Sciences
Sponsor: SEER Technologies
Funding: Naval Postgraduate School

OBJECTIVE: This is the continuation of an empirical research project, whose purpose is to identify (and quantify) factors which determine the success of efforts to reuse existing software for new application systems.

SUMMARY: We have been studying two sites (one investment bank and one retailer) which are using an integrated. Object-based CASE development environment. In the past year the emphasis was on comparing the sites' different management approaches to software reuse. Although they were quite different - the bank choosing a more lazes-faire policy and the retailer attempting to monitor and control reuse- the sites achieved almost identical levels of success. Our earlier research gave us a number of testable hypotheses to explain these results, and this past year we were able to obtain data from the sites' object-repositories and to quantitatively test these hypotheses. The success of both programs of software reuse was greater than we had initially estimated, but both were constrained by a need for better search and classification mechanisms. This accords with generally held opinions about software reuse, but there has previously been little empirical work to support those opinions.

CONFERENCE PRESENTATIONS: Banker, R.D., R.J. Kauffman, and D. Zweig, "The Integral Tool: An Automated Approach to Repository Evaluation and Software Asset management," second MITRE Software Engineering Economics Conference, 13 July 1992.

OTHER: "Automating Output Size and

Reusability Metrics in an Object-Based CASE Environment," is under review at IEEE Software Transactions, and an article based upon the conference presentation was requested for a forthcoming book, and is currently being written.

DEPARTMENT OF ADMINISTRATIVE SCIENCES

1992
Faculty Publications and Presentations

TECHNICAL REPORTS

Bhargava, H. and Kang, K., "Policy and Modeling Altenatives for Fleet Mix Planning the U. S. Coast Guard," Research Report, 1992.

Boger, D.C. and Liao, S.S., "Aircraft Modifications Cost Analysis, Volume 7: Availability and Reliability of Aircraft Modification Cost Data from the Naval Aviation Depots," NPS Technical Report, NPS-AS-93-011PR, November 1992.

Boger, D.C. and Liao, S.S., "Aircraft Modifications Cost Analysis, Volume 9: The B-1B Offensive Avionics System Modification," NPS Technical Report, NPS-AS-92-012PR, March 1992.

Boger, D.C. and Liao, S.S., "Aircraft Modifications Cost Analysis, Volume 8: The B-52 Strategic Radar Modification," NPS Technical Report, NPS-AS-92011PR, February 1992.

Boger, D.C. and Liao, S.S., "Aircraft Modifications Cost Analysis, Volume 10: The KC-135R Engine Modification, " NPS Technical Report, NPS-AS-009PR, October 1992.

Crawford, A.M., "A Profile of Scientist and Engineer Training at the Naval Avionics Center 1981 to 1991," NPS Technical Report, 1992.

Crawford, A.M. and Gregory, M.L., "Evaluation of The Training System for Scientists and Engineers at the Naval Avionics Center," NPS Technical Report, 1992.

Crawford, A. M. and Hocivar, S.P., "Employee Perceptions of Selected Management Training Courses at the Naval Avionics Center," NPS Technical Report, NPS-AS-92-014PR, 1992.

Eitelberg, Mark J. and Mehay, Stephen L., "The Shape of Things to Come: Trends and Projections Affecting Military Recruiting and Manpower in the 21st Century, NPS Technical Report NPS-AS-92-023, 1992.

Eitelberg, M. and Mehay, Stephen L., "The Shape of Things to Come: Trends and Projections Affecting Military Recruiting and Manpower in the 21st Century," NPS Technical Report, NPS-AS-92-023, 1992.

Hocivar, S. P., "Culture Gap Study, 1990-1992," NPS Technical Report, NPS-AS-92-024PR, August 1992.

Jones, L.R., McCaffery, J.L. and Kackson, R., "A Comparison Graduate Financial Management Programs Offered in U.S. institutions of Higher Learning." NPS Technical Report, August 1992.

Jones, L.R., "Financial Management Reform in the Federal Government," NPS Technical Report, NPS-AS-92-04, August 1992, (co-authored with J.M. McCaffery and J. Shields).

Mehay, S. and Swibies, G., "USAR Recruiting and Manpower in the 21st Century." NPS Technical Report, 1992.

Moses, O. D., "On the Reliability of Indicator of Learning Curve Models Accuracy," NPS Technical Report NPS-AS-92-16, July 1992.

Schneidewind, Norman F., Editor, "IEEE Standard for a Software Quality Metrics Methodology," Technical Report P1061,D24, 1 May 1992.

Sohn, S. Young, "An Application of Growth Curve Analysis to the Ammunition Deterioration Model," NPS Technical Report NPS-OR-92-013, 1992.

Sumner, J.D. and Kang, K., "Analysis of Material Handling Equipment for Maritime Prepositioning Ships (MPS) Offloading," NPS Technical Report, NPS-AS-92-018, April 1992.

Whitaker, L. and Bailey, M.P., "Pyrotechnic Device Reliability," NPS Technical Report NPS-OR-92-05, 1992.

JOURNAL ARTICLES

Bailey, M.P., Bartoli, M., Kang, K., and Callahan, A.J., "Establishing Reliability Goals for Naval Major Caliber Ammunition," *Naval Research Logistics*, Vol 39, 1992, pp. 877-892.

Doyle, R. and McCaffery, J.L., "The Budget Enforcement Act-One Year Later," *Public Budgeting and Finance*, 11/3, 1992.

Evered, Roger and Tanenbaum, R., "A Dialog on the Nature of Dialog," *Journal of Mangement Inquiry*, February 1992, pp. 43-45.

Evered, Roger, Vail, P. and McWhinney, W., "A Dialog Between Reviewers," *Journal of Management Inquiry*, August 1992, pp 190-215.

Jones, L.R., "The Defense Squeeze," *Government Executive*, 24/2, February 1992.

Jones, L.R., "Minding the Pentagon's Business," *Government Executive*, 24/10, October 1992.

Kamel, M.N. and Kamel, N.N., "The Federated Database Management System: Requirements, Issues and Solutions," *Journal of Computer Communications*, Vol. 15, No. 4, May 1992, pp 270-278.

Kang, K., Bailey, M. and Eu, J. H., "Statistical Properties of Out-of-Frame Detection Schemes for Digital Transmission Systems," *IEEE Transactions on Communications*, Vol. 40, No. 5, 1992, pp. 980-987.

Liao, S., "A Transportation And Logistic Support Model for Aircraft Aboard Navy Carriers," *Transportation Research*, Part A, Vol. 26A, No. 3, (1992), pp. 231-245. (with Tomas P. Moore and Andrew G. Mackel).

Ramesh, B. and Dhar, V., "Supporting Systems Development Using Knowledge Captured During Requirements Engineering," *IEEE Transactions on Software Engineering*, June 1992.

Ramesh, B. and Dhar, V., "Group Support and Change Propagation in Requirements Engineering," in Jarke M. (Ed.): *Development Assistance for Interactive Database Applications*," Springer-Verlag, Hidelberg, Fall 1992.

Sargent, R. G., Kang, K. and Goldsman, D., "An Investigation of Small Sample Size Behavior of Confidence Interval Estimation Procedures," *Operations Research*, Vol. 40, No. 5, 1992, pp. 989-913.

Schneidewind, Norman F. and Keller, T.W., "Application of Reliability Models to the Space Shuttle,", *IEEE Software*, July 1992 pp. 28-33.

Schneidewind, Norman F., "Methodology for Validating Software Metrics," *IEEE Transactions on Software Engineering*," May 1992, PP.410-422.

T[illegible], **K. W. and Tymon, W. G.**, "Conflict and Conflict Management: Reflections a[illegible]date," *Journal of Organizational Behavior*, Vol. 13, No. 3, 1992, pp. 265-279.

CONFERENCE PUBLICATIONS

Eitelberg, Mark J., and Mehay, Stephen L., "The Shape of Things to Come," in David R. Segal, Sociocultural Dimension of the Future Army. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences, 1992.

Entin, E., Serfaty, D., Kleinman, D. and Sengupta, K., "Identification Error Under Stress in Navy Teams," Proceedings of the Annual Conference of the American Psychological Association, Washington, D.C., August 1992.

Kamel, N. N., Song, T. and Kamel, M. N., "Incorporating GUI in Integration of Molecular Biology Databases," in Proceedings of the Third Workshop on Future Trends of Distributed Computing Systems, Taipei, Taiwan, April 1992, pp. 404-410.

Kamel, M. N., Briede, T. N. and Boxall, R. N., "An Integrated Software Engineering Environment for DoD," in Proceedings of the Ninth Annual Database Colloquium, Database 91," San Diego, CA, August 1992.

Kamel, M. N., and Boxall, R. N., "A Prototype Expert Database System for Programming Decisions," in Proceedings of the International Conference on Database and Expert Systems Applications (DEXA 92), Valencia, Spain, September, 1992.

Keller, T. W. and Schneidewind, N.F., "Applying Reliability Models to the Maintenance of Space Systems Software," Proceedings of the 1992 International Simulation Technology Conference, 4-6 November 1992, Clear Lake, TX., pp 273-278.

Ramesh, V. and Dhar, V., "Applying Artificial Intelligence to Software Problems in REMAP project," In Proceedings of the IEEE Conference on AI Applications workshop on Applying AI to Software Problems, Monterey, CA, January 1992.

Ramesh, B. and Dhar, V., "Process knowledge Based Modification in Systems Development," in Proceedings of the American Association for Artificial Intelligence Spring Symposium on Computational Considerations in Modification and Reuse, Stanford, CA, March 1992.

Ramesh, B., and Edwards, M., "An Initial Model of Requirements Traceability," in Proceedings of the Workshop on Complex Systems Design, Naval Surface Warfare Center, Silver Springs, MD, September 1991.

Ramesh, B., and Dhar, V., "Role of Process Knowledge in Group Decision Support Systems " in Proceedings of the International Society for Decision Support Systems Conference, Ulm, Germany, June 1992.

Ramesh, B., and Dhar, V., "Design Rationale Capture and Use in REMAP," in Proceedings of the American Association for AI National Conference on AI workshop on Design Rationale, San Jose, CA, June 1992.

Ramesh, B. and Dhar, V., "Design Process Knowledge Based Systems Development," in Proceedings of the Conference on Artificial Intelligence Applications, New Port News, VA, April 1992.

San Miguel, Joseph G., "Decision Making and Information Mangement in Mangement Planning and Control," Proceedings of the SHARE Winter 1992 Meeting, Anaheim, California.

Schneideweind, Norman F., "Applying Reliability Models to the Maintenance of Space Shuttle Software," Proceedings of the NASA/Goddard Software Engineering Laboratory Seventeenth Annual Software Engineering Workshop, Greenbelt, MD, 2 December 1992.

Schneidewind, Norman F., "Reliability Models and Metrics for Space Shuttle Maintenance," (Position Statement), Conference on Software Maintenance, 1992, Orlando, FLA, 12 November 1992, pp. 386.

Schneidewind, Norman F., "Panel on American Institute of Aeronautics and Astronautics Recommended Practice for Software Reliability: Overview," Proceedings of the Third International Symposium on Software Reliability Engineering," Raleigh, NC, 8 October 1992, pp. 124-125.

Schneidewind, Norman F., and Keller, T.W., "Application of Software Reliability Models to Space Systems," Fourth Annual Laboratory Software Quality Workshop, 5 August 1992. This paper was also reported in the Data Analysis Center for Software Newsletter, Vol. XI, No. 1, Fall 1992.

Schneidewind, Norman F., "Methodology for Validating Software Metrics," Proceedings of the 1992 Complex Systems Engineering Synthesis and Assessment Technology Workshop, Naval Surface Warfare Center, white Oak, MD, 21 July 1992, pp. 171-199.

Schneidewind, Norman F., "Using Software Reliability Models for Developing Test Strategies," Proceedings of the Fourth Annual Oregon Workshop on Software Metrics, Silver Falls, OR, 23 March 1992.

Schneidewind, Norman F., "Minimizing Risks in Applying Metrics on Multiple Projects," Proceedings of the Third International Symposium on Software Reliability Engineering, Raleigh, NC, 9 October 1992, pp.173-182.

Schneidewind, Norman F., "Experimental Designs for Validating Metrics and Applying them across Multiple Projects," Proceedings of the Experimental Software Engineering Issues Seminar, Dagstuhl Castle, Germany, 14-16 September 1992, Springer-Verlag.

Sengupta, K., Jones, C. and Wright, B., "Adding Intelligence to Simulators for Distributed Decision Making, "Procceedings of the JDL Conference on Command and Control, **Monterey, CA 1992.**

Serfaty, D., Sengupta, K., Kleinman, D.L., Song, A., and Deckert, J., "Hierarchical Decision Making and Resource Allocation in Command Teams," Proceedings of the IEEE Conference on Systems, Man and Cybernetics, Chicago, IL, October 1992.

Serfaty, D., Kleinman, D.L., Entin, E., Sengupta, K. and Song, A., "Resource Allocation in Command Teams,"Proceedings of the JDL Conference on Command and Control, Monterey, CA 1992.

Sumner, J. D. and Kang, K., "Analysis of Material Handling Equipment for Maritime Prepositioning Ships (MPS) Offloading," Proceedings of 1992 Winter Simulation Conference (ed. J. J. Swain, D. Goldsman, R. C. Crain, J. R. Wilson), December 1992, pp. 1087-1094.

CONFERENCE PRESENTATIONS

Boger, D. C. and Malcolm, D.R., "Development Phase Drivers for Production Costs: The Case of Tracked Vehicles," Twenty-Six Annual Department of Defense Cost Analysis Symposium, Washington, D.C., September 1992.

Bui, Tung, "A Cognitive Model of Tank Commanders", Military Operations Research Society (MORS) conference, Monterey, May 1992.

Doyle, Richard, "The Impact of the Budget Enforcement Act of 1990 on Defense Budgets," presented at the annual meeting of the International Security Studies Section and the International Studies Association-West, Fall 1992.

Doyle, Richard, "Reconciliation Revisited: A Decade of Practice and Policy," presented at the annual meeting of the Section on Budgeting and Financial Management of the American Society for Public Administration, October 1992.

Eitelberg, Mark J., "Military Manpower Policy and the Defense Department's Reduction-in-Force," Annual Meeting of The Military Testing Association, San Diego, California, October 1992.

Eitelberg, Mark J., "Human Resource Development Issues in the U.S. Department of Defense," Annual Meeting of UTP-3, The Technical Cooperation Program, Kingston, Ontario, Canada, July 1992

Eitelberg, Mark J. and Mehay, Stephen L., "Demographics and the American Military at the end of the 20th Century." Paper presented at Conference and Workshop on U.S. Domestic and National Security Agendas: Into the 21st Century. Sponsored by the U.S. Army War College, the National Strategy Forum, and the Robert R. McCormick Tribune Foundation. Cantigny, Illinois, September 1992.

Eitelberg, Mark J. and Mehay, Stephen L., "The Shape of Things to Come: Trends and Projections Affecting Military Recruiting and Manpower in the 21st Century." Paper presented at a "Workshop on Sociocultural Designs for the Future Army." University of Maryland, March 1992 (50)

Euske, K.J., "Management Performance in an Industrial Setting: A Survey of Current Practice." (With M.J. Lebas and C.J. McNair). The Second European Management Control Symposium, Hautes Etudes Commerciales, France, 9-11 July 1992.

Evered, Roger, "The Role of Dialogue in Management Practice and Research," Western Academy of Management Meeting, Las Vegas, Nevada, March 1992.

Haga, William, Foster, Scott E., Teresawa, Katsuaki L. and Barrett, Frank J., "Surplus Value in Organizational Communication," Western Economic Association, San Francisco, CA, July 1992.

Henderson, David R., "A Humane Economist's Case for Drug Legalization," presentation at the Cato-Institute-CISLE Conference, Liberating the Hemisphere: Free Trade and Beyond," Mexico City, 22 May 1992.

Hocivar, S. P., Discussant for a paper session for the Organization Development and Change Division at the National Meeting of the Academy of Management, Miami, Florida, August 1992.

Jones, L.R., Presented a paper on "Corporate Environmental Policy" at International Conference on Public Service Ethics in Siena, Italy, June 1992.

Jones, L.R., Paper on "U.S.-Japan Economic, Trade and Security Relations" at the annual research conference of the Association for Public Policy and Management, Denver, CO, October 1992. Speech on the DMR process delivered to the San Diego Chapter of the American Society of Military Comptrollers, San Diego, CA. February 1992.

Jones, L.R., Presented paper on "DoD Financial Management Education and Training" at annual conference of the Comptroller, DoD in Monterey, September 1992.

Kang, Keebom, "A Logistic Model for Navy Depot Consolidation," ORSA/TIMS National Meeting, Orlando, Florida, April 1992.

Kang, Keebom, "Readiness Issues in Inventory Reduction and Depot Consolidation," ORSA/TIMS National Meeting, San Francisco, California, November 1992.

Kang, Keebom, "Performance Evaluation of Fleet-Mix for U. S. Coast Guard," ORSA/TIMS National Meeting, Orlando, Florida, April 1992.

Kang, Keebom, "Analysis of Material Handling Equipment for Maritime Prepositioning Ships (MPS) Offloading," 1992 Winter Simulation Conference, Washington, D. C., December 1992.

Lamm, D.V., "Acquisition Research," Fifth Annual Academic Conference for Contract Management Educators, University of California, Pomona, CA, 13 August 1992.

Lamm, D. V., "Professional Education Survey," Fifth Annual Academic Conference for Contract Management Educators, University of California, Pomona, CA, 13 August 1992.

Lamm, D.V. for J.J. Pendergast, "Application of a Taxonomic Structure for Classifying Federal Goods", 1992 National Purchasing and Materials Management Research Symposium, California State University, Fresno, 13 March 1992.

Means, T. and Mehay, S., "Congestion Function Specifications and Estimates of the Degree of Publicness of Local Government Output," paper presented to the Western Economic Association Meetings, July 1992, San Francisco, CA.

Moses, O.D., "Learning Curve and Rate Adjustment Models: Evidence on Accuracy and Bias," Society of Cost Estimating and Analysis National Conference, Washington, D.C., July 1992.

Moses, O. D., "An Investigation of Indicators of Cost Progress Model Accuracy," 26th Annual DoD Cost Analysis Symposium, Washington, D.C., September 1992.

Moses, O. D., "On the Reliability of Indicators of Learning Curve Model Accuracy," Decision Sciences Institute National Meeting, San Francisco, CA, November 1992.

Roberts, N. C., and Bradley, R.T., "Dynamics of Collective Organization," paper presented to the International Sunbelt Network Conference, San Diego, CA, 14-17 February 1992.

Roberts, N.C., "Strategic Planning in Public Bureaus," presentation to the Navy TQL Executive Leaders Seminar, 9 January 1992.

Roberts, N.C., "Reflections on the Shootdown of Fight 655," presentation to the 9th Annual Conference on C2 Decision Aids. Luncheon Speaker with Captain Will Rogers, 8 June 1992.

Saas, T. and Mehay, S., "The Effect of District Election Methods on Minority Representation and Fiscal Outcomes in Local Governments," Paper presented to the Department of Economics, Florida State University, November 1992.

San Miguel, Joseph G., "Decision Making and Information Management in Management Planning and Control," SHARE, IBM User Group, Winter 1992 Meeting, Anaheim, CA, 1-6 March 1992.

San Miguel, Joseph G., "Management Accounting and Cost Mangement: Strategy, Technology, and Control," Faculty Seminar, Peter F. Drucker Graduate Management Center, Claremont Graduate School, February, 1992.

San Miguel, Joseph G., "The Impact of Management and Information Technology on Organizations: Preliminary Findings," Information Systems Seminar, Naval Postgraduate School, Monterey, CA.

Schneidewind, Norman F., Panel: "Collection and Application od Software Quality Data," Third International Symposium of Software Reliability Engineering, Raleigh, NC, October 1992, pp. 283-284.

Schneidewind, Norman F., "Application of Assessment Techniques Throughout the System Development Process," 1992 Complex Systems Engineering Synthesis and Assessment Technology Workshop, Naval Surface Warfare Center, White Oak, MD, 21 July 1992.

Schneidewind, Norman F. and Keller, T.W., "Application of Software Reliability Models to Space Systems," Fourth Annual Laboratory Software Quality Workshop, 5 August 1992. This paper was also reported in the Data Analysis Center for Software Newsletter, Vol. XI, No. 1, Fall 1992.

Schneidewind, Norman F., "A Software Reliability Model with Optimal Selection of Failure Data," Computer Science Symposium, University of Houston, TX, 5 November 1992.

Schneidewind, Norman F., "A Software Reliability Model with Optimal Selection of Failure Data," IBM Federal Sector Services Corporation, Houston, TX, 4 November 1992.

Schneidewind, Norman F., "Overview of the Schneidewind Software Reliability Model," NASA, Houston, TX, 4 November 1992.

Schneidewind, Norman F., "Applying Reliability Models to the Maintenance of Space System Software," Software Process Improvement Network, University of California, Irvine, CA, 31 July 1992.

Schneidewind, Norman F., "Minimizing Risk in Applying Metrics on Multiple Projects," Florida Atlantic University, Department of Computer Science and Engineering, 13 November 1992.

Schneidewind, Norman F., "Status of Software Metrics: Methodology and Validation," University of California at Berkeley, Department of Electrical Engineering and Computer Sciences, Computer Science Colloquium, 11 March 1992.

Sohn, S.Y., "An Application of Growth Curve Analysis to the Ammunition Deterioration Model," ORSA/TIMS National Conference, San Francisco, CA, November 1992.

Thomas, K. W., "The Stress Resiliency Profile: A Way to Teach Skills for Coping with Stress," Best of America HR Conference and Expo, Tampa, Florida, 11 February 1992.

Tymon Jr., G. W. and Thomas, K.W., "Interpretive Habits of Individuals and Stress," for poster session on "Job Stress Theory," presented at "Stress in the 90's: A Changing Workforce in a Changing Workplace," Conference sponsored by the American Psychological Association and the National Institute for Occupational Safety and Health, Washington, D.C., November 1992.

Zweig, D., Banker, R.D. and Kauffman, R.J., "The Integral Tool: An Automated Approach to Repository Evaluation and Software Asset management," Second MITRE Software Engineering Economics Conference, 13 July 1992.

BOOKS

Jones, L. R., "Mission Budgeting to Realign National Defense," (Greenwich, CT:JAI Press, 1992. Co-Authored with G. Boxler).

BOOK CONTRIBUTIONS

Brown, David G., "Freight Service Quality Cost Economics and a Hypothetical Railroad Example," Transportation Research Record, 1341, pp. 39-52, Transportation Research Board, Washington, D.C., 1992.

Euske, K. J., "An Examination of Control Mechanisms in Organization with III-Defined Technology and Output," in W. J. Bruns, Jr. (Ed.) Performance Measurement, Evaluation, and Incentives, (Harvard Business School Press, 1992, 245-277).

Gonzales, R. and Mehay, S., "Spillover Benefits of Intergovernmental Contracting Police Service," in Privatization of the U. S. Justice System, Jefferson McFarland & Co. (editors, G. Brown, S. Hakim, and P. Seidenstat).

Jones, L. R., "Public Budget Execution Control," in J. Rabin ed., Handbook of Public Budgeting and Financial Management, (New York, NY: Marcel Dekker, 1992).

Liao, S., "Managing Accounts Receivable Through Payment Pattern Analysis," in Management Accounting I, Certified General Accountants Association of Canada, 1992.

Thomas, K. W., "Conflict and Negotiation Process in Organizations," pp. 651-717 in Volume 3 of Marvin D. Dunnette and Leaetta M. Hough (eds.), Handbook of Industrial and Organizational Psychology, Second Edition (Palo Alto, CA: Consulting Psychologists Press, 1992.

MAGAZINE ARTICLES

Henderson, David R., "Capitalism: An Olympic Winner," The Freeman, July 1992.

Henderson, David R., "Academic Frauds" review of Impostors in the Temple by Martin Anderson, Fortune, 16 November 1992.

Henderson, David R., "What Should the President Read?", Reason, December 1992.

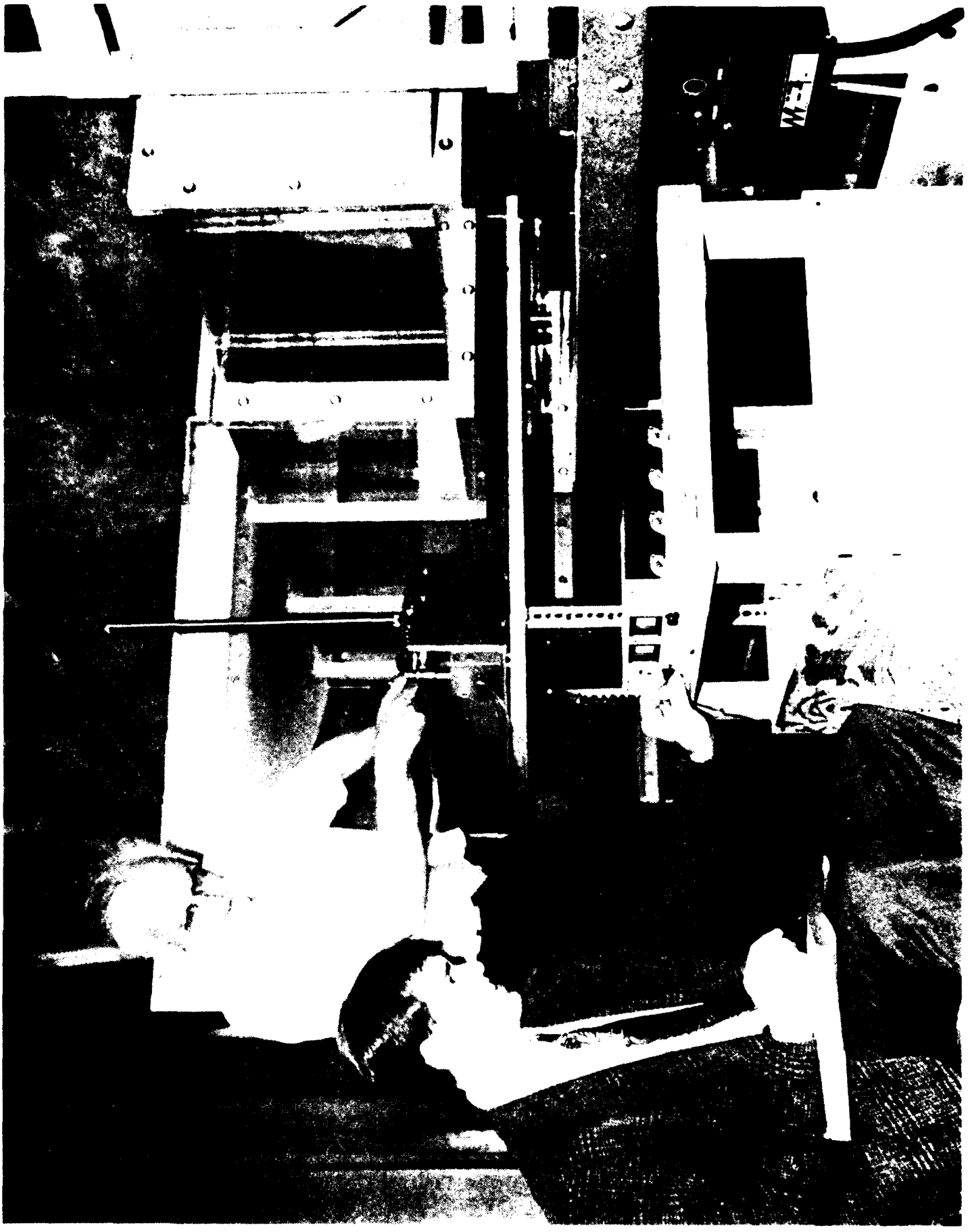
Liao, S., "Make a Data With WYSIWYG," Lotus, February 1992, pp. 40-42.

NEWSPAPER ARTICLES

Henderson, David R., "Adultery's Legal; Why not Marijuana?," Los Angeles Times, 13 February 1992.

DEPARTMENT OF AERONAUTICS AND ASTRONAUTICS

Professor D.J. Collins
Chairman



DEPARTMENT OF AERONAUTICS AND ASTRONAUTICS

The research program in the Department of Aeronautics and Astronautics is the product of the activities of the Department's five technical groups; namely, Aerodynamics, Structures, Propulsion, Flight Mechanics and Controls, and System Design (both air and spacecraft). Within, and across, these technical disciplines, the research effort is focussed on topics of critical importance to Navy and other military weapons systems. With the exception of one project by **Professor Biblarz**, which involves wind tunnel tests and analysis to explain errors in the Navy's Service Aircraft Instrumentation Package (SAIP) for NAWC, Point Magu, the Department's research activities are concentrated in the following areas:

F18, X31, HIGH-ALPHA AERODYNAMICS AND ENHANCED AIRCRAFT MANEUVERABILITY STUDIES

Initiated concurrently with the Navy's X31 research aircraft project, a collaborative effort by **Professors Platzer, Chandrasekhara, Ekaterinaris and Hebbar** is underway to investigate the flow behavior around current and proposed fighter configurations during high angle of attack maneuvers. The effort involves both experimental and advanced computational (CFD) tasks conducted at NPS and at NASA Ames Research Center through the auspices of the NPS-Ames Joint Institute. Low speed wind and water tunnel studies have been carried out at NPS with an X-31A-like fighter model (with and without oscillating canards), double delta and YF-17 aircraft models. The latter study complimented full-scale F/A-18 tests in the Ames 80x120 ft wind tunnel. Experiments to establish compressibility effects of dynamic stall are conducted at Ames. Methods to predict the complex flow structures and resulting unsteady forces and movements are under development using both Navier-Stokes and Viscous-Inviscid Interaction approaches. In a separate effort carried out at NPS by **Professor Howard**, the canard-vortex/wing-vortex interaction of a close-coupled canard aircraft configuration was visualized and probed in a low speed wind tunnel to explain the underlying mechanism for achieving enhanced lift. Both static and oscillating canards were investigated. Presently, pneumatic flow control of strake vortices is being studied.

HIGH-ANGLE-OF-ATTACK MISSILE AERODYNAMICS

In support of the Naval Air Warfare Center-China Lake, **Professors Platzer and Ekaterinaris** are developing Navier-Stokes solutions for turbulent flow over missile configurations in steady and unsteady high angle of attack flight at subsonic, transonic, and supersonic Mach numbers. Also, a canard-controlled

missile was tested in the NPS low speed wind tunnel to determine its high-angle-of-attack aerodynamic characteristics.

ADVANCED HELICOPTER STUDIES

A program led by **Professor Wood** has four areas. First, higher harmonic control (HHC) for helicopters is being studied using flight test results obtained earlier in a NASA/Ames/Hughes HHC flight test program. HHC is an active control system which promises vastly reduced structural vibrations, and radiated noise, and potentially improved performance. Second, the no tail-rotor (NOTAR) concept is being examined and scale models of alternate concepts have been built for testing. Third, the use of radio-controlled scale model flight testing is being evaluated as a tool for helicopter R&D. Finally, computer flight simulation is being applied to both full scale and UAV scale model helicopters. In a separate study, aimed at the "retreating blade" problem, **Professors Chandrasekhara and Platzer** are conducting unique experiments to examine the effects of compressibility on the dynamic stall of oscillating airfoils with a view to eventually controlling the stall of the retreating blade.

UNMANNED AIR VEHICLE (UAV) TECHNOLOGY

In support of the Navy's lead role in the development of UAV's, **Professor Howard** has developed a UAV laboratory at NPS which now contains nineteen vehicles for flight or wind tunnel tests. The broad goal is to develop technologies and techniques applicable to UAV's, including Maritime, Close-Range and Vertical Takeoff & Landing (VTOL) types. In this past year, the design, construction and testing of a full scale VTOL UAV was initiated. Current focus, jointly with **Professor Kaminer**, is on flight controls and stability augmentation for this unique vehicle configuration. Also, studies which were completed of the aerodynamics of the Pioneer UAV and of the handling qualities of other half scale vehicles established by flight and wind tunnel testing, were reported. In a new project sponsored by the UAV Joint Project Office, an evaluation of candidate technologies for an Autonomous Landing, and Takeoff System (ALTOS) was carried out by **Professor Wood** and his students, in association with a contracted study at Orion Aviation Inc. Recommendations given in the final report included the identification of promising technologies for further study.

IMPROVING AIR VEHICLE CONTROLS AND MILITARY APPLICATIONS OF NEURAL NETWORKS

Tracking controllers for advanced air vehicles need to be robust. **Professor Kaminer** has begun a study of the application of H_2 and a synthesis of

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

FAILURE AND LIFE PREDICTION FOR ADVANCED COMPOSITE AND AGING ALUMINUM VEHICLE STRUCTURES

Increased use of composite structures in all weapons platforms requires that there be developed reliable predictive methods for failure and probable structural life. **Professor Wu** has undertaken this fundamental problem using an analytical approach which separates fiber, matrix and interface mechanisms, and uses carefully controlled experiments to establish necessary statistical strength and life data. A unique new laboratory for composites has been established at NPS and the first successful research results were recently reported. The important problem of predicting fatigue lifetimes of current Navy Aircraft, including the A-6 and SH-60B is the goal of **Professor Lindsey's** research efforts.

ADVANCED AIRCRAFT ENGINE AND MISSILE PROPULSION STUDIES

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

developed for velocity field mapping. The development of successful diagnostic techniques to resolve small scale three-dimensional effects near to walls is necessary to achieve the goals of this and the IHPTET program.

Professor Netzer's work at the Combustion Laboratory has two thrusts relating to missile propulsion. First, toward IR signature reduction, under Air Force Sponsorship, a technique for evaluating the effects of rocket motor chamber conditions and fuel additives on the emissivity of the plume is being developed. The study involves experiments in which plume particle size and concentration measurements are made and plume radiation is compared with computational code predictions. Second, under Navy sponsorship, a number of advanced ramjet propulsion ideas are investigated experimentally. These include supersonic combustion with solid fuels, ignition and plume characteristics with boron/boron-carbide fuel and investigations relating to the combustion of metallized slurry fuels.

SPACECRAFT AND SPACE-BASED WEAPONS

The dynamics and control of spacecraft is the focus of Professor Agrawal's research. The application of piezoelectric actuators and sensors in actively suppressing vibrations in flexible spacecraft structures has been demonstrated in laboratory experiments. Several control techniques have been studied for the slew maneuver of flexible spacecraft and first experimental and analytical results were published recently. The Fltsatcom satellite installed at NPS (a unique resource) will be used to test command software for the Navy Satellite Operation Center (NAVSOC). Professor Ross' interests are directed toward the optimization of trajectories within the atmosphere, such as would be important to the design of Aerodynamically Assisted Orbital Transfer (AOTV) vehicles. Toward practical space propulsion, Professor Biblarz has made significant progress in understanding the thermionic breakdown which is an essential step toward the optimum design of xenon ion engines. Towards high energy laser weapons, the contributions of bound clusters to mirror damage, and to the operation of uncooled optics, are also being examined.

AIRCRAFT COMBAT SURVIVABILITY LETHALITY ASSESSMENT

Professor Ball originated the study of survivability at NPS 19 years ago and has since provided technical support to NAVAIR and the Joint Technical Coordinating Group on Aircraft Survivability (JTCG/AS) by providing 5 day short (and "shorter", 2 day) courses and conducting analytical studies on specific weapons systems. One recent classified project (as an example) involved simulating several possible ordnance delivery profiles for the A-6 and F/A-18 aircraft using standard low drag and high drag MK 80 series bombs, and an advanced bomb family, and determining the survivability of the aircraft for each profile. Weapons data were provided by Naval Strike Warfare. Computer programs

BLUEMAX, ESAMS and RADGUNS were used to determine delivery profiles and assess survivability. Recently NAVAIR has sponsored the development of a survivability and lethality assessment center within the NPS Wargaming Analysis & Research Laboratory. To date extensive software packages have been loaded onto the Laboratory's Vax computer after hardware upgrades were made to the system. Also, a study of the survivability of the F-14A Tomcat in the overland strike role has been carried out in association with the Naval Air Warfare Center-Weapons Division.

ATTITUDE CONTROL OF FLEXIBLE SPACECRAFT

B. N. Agrawal, Professor
Department of Aeronautics and Astronautics
Sponsor: Navy Center for Space Technology
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project is to develop improved control techniques for flexible spacecraft and space robotics and validate them by experimental tests. It is a continuing project.

SUMMARY: The application of piezoelectric actuators and sensors in the vibration suppression of flexible space structures was demonstrated experimentally. Damping of the first structural mode was increased by a factor 4 by using this active control. Several control techniques, proportional-derivative control, reference trajectories, and optimal control were evaluated analytically and experimentally for the slew maneuver of a flexible *spacecraft simulator*. Reference trajectory using sinusoidal torque profile provided the best performance. Thruster control was also studied for slew maneuver. The analytical and experimental results are in good agreement.

PUBLICATION: Agrawal, B.N., "Dynamic Characteristics of Liquid Motion in Partially Filled Tanks of Spinning Spacecraft, " *AIAA Journal of Guidance, Control, and Dynamics*, (July-August 1993) Forthcoming.

CONFERENCE PRESENTATIONS: Hailey, J., C. Sortun and B. Agrawal, "Experimental Verification of Attitude Control Techniques for Slew Maneuvers of Flexible Spacecraft," AIAA 92-4456, Proceeding of 1992 AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, 10-12 August 1992.

Agrawal, B.N., H. Bang, and E. Jones, "Applications of Piezoelectric Actuators and Sensors in the Vibration Control of Flexible Spacecraft Structures," IAF-92-0319, 43rd Congress of the International Astronautical Federation, Washington, DC, 28 August - 5 September 1992.

Agrawal, B.N. and J. Hailey, "Optimal Slew Maneuver of a Flexible Spacecraft- Analytical and Experimental Results," IAF-92-0024, 43rd Congress of the International Astronautical Federation, Washington, DC, 28 August - 5 September 1992.

Agrawal, B.N.," Attitude Control of Flexible Spacecraft, "Proceedings of International Symposium on Advances in Aerospace Sciences and Engineering, Banglore, India, 12-15 December 1992

Agrawal, B.N., "Liquid Dynamic Characteristics in Spinning Spacecraft," Presented at International Conference on Computational Engineering Science (ICES'92) , Hong Kong, 17-22 December 1992.

THESES DIRECTED: Jones, E., LT, USN, "Application of Active Damping of the Attitude Control of Flexible Spacecraft," Master's Thesis, December, 1991.

Hailey, J. A., LT, USN,"Experimental Verification of Attitude Control Techniques for Flexible Spacecraft Slew Maneuvers, " Engineer's Thesis, March 1992.

D. Sorensen, LT, USN," Design and

Control of a Space Based Two Link Manipulator with Lyapunov Based Control Laws," Engineer's Theses, September 1992.

Newman, S., LT, USN," Active Damping Control of A Flexible Space Structure Using Piezoelectric Sensors/Actuators, " Master's Thesis, December, 1992.

SPACECRAFT SYSTEMS

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

OBJECTIVE: To develop improved spacecraft system design techniques and continue development of spacecraft laboratories to perform research in spacecraft systems. It is a continuing project.

SUMMARY: Fltsatcom satellite was moved into a newly constructed room. A joint project was initiated with the Navy Satellite Operation Center (NAVSOC) to test command software using Fltsatcom at NPS. Piezoelectric actuators and sensors, thruster system, and a two-link manipulator were added to the flexible spacecraft simulator. Two spacecraft system design projects were completed. Development of a general purpose spacecraft design computer program was initiated.

PUBLICATION: Agrawal, B., "High Latitude Communications Satellite," *Navy Engineer Journal*, (September 1993). "Forthcoming"

CONFERENCE PRESENTATION: Agrawal, B.N., "Design of Multipurpose Spacecraft Bus," AIAA 92-980, 1992 Aerospace Design Conference, Irvine, CA, February 3-6, 1992.

THESES DIRECTED: Lashbrook, L.D., LCDR, USN,"Computer Based Satellite Design, " Master's Thesis, September 1992.

NPS SURVIVABILITY SUPPORT

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

OBJECTIVE: The objective of this effort is to continue the technical support provided to the JTCG/AS for the past 19 years by conducting research, presenting shorter courses, developing educational material, and performing analyses in aircraft combat survivability. The accomplishments during FY 92 are given below. (Prof Ball was only available during the first and third quarters.)

SUMMARY: Short and Shorter Courses. For about the past twelve years, the one week NPS/JTCG/AS short course has been offered every other year, primarily in Monterey. In order to

make the material available to more people, Prof. Ball conducted two 16 hour versions of the short course, known as the shorter course, to the Army Aviation and Troop Command in St. Louis and to the Air Force Material Command in Dayton. Approximately 25 and 50 students attended, respectively. In the last half of the year, Prof. Ball began the preparations for the 1993 one week short course to be held at NPS during the week of April 19th. These preparations consist of preparing the course schedule and the flyer announcing the course. An announcement of the course for the JTCG/AS and SURVIAC newsletters was written.

EDUCATIONAL MATERIALS: In the third quarter, Prof. Ball began a major effort to update the short course and shorter course notebook materials. Many of the materials were 15 years old. (Time flies.) He has nearly finished the notebooks. He has also started an initiative regarding consistent definitions of the words and terms used in survivability, lethality, and munitions effectiveness.

OTHER: One classified project was completed in December of 1992. It consists of simulating several possible ordnance delivery profiles using both the standard low drag and high drag MK 80 series of bombs and the advanced bomb family and determining the survivability of the aircraft for each profile. The order of battle and the weapon laydown was provided by the Naval Strike Warfare, Fallon, Nevada. BLUEMAX is used to determine the aircraft delivery profiles, and the ESAMS and RADGUNS programs are used to assess the survivability of the aircraft. The NWC Mk 80 and the ABF delivery programs are used to assess the accuracy of ordnance delivery. Both A-6 and F/A-18 aircraft are considered.

THESES DIRECTED: Ferrell, R.E., Classified Thesis, Master's Thesis, December 1991.

NPS SURVAIVABILITY & LETHALITY ASSESSMENT CENTER

Robert E. Ball, Professor
Department of Aeronautics and Astronautics
Sponsor and Funding: The Naval Air Systems Command

OBJECTIVE: The objectives of this project are (1) to develop a survivability and lethality assessment center within the NPS Wargaming Analysis & Research Laboratory, and (2) to use the center to conduct survivability and lethality studies. The computer programs in the center are available to the students and faculty at NPS for research in specific survivability and lethality topics as well as research on the programs themselves. The following efforts were completed or are still underway at the end of 1992. (Professor Ball was not able to work directly on this project during the first three quarters, and he was teaching half time during the fourth quarter.)

SUMMARY: The JTCG/AS surface-to-air missile program ESAMS was obtained from the JTCG/AS and installed on the center's VAX computer. During the first two quarters, a study of the survivability of the F-14A TOMCAT in the overland strike role, with and

without fuel system protection, was conducted using ESAMS and the JTCG/AS endgame program JSEM. A tactical scenario and order of battle were obtained from the Naval Strike Warfare Center, Fallon, NV. Typical flight profiles were developed using several weapon delivery profiles. The survivability of the F-14 was determined using ESAMS for the flyout and JSEM for the endgame. The JSEM runs were executed by the Survivability and Lethality Division, Naval Weapons Center, using the flyout data generated by ESAMS in the center at NPS and the proposed reduction in fuel system vulnerability.

The JTCG/AS endgame program JSEM was obtained and installed on the center's VAX computer. A comparison of the endgame models in MICE II, ESAMS, and JSEM was completed in June. The output of this study is a document that can be used by anyone desiring to conduct either endgame studies or survivability studies using any of these programs. This manual is incorporated into the assessment center's library. The JTCG/AS radar detection program ALARM was installed on the assessment center's VAX computer. A thesis project to verify the code (as much as possible) and to expand the capabilities of ALARM to work over water by including radar clutter at sea. A version of ALARM for the SUN workstation was developed, and a user-friendly input program was written. The new program is called ALARM-NPS.

All of the JTCG/AS programs, except FASTGEN, have been obtained from SURVIAC and are now installed on the VAX in the assessment center. In addition, upgrades to the VAX capabilities and in the available output options have been accomplished as a result of this funding.

THESES DIRECTED: Gil, L. D., Jr., "A Comparison of Three Computer Weapon-Target Simulations for Aircraft," Master's Thesis, June 1992.

Mosher, T. D., "Improvements to the Advanced Low Altitude Radar Model (ALARM 91)," Master's Thesis, September 1992.

EFFECTS OF BOUND CLUSTERS ON THE OPTICAL AND THERMAL PROPERTIES

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

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

SUMMARY: High energy laser mirrors exhibit damage of unknown origin. We are studying possible contributions from intrinsic clusters to this damage. Bound clusters which originate from the substrate have the same chemical elements as the rest of the surface but manifest a different structure. They have, therefore, different properties, both optical and thermal. The existence of these clusters is predicted from equilibrium

relationships. By studying damage and relating it known cluster characteristics, we would anticipate improving damage thresholds.

THESIS DIRECTED: Moroney, D.T., LCDR, USN, "Use of an Optical Multichannel Analyzer for Reflectivity Measurements" Master's Thesis, March 1992.

LOW-VOLTAGE, THERMIONIC BREAKDOWN FOR XENON ION ENGINES

Oscar Biblarz, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Research Laboratories
Funding: Naval Postgraduate School

OBJECTIVE: To better understand low-voltage thermionic discharges so that they may be implemented to ionization chambers. The advantages of low voltage operation may translate into less demand from power-conditioning equipment as well as less sputtering from energetic ions. These discharges are also of interest to many other arc devices. This is a continuing project.

SUMMARY: We have arrived at an equivalent form of Paschen's law which applies to low-voltage, thermionic discharges. The key element is that there be a source of electrons at the cathode sheath prior to the formation of the arc. The small voltages observed require very small gaps so that the implementation of the scheme requires an auxiliary device such as an incandescent filament across the electrodes. NASA's work with the ionization xenon for ion engines has been scrutinized. Some preliminary modifications to this ionizer have been looked at.

CONFERENCE PRESENTATION: Biblarz, O., "Thermionic Arc Initiation," IEEE International Conf. on Plasma Sci., Tampa, FL, June 1992.

THESIS DIRECTED: Bell, W.J., LT, USN, "Proposed Model of Thermionically Assisted Breakdown an Implementation on Electrostatic Thrusters," Master's Thesis, December 1991.

OTHER: A publication has been submitted to the IEEE Transactions on Plasma Science.

IMPROVEMENT OF THE ALTITUDE MEASUREMENT CAPABILITY OF THE SAIP

Oscar Biblarz, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: PMTC, Point Mugu, CA
Funding: Unfunded

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). Errors have been observed beyond those standard for this technique. In the long term we had hoped to influence new designs. This is a continuing project.

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] indicated that there is a grounding problem arising from an ambiguous specification. After correcting this, however, the probe continues to read above the static value of the pressure and we have identified the 5"-body of the SAIP as the culprit along with the aircraft mounting location. We have refined a computer description and are presently looking very closely at the way the data are reduced in order to define parameter sensitivity.

THESES DIRECTED: Rixey, J. W., LT, USN, "A Multifaceted Engineering Study of Aerodynamic Errors of the Service Aircraft Instrumentation Package (SAIP)", Master's Thesis, September 1992.

OTHER: Briefing at NAWC Weapons Division, Point Mugu.

COMPRESSIBILITY EFFECTS ON AND CONTROL OF DYNAMIC STALL OF OSCILLATING AIRFOILS

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

OBJECTIVE: To study the effects of compressibility on 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 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, the new flow field diagnostic technique known as Point Diffraction Interferometry, (PDI), was refined, developed further and used to measure the flow field. Also, a fringe analysis software package was developed to rapidly process the digitized interferogram images. A number of the images obtained from earlier experiments were processed. The unique feature of this package is its semi-automation and ability to produce graphical information of the flow variables. Also, the LDV data obtained in the previous year was analyzed, papers were prepared and presented.

PUBLICATIONS: Carr, L.W. and M.S. Chandrasekhara, "Design and Development of a Compressible Dynamic Facility", *AIAA Journal of Aircraft*, Vol. 29, No. 3, May-June 1992, pp. 314-318.

Forthcoming: Hess, R.A., N.J. Brock, L.W. Carr and M.S. Chandrasekhara, "A Holographic Animation of Compressible Flow Interferograms", **Prize Winning Entry** at the 44th American Physical Society, Fluid Dynamics Division Photo Contest, Physics of Fluids, March 1992.

CONFERENCE PRESENTATIONS: Chandrasekhara, M.S., "Oscillating Airfoil Compressible Dynamic Stall Studies", **Invited Paper** presented at the Indian Institute of Science International Symposium on Advances in Sciences and Engineering, Bangalore, India, 12-15 December 1992.

Chandrasekhara. M.S., L.W. Carr, J.A. Ekaterinaris and M.F. Platzer, "Interferometry and Computational Studies of an Oscillating Airfoil Compressible Dynamic Stall", presented at the 5th Asian Congress of Fluid Mechanics, Taejon City, Korea, 10-13 August 1992.

VanDyken, R.D., and M.S. Chandrasekhara, "Leading Edge Velocity Field of an Oscillating Airfoil in Compressible Dynamic Stall", AIAA Paper No. 92-0193, presented at the AIAA 30th Aerospace Sciences Meeting, Reno, NV, 6-9 January 1992.

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

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

OBJECTIVE: To study the effects of compressibility on dynamic stall of an airfoil undergoing a rapid ramp type pitching motion with applications to supermaneuverability of fighter aircraft. On-going project since October 1989.

SUMMARY: In the reporting period, the technique of Point Diffraction Interferometry (PDI) developed in the Navy- NASA Joint Institute of Aeronautics was used extensively to document the full flow field as well as the leading edge flow field over an airfoil executing rapid transient pitch maneuvers from 0-60 degrees angle of attack. The data was analyzed using an in-house developed fringe analysis software package. The results showed that compressibility unfavorably interacts with the outer inviscid flow to limit the airfoil performance. These studies also led to the concept that if the pressure distribution over the airfoil could some how be modified, then the airfoil could be made stall-free. Based on this, a new proposal to control dynamic stall using adaptive geometries was proposed, which was accepted and funded.

CONFERENCE PRESENTATIONS: Platzer, M.F., M.S. Chandrasekhara, J.A. Ekaterinaris and L.W. Carr, "Dynamic Airfoil Stall Investigations" presented at the 5th Symposium on Numerical and Physical Aspects of Aerodynamic Flows, Long Beach, CA, 13-16 January 1992.

Ekaterinaris, J.A., M.F. Platzer, and M.S. Chandrasekhara, "Low Reynolds Number Airfoil Predictions", presented at the 45th APS Meeting, Tallahassee, FL, 22-24 November 1992.

MODELING THE IONOSPHERE FOR OVER THE HORIZON RADAR

Daniel J. Collins, Professor
Department of Aeronautics and Astronautics
Sponsor: NRL Code 5324, Dr. J. Thompson
Funding: Naval Postgraduate School

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.

Neural Networks have been created that accurately model the daily variations of ionosphere. Further work on a complete seasonal modelling has been begun.

NEURAL NETWORK IDENTIFICATION OF SONAR SIGNALS

Daniel J. Collins, Professor
Department of Aeronautics and Astronautics
Sponsor: CDR McLaughton, Code 546 W
Washington, D.C. 20361

OBJECTIVE: Neural Networks are used to identify transient sonar signals and identify key frequencies of sonar signals.

SUMMARY: Backpropagation networks have been developed to identify actual sonar signals. Excellent results have been obtained both for transient signals and for key frequencies.

Further work has begun on "Beartrap DATA".

OTHER: Theses in process "Passive Acoustic Classification by Means of Neural Networks," LT Downing.

CONFERENCE PRESENTATIONS: Bertrand, S.R., Collins, D.J. "Neural Network Controllers for the X29 Aircraft: IJCNN Vol. 1, Baltimore, Maryland, 7-11 June 1992.

Shipley, M. and Collins, D.J. "Classification of Acoustic Transients by means of Neural Networks", Third Annual R&D Conference, Naval Surface Warfare Center, Silver Spring, Maryland, April 1992.

HIGH-ALPHA LOW-SPEED AIRCRAFT AERODYNAMICS RESEARCH

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

OBJECTIVE: This is a multiyear 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 carryout the investigations related to enhanced fighter maneuverability. During the period under review (last year of the multiyear program), the following major tasks were accomplished: (a) Flow visualization studies of a 2.3% canard-configured X-31A-like fighter aircraft model during sideslipping maneuvers. (b) Water tunnel studies of the X-31A-like model with an oscillating canard. (c) Fabrication of several double-delta wing models with different geometric modifications (fillets) at the kink. (d) Static and dynamic flow visualization studies of two double-delta wing models at high angles of attack.

PUBLICATIONS: Hebbar, S.K., M.F. Platzer, and O.V. Cavazos, "Pitch Rate/Sideslip Effects on LEX Vortices of an F/A-18 Aircraft Model," *Journal of Aircraft*, Vol. 29, No.4, Jul-Aug. 1992, p. 720.

Hebbar, S.K., 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," *High-Angle-of-Attack Technology*, Vol.1, NASA CP-3149, Part 3, May 1992, p. 1025.

Hebbar, S.K., M.F. Platzer, and C.H. Kim, "Water Tunnel Visualization of Dynamic Effects during Sideslipping of a Canard-Configured Fighter Model," Proceedings of Fifth Asian Congress of Fluid Mechanics, Vol. 2, Aug. 1992, p. 1161.

Small, J.F., S.K. Hebbar, and M.F. Platzer, "Flow Visualization and Wake Analysis for Complex Three-Dimensional Bluff Bodies at Subcritical through Critical Reynolds Numbers," AIAA-92-0155, Jan. 1992.

CONFERENCE PRESENTATIONS: Hebbar, S.K., M.F. Platzer, and C.H. Kim,"Water Tunnel Visualization of Dynamic Effects during Sideslipping of a Canard-Configured Fighter Model," Fifth Asian Congress of Fluid Mechanics, Taejon, Korea, 10-14 August 1992.

Small, J.F., S.K. Hebbar, and M.F. Platzer, "Flow Visualization and Wake Analysis for Complex Three Dimensional Bluff Bodies at Subcritical through Critical Reynolds Numbers," AIAA 30th Aerospace Sciences Meeting, Reno, Nevada, 6-9 January 1992.

THESES DIRECTED: Liu, D.M., LCDR, ROC Navy, "Effect of Canard Oscillations on the Vortical Flowfield of a X-31A-Like Fighter Aircraft Model," M.S. Thesis, March

1992.

Li, F.H., CDR, ROC Navy, "Static and Dynamic Flow Visualization Studies of Two Double-Delta Wing Models at High Angles of Attack," Master's Thesis, March 1992.

OTHER: The results of the wind tunnel investigation on F/A-18 model with and without LEX fences will be presented in the AIAA 31st Aerospace Sciences Meeting, Reno, Nevada, 11-14 January 1993. Also presented in the same meeting will be the results of the wind tunnel tests on a canard-controlled sidewinder missile model at high angles of attack. The results of the water tunnel investigations on the oscillating canard model and two double-delta wing models have been submitted for presentation in the forthcoming AIAA Fluid Dynamics Conference (July 93, Orlando, Florida), and Applied Aerodynamics Conference (August 93, Monterey, California). A manuscript entitled "Water Tunnel Investigation of a Canard-Configured X-31A-Like Aircraft Model in Dynamic Motion," has been submitted for publication in the Journal Zeitschrift fur flugwissenschaften and Weltraumforschung (ZFW).

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

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

OBJECTIVE: This is the continuation of the second project of a series of cooperative studies of F/A-18 between the Aeronautics and Astronautics 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, with and without the LEX fences.

SUMMARY: A low speed investigation was conducted in the NPS wind tunnel to examine the vortex wake downstream of a 3% scale model of the YF-17 lightweight fighter prototype at high angles of attack. The study was in support 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 earlier data from hot wire surveys and power spectra measurements (already reported in a M.S. Thesis) was further analyzed and the trends compared with similar work done elsewhere. A comprehensive report was prepared and submitted to NASA Project Director, NFAC F-18 High Alpha Test.

OTHER: The results of this investigation are being summarized in the form of a Technical/Engineering Note for publication in a journal.

TURBINE TIP-LEAKAGE FLOWS

G.V. Hobson, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Warfare Center (Trenton)
Funding: Naval Postgraduate School

OBJECTIVE: Investigate the nature of turbine tip-leakage flows in the new annular turbine cascade as well as in the Space Shuttle Main Engine High Pressure Fuel Turbo Pump.

SUMMARY: The turbine tip- leakage study will be continued in a newly designed annular turbine cascade facility. The intent for this cascade is to gain experience in taking three-component LDV measurements through a curved window in a highly swirling flow. A stationary tip leakage flow (no relative movement between the tip wall and blades) can be simulated in this facility on a scale typical of small to medium gas turbines. The new three-component fibre-optics LDV has been commissioned and a new three-axis traverse mechanism has also been purchased with NPS OPN funds. This traverse is currently being mounted onto a mobile table so that exploratory three-component measurements can be performed in the corner vortex flow of the Low Speed Cascade. A capability of analyzing 3-D turbomachinery flows now exists at the Department of Aeronautics and Astronautics, with the installation of Rotor Viscous Code Three Dimensional (RVC3D), written by Rod Chima of NASA Lewis Research Center, on the Schools' Supercomputer Workstations.

CONFERENCE PUBLICATION: Hobson, G. V., and Wang, C-W., "A Turbulence Model Based on RNG for Quasi-Three-Dimensional Cascade Flows," AIAA paper 92-3312, presented at the AIAA/SAE/ ASME/ASEE 28th Joint Propulsion Conference, Nashville, 1992.

TRANSONIC TURBINE RIG - LASER DOPPLER VELOCIMETRY MEASUREMENTS

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

OBJECTIVE: Establish a continuous running turbine facility for laser Doppler measurements of the intra-blade flows, and establish an experimental database for computer code verification as part of the NASA MSFC Turbine CFD Consortium.

SUMMARY: The SSME turbine has two stages thus the Turbine Test Rig will have to be modified to accommodate the additional stage. Once all the necessary modifications to the rig and the dynamometer coupling has been made the new turbine will be installed and essential performance monitoring probes will be connected. Initial performance tests will be performed to verify these measurements with those made by NASA MSFC in their blowdown facility.

Before these performance tests can been carried out the casing of the turbine will have to be modified to accommodate a laser access optical

window. After the performance tests have been completed the LDV measurements will commence. Initially two-component measurements at mid span of the turbine blades will be performed. Depending on the success of these measurements three-component measurements will be taken.

MEASUREMENT AND COMPUTATION OF TURBOMACHINERY FLOWS

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

OBJECTIVE: Develop an improved design capability for turbo- machinery components by con- ducting an experimental and computational investigation into the viscous flow behavior in such components.

SUMMARY: The experimental investigation of the NASA Controlled-Diffusion Compressor Blades continued with laser sheet flow visualization video recordings of the leading edge separation bubble at 48 degrees inlet flow angle. These results were presented at a seminar at NASA LeRC in May, 1992. The inlet manifold and suction slots on the Low Speed Cascade Tunnel, have been completed and preliminary endwall boundary layer suction was performed with the inlet flow angle at 48 degrees. Initial span wise pitot-static probe measurements have indicated that the suction slots decrease the endwall boundary layer to approximately half its original thickness. Presently the cascade inlet flow angle has been reduced to 43 degrees and baseline rake probe surveys have been completed upstream of the cascade, with no endwall slots installed. The slots have been modified to include a porous wall behind the slot openings for more even suction in the pitchwise direction. Two-component LDV measurements are complete at this inlet flow angle to establish a baseline flowfield. The TPL took delivery of all the fibre optics for a three-component LDV system, which is currently being commissioned for 3D endwall measurements in the cascade.

PUBLICATIONS: Hobson, G. V., "A Navier-Stokes Analysis of a Controlled- Diffusion Compressor Cascade at Very High Incidence," AIAA 92-3313, presented at the AIAA/SAE/ASME/ASEE 28th Joint Propulsion Conference, Nashville, 1992.

Hobson, G. V., and Shreeve, R. P. S., "Inlet Turbulence Distortion and Viscous Flow Development in a Controlled-Diffusion Compressor Cascade at Very High Incidence," AIAA 91-2004, Presented at the AIAA/SAE/ ASME/ASEE 27th Joint Propulsion Conference, Sacramento, 1991.

CANARD/WING INTERACTION FOR ENHANCED LIFT IN AIRCRAFT SUPERMANEUVERABILITY

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

OBJECTIVE: The goal of this project was to define the vortex-interaction flow mechanism for a close-coupled-canard aircraft configuration by flowfield measurements in downstream crossplanes. The measurements determined local velocity magnitudes and flow pitch and yaw angles, as well as contours of loss in total pressure.

SUMMARY: The maintenance of air superiority in the future will depend an ability to perform high-lift maneuvers, often into the post-stall flight regime. Canards located in close proximity to swept wings are known to provide increased lift due to the canard and wing leading-edge vortices. Studies of flowfield measurements at the angles of attack for which major lift enhancements are found have been lacking. Wake surveys at an angle of attack of 22 degrees were conducted at three crossplane to produce plots of crossplane velocity vectors and contours of total pressure. The canard vortex clearly provided the mechanism for massive flow reattachment over the inboard wing section.

Flow visualization indicated the previously-separated flow over the wing became a strong coherent leading-edge vortex under the influence of the canard vortex.

THESES DIRECTED: O'Leary, C.F., CPT, USMC, "Flowfield Study of a Close-Coupled Canard Configuration," Master's Thesis, June 1992.

Schmidt, D.C., LT, USN, "Lift Enhancement Using a Close-Coupled Oscillating Canard," Master's Thesis, September 1992.

Willson, J.G., LT, USN, "Quantitative Force Measurements of Pneumatic Control on a Wing/Strake Model," Master's Thesis, September 1992.

OTHER: Howard R.M. and J.F. O'Leary, "A Flowfield Study of a Close-Coupled Canard Configuration," AIAA 11th Applied Aerodynamics Conference, 9-11 August 1993, submitted.

ADVANCED DEVELOPMENT RESEARCH PROGRAM FOR JOINT-SERVICE UNMANNED AIR VEHICLES

R.M. Howard, Associate Professor
Department of Aeronautics and Astronautics
Sponsor: None
Funding: Unfunded

OBJECTIVE: The goal of this project is to develop technologies applicable to the new class of Unmanned Air Vehicles: Maritime, Close-Range, and Vertical Takeoff and Landing (VTOL).

SUMMARY: Current launch-and-recovery techniques of UAVs at sea are inadequate for future systems, which will operate from small surface combatants. Air vehicles will be required to takeoff and land vertically, to provide an adequate amount of deck safety from whirling blades, and to transit at speeds of fixed-wing platforms. The design, construction and testing of a full-scale VTOL UAV was begun this past year, using available assets from canceled DoD programs. The UAV is a tailsitter configuration, taking off vertically and transitioning to forward flight through a pushover maneuver. This year, progress was made in the design and construction of the spar structure to mount wings to the ducted-fan platform, and in testing of control vane effectiveness using a newly constructed torque/thrust stand.

PUBLICATIONS: Howard, R.M., J.C. Tanner and D.F. Lyons, "Flight Test of a Half-Scale Unmanned Air Vehicle," *Journal of Aircraft*, Vol. 28, No. 12, Dec. 1991, pp. 843-848

CONFERENCE PRESENTATIONS: Howard, R.M. and R.M. Bray, "Flight Test and Wind-Tunnel Study of a Scaled Unmanned Air Vehicle," AIAA Paper 92-4075, AIAA 6th Biennial Flight Test Conference, Hilton Head, SC, 24-26 August 1992.

Bray, R.M., D.F. Lyons, and R.M. Howard, "Aerodynamic Analysis of the Pioneer Unmanned Air Vehicle," AIAA Paper 92-4635, AIAA Atmospheric Flight Mechanics Conference, Hilton Head, SC, 10-12 August 1992.

Howard, R.M., J.D. Salmons, K.R. Aitcheson, and P.A. Koch, "Flying-Qualities Flight Test of a Half-Scale Unmanned Air Vehicle," Proceedings of the Society of Flight Test Engineers 23rd Annual Symposium, Hauppauge, NY, 3-7 August 1992, pp. 5-41 - 5-49.

Howard, R.M., "Scaled Research for UAVs: Short, Close- Maritime, Endurance," Civilian and Military Needs for Auto- mated Instrument Platforms, Association for Unmanned Vehicle Systems Workshop, Menlo Park, CA, 28-30 January 1992.

THESES DIRECTED: Brynestad, M.A., LCDR, USN, "Investigation of the Flight Control Requirements of a Half-Scale Ducted Fan Unmanned Air Vehicle," *Master's Thesis*, March 1992.

Koch, P.A., LT, USN, "Flight Testing of a Half-Scale Remotely, Piloted Vehicle," Master's Thesis, March 1992.

Kress, G.A., LT, USN, "Preliminary Development of a VTOL Unmanned Air Vehicle for the Close-Range Mission," Master's Thesis, September 1992.

CANARD/WING INTERACTION FOR ENHANCED LIFT IN AIRCRAFT SUPERMANEUVERABILITY

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

OBJECTIVE: The goal of this project was to define the vortex-interaction flow mechanism for a close-coupled-canard aircraft configuration by flowfield measurements in downstream crossplanes. The measurements determined local velocity magnitudes and flow pitch and yaw angles, as well as contours of loss in total pressure.

SUMMARY: The maintenance of air superiority in the future will depend an ability to perform high-lift maneuvers, often into the post-stall flight regime. Canards located in close proximity to swept wings are known to provide increased lift due to the canard and wing leading-edge vortices. Studies of flowfield measurements at the angles of attack for which major lift enhancements are found have been lacking. Wake surveys at an angle of attack of 22 degrees were conducted at three crossplanes to produce plots of crossplane velocity vectors and contours of total pressure. The canard vortex clearly provided the mechanism for massive flow reattachment over the inboard wing section.

Flow visualization indicated the previously-separated flow over the wing became a strong coherent leading-edge vortex under the influence of the canard vortex.

THESES DIRECTED: O'Leary, C.F., CPT, USMC, "Flowfield Study of a Close-Coupled Canard Configuration," Master's Thesis, June 1992.

Schmidt, D.C., LT, USN, "Lift Enhancement Using a Close-Coupled Oscillating Canard," Master's Thesis, September 1992.

Willson, J.G., LT, USN, "Quantitative Force Measurements of Pneumatic Control on a Wing/Strake Model," Master's Thesis, September 1992.

APPLICATION OF H∞ AND MIXED H_2/H∞ SYNTHESIS TO DESIGN OF ROBUST TRACKING CONTROLLERS AND RELATED THEORY

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

OBJECTIVE: To investigate the application of H∞ and mixed H_2/H∞ synthesis techniques to the design of robust tracking controllers. Furthermore, should there be a lack of theoretical tools needed to accomplish this task, such tools will be developed.

SUMMARY: In the work covered by this proposal we would like to address certain issues which are important

for the design of control systems for air vehicles. In particular, we propose to apply recently developed robust control design methodologies to a number of real-life control design problems. For the case of nonlinear plants such designs are usually done for linear models of the plant around a number of nominal operating conditions. It turns out that for a certain class of nonlinear plants such designs result in gain-scheduled controllers. The issue of properly implementing such controllers has received little attention in the literature. Therefore, we propose to develop a methodology to properly implement gain-scheduled controllers on the nonlinear plants.

ADVANCED AVIONICS TECHNOLOGY

I. I. Kaminer, Assistant Professor
Department of Aeronautics and Astronautics
Sponsor and Funding: Naval Air Command AAS&T

OBJECTIVE: To perform research and development in advanced avionics technology topics.

SUMMARY: In the work covered by this proposal we would like to address certain issues which are important for the design of avionics systems for air vehicles. In particular, we propose to investigate the applicability of sensor and actuator failure detection and isolation techniques (FDI) developed for automobile electronic systems to aircraft avionics systems. Next, we propose to develop differential GPS/INS navigation system for aircraft avionics autoland systems. Finally, in order to facilitate proper development and testing of the above systems we propose to build the real-time hardware-in-the-loop simulation station with the 3D animation capability.

AIRCRAFT FATIGUE LOAD SPECTRA

Gerald H. Lindsey, Professor
Department of Aeronautics and Astronautics
Sponsor and Funding: Naval Air Systems Command

OBJECTIVE: The goals of this research effort were to (1) perform statistical analyses of the loads experienced by A-6 and SH-60B aircraft, (2) produce a model spectrum for each and (3) perform fatigue analyses on each, studying the effects of the load spectrum, load sequence, material property variations and mean stresses on the predicted life.

SUMMARY: A-6 flight loads in the form of acceleration counts were not amenable to modeling with probability distribution functions; however, it was possible to describe the data with a Weibull expression in the upper twenty five percent of the distribution. Flight load spectra for the seventy fifth percentile aircraft and above were created and model flight load histories were generated and used in fatigue life calculations to study the effects of load spectra percentile and

variations in material properties. A statistical model was developed for the spectrum of flight loads expected to act upon the servo beam of the SH-60 helicopter during symmetric pull-out maneuvers. In addition, the maximum loads for all pull-out maneuvers were modeled with an extreme value distribution, and the two can be used together to make damage predictions for any desireddegree of conservatism as expressed by percentiles of maximum loads to be expected. Mean stress effects on the damage calculations were also evaluated by using a cycle by cycle method of determining mean stresses at each stage of the maneuver. This effect made a significant difference in the damage calculations and the resulting life predictions.

PUBLICATION: Lindsey, G.H., "Final Report on Aircraft Fatigue Load Spectra Investigation," NPS Technical Report, November 1992

THESES DIRECTED: Walter, Richard W. II, LT USN, "Study of Statistical Variations of Load Spectra and Material Properties on Aircraft Fatigue Life," Master's Thesis, September 1992.

deGozzaldi, Sally, LT, USN, "Statistical Fatigue Analysis of the SH-60B Servo Beam Rail Component," Master's Thesis, September 1992.

OTHER: The investigator is preparing a manuscript describing the results of this research for publication as an AA article.

IR SIGNATURE AND PARTICULATE BEHAVIOR IN SOLID ROCKET MOTOR PLUMES

D.W. Netzer, Professor
D. Laredo, NRC Research Associate
Department of Aeronautics and Astronautics
Sponsors: Air Force Phillips Laboratory and National Research Council
Funding: Air Force Phillips Laboratory and Naval Postgraduate School

OBJECTIVE: Measure as a function of motor operating conditions and propellant composition the spatial variations of particle size distribution and optical properties and the plume temperature, IR signature and size using a small rocket motor which utilizes aluminized propellant. Compare measured results with SPFIII/R/SIRRMII predictions. Develop a technique for evaluating the effects of motor operating conditions and contaminants /additives on the emissivity of collected particulate as a function of temperature. This is a continuing investigation.

SUMMARY: No one diagnostic technique has been found adequate for measuring the particle size distributions in motors and plumes due to the wide dynamic range and high number density of particles and to the presence of large thermal gradients. A combination of single and ensemble particle analyzers, combined optical/ collection probes and SEM analysis of collected samples have been found necessary. Condensed Al_2O_3 was found to be the major source of radiation in the 3.5-5μ band in the near-plume and gas phase radiation in the far-

plume. Afterburning effects were predominantly confined to reheating of the alumina, which then radiates more than the gaseous species. Highly metallized propellants produced plumes with volume distributed radiation sources and with apparent emissivities predominantly between 0.16-0.19. Particle size distributions were normally bimodal at the nozzle entrance (with 50-90% of the number and <10% of the volume in particles smaller than 1μ) and tri- or quadra-modal in the near plume (with approximately 50% of the volume in particles <1μ). The small particles in the edges of the plume are primarily gamma- alumina with an index of refraction of 1.64. A technique has been developed using rotating tungsten wires in the plume and post-collection examination with an IR microscope to measure the emissivity of plume particulate as a function of temperature. To date, difficulties with convergence have prevented a complete solution of SPFIII/R from being attained for the subscale motor and test conditions employed.

PUBLICATIONS: Brennan, W.D., D.L. Hovland and D.W. Netzer,"Measured Aluminum/ Aluminum Oxide Particle Behavior in a Subscale Solid Propellant Rocket Motor", *Jet Propulsion and Power*, Vol. 8, No. 5, September/October 1992, 954-960.

Laredo, D. and D.W. Netzer, "The Dominant Effect of Alumina on Nearfield Plume Radiation", J. Quantitative Spectroscopy and Radiative Transfer, November 1992.

CONFERENCE PRESENTATIONS: Laredo, D. and D.W. Netzer, "Application of Optical Diagnostics to Particle Measurements in solid Propellant Rocket Motors and Plumes", 23rd Annual Meeting of The Fine Particle Society, 13-17 July 1992, Las Vegas, NV.

THESES DIRECTED: Whisman, C.D. "Emissivity of Rocket Plume Particulates", Master's Thesis, September 1992.

McCrorie, J.D., II, "Particle Behavior in Solid Propellant Rocket Motors and Plumes, Master's Thesis, December 1992.

Vaughn, J.K., "Measurement of Sub-Micron Al_2O_3 Particles in Rocket Plumes", Master's Thesis, December 1992.

SOLID FUEL RAMJET AND SLURRY FUEL COMBUSTION

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

OBJECTIVES: (1) To complete demonstration of the feasibility of supersonic combustion in solid fuel ramjets, (2) To develop techniques to measure the ignition and combustion characteristics of B/B_4C and to measure the optical properties of plume particulate and (3) to determine the effects of atomizer design on the obtainable particle size distribution and combustion efficiency of gelled, metallized slurry fuels.

SUMMARY: Work was completed on the development and demonstration of a subscale supersonic combustion solid fuel ramjet utilizing Plexiglas fuel. The combustor used a mixed supersonic-subsonic flame stabilization region with a small amount of hydrogen pilot gas. Inlet air at M=1.5 was thermally choked in a constant area section and then expanded in a diverging section. Combustor exit Mach numbers were 1.1-1.4 with combustion efficiencies as high as 87% for equivalence ratios between 0.49-0.67. A technique was developed to measure the emissivity of plume particulate in which wires are placed in the plume to collect particles. The wires are then placed under an IR microscope. By accurately measuring the resistance of the electrically heated wire the temperature is determined as the IR image is recorded to yield the emissivity. An initial technique using heated air to heat the wire was unsuccessful. Use of the IR camera to measure the ignition and combustion characteristics of B/B_4C was not accomplished due both to limitations of the IR system temperature range and to a shifting of emphasis to the gelled slurry fuels. Recent IR system upgrades have corrected the high temperature calibration problems. The particle sizes produced by two air-blast and one ultrasonic atomizers were measured using a Malvern particle analyzer. The air-blast atomizers were capable of producing the desired D_{32} of 30-40μ, but only with unacceptably high air pressure drops and high atomizer air-fuel ratios. The ultrasonic atomizer uses more of the available air, but requires very low pressure drops to obtain the desired atomization quality. A combustor was designed and used with center dump, inlet air swirl and axial fuel injection. The air-blast atomizer would not sustain combustion. The ultrasonic atomizer sustained combustion with an efficiency of 76% at an equivalence ratio of 0.78.

PUBLICATIONS: Campbell, W.H., Jr., B.N. Ko, S.R. Lowe and D.W. Netzer, "Solid Fuel Ramjet Regression Rate/Thrust Modulation", *Jet Propulsion and Power*, Vol. 8, No. 3, May-June 1992, 624-629.

Lee, T. and D.W. Netzer, "Temperature Effects on Solid Fuel Ramjet Fuel Properties and Combustion", *Jet Propulsion and Power*, Vol. 8, No. 3, May-June 1992, 721-723.

Vaught, C., M. Witt, A Gany and D. Netzer, "An Investigation of Solid-Fuel, Dual Mode Combustion Ramjets", *Jet Propulsion and Power*, Vol. 8, No. 5, September/October 1992, 1004-1011.

Nabity, J., T. Lee, B. Natan and D. Netzer, "Combustion Behavior of Boron Carbide Fuel in Solid Fuel Ramjets", Combustion of Boron-Based Solid Propellants and Solid Fuels, Ed. K.K. Kuo and R. Pein, CRC Press/Begell House, 1992, 287-302.

Natan B. and D.W. Netzer, "Experimental Investigation of the Effects of Bypass Air on Boron Combustion in a Solid Fuel Ramjet", Combustion of Boron-Based Solid Propellants and Solid Fuels, Ed. K.K. Kuo and R. Pein, CRC Press/Begell House, 1992, 427-437.

PRESENTATIONS: Angus, W.J., M.A. Witt, D. Laredo and D.W. Netzer, Solid Fuel Supersonic Combustion", 29th JANNAF Combustion Subcommittee Meeting, Hampton, VA, 19-23 October 1992.

Netzer, D.W., "*NPS* Ramjet Combustion

Air Launched/Surface Launched Weaponry Propulsion 6.2 Program Technology Exchange, NAWCWD, China Lake, CA, 26-27 March 1992.

THESES DIRECTED: Yang, J-C., "IR Imaging for Combustion Characteristics and Optical Properties of Boron/ Boron Carbide, Master's Thesis, June 1992.

Guglielmi, J.D., "Atomization of JP-10/B_4C Gelled Slurry Fuel, Master's Thesis, June 1992.

Urbon, B.C., "Atomization and Combustion of a Gelled, Metallized Slurry Fuel", Master's Thesis, December 1992.

EXERGY METHODS FOR AIRCRAFT DESIGN

C.F. Newberry, Professor
Department of Aeronautics and Astronautics
Sponsor and Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project is to identify a methodology for using exergy as an aerospace vehicle design tool.

SUMMARY: Research publications related to exergy were examined to ascertain the extent to which exergy has been used to support aerospace vehicle analysis/design. Attention has been given to simple models of vehicle components/flowfields. Consideration has been given to methodologies which permit an assessment of the degree to which exergy can be used as a design and design optimization tool. Research has been focused on launch vehicle flowfields and acoustic refrigerators.

WAVERIDER DESIGN

C.F. Newberry, Professor
Department of Aeronautics and Astronautics
Sponsor and Funding: NASA/USRA Advanced Design Program

OBJECTIVE: The goal of this project is to determine whether or not waverider configurations are feasible for actual airplane designs; in particular, are such configurations suitable for tactical aircraft designs. Participation in this NASA/USRA program is expected to enhance all aeronautical design education programs at the Naval Postgraduate School.

SUMMARY: Design teams within the AE 4273 Aircraft Design class are considering waverider configurations for a long range, M=3-6, carrier compatible interceptor.

OTHER: A paper summarizing the results of four design teams has been accepted for the 1993 Aircraft Design Conference.

AIRCRAFT AND JET ENGINE UNSTEADY FLOW COMPUTATIONS

M. F. Platzer, Professor
J. A. Ekaterinaris, Research Associate Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Systems Command
Funding: Naval Postgraduate School

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: Potential flow, viscous-inviscid interaction and compressible Navier-Stokes computations were completed to study the dynamic stall characteristics of oscillating and rapidly pitching airfoils and the interaction effects between airfoils.

CONFERENCE PRESENTATIONS: Cricelli, A. S., J.A. Ekaterinaris, and M.F. Platzer, "Unsteady Airfoil Flow Solutions on Moving Zonal Grids," AIAA Paper 92-0543, 30th Aerospace Sciences Meeting, Reno, NV, 6-9 January 1992.

Platzer, M.F., M.S. Chandrasekhara, J.A. Ekaterinaris, and L.W. Carr, "Dynamic Airfoil Stall Investigations," 5th Symposium on Numerical and Physical Aspects of Aerodynamic Flows, Long Beach, CA, 13-15 January 1992.

Criscelli, A.S., M.F. Platzer, H.M. Jang, and H.H. Chen, "A Viscous Inviscid Interaction Approach to the Calculation of Dynamic Stall Initiation on Airfoils," ASME Paper 92-GT-128, International Gas Turbine and Aeroengine Congress, Cologne, Germany, 1-4 June, 1992 (accepted for publication in the Transactions of ASME).

THESES DIRECTED: Neace, Kerry, S. "Computational and Experimental Investigation of the Propulsive and Lifting Characteristics of Oscillating Airfoils and Airfoil Combinations in Incompressible Flow," Master's Thesis, September 1992.

Nowak, Lisa M., "Computational Investigations of a NACA 0012 Airfoil in Low Reynolds Number Flows," Master's Thesis, September 1992.

Cricelli, Antonio, S., "Unsteady Airfoil Flow Solutions on Moving Zonal Grids," M.S. in Aeronautical Engineering, December 1992.

DYNAMIC LIFT STUDIES FOR ENHANCED FIGHTER MANEUVERABILITY

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

OBJECTIVE: Identify promising methods for the generation and exploitation of dynamic lift. To this end, perform detailed experimental and computational studies on airfoils, double delta wings and complete aircraft configurations in dynamic motion.

SUMMARY: Water tunnel studies were conducted to determine the following effects: a) pitch rate/sideslip effects on leading-edge extension vortices of an F/A-18 aircraft model, b) dynamic effects during sideslipping of a canard-configured fighter model, c) the effect of canard oscillations on the vortical flow development, d) the effect of fillets on the vortex development over double-delta wings. Furthermore, Navier-Stokes calculations were continued for flows over airfoils, double-delta wings and wing-body configurations at high angles of attack.

PUBLICATIONS: Hebbar, S.K., Hebbar, M., F. Platzer, C.H. Kim, "Water Tunnel Visualization of Dynamic Effects during Sideslipping of a Canard-Configured Fighter Model," Proceedings of Fifth Asian Congress of Fluid Mechanics, Vol. 2, August 1992, p. 1161.

Cricelli, J.A. Ekaterinaris, and M.F. Platzer, "Unsteady Airfoil Flow Solutions on Moving Zonal Grids," AIAA Paper 92-0543, 30th Aerospace Sciences Meeting, Reno, NV, 6-9 January 1992.

THESES DIRECTED: Feng-Hsi Li, "Static and Dynamic Flow Visualization Studies of Two Double-Delta Wing Models at High Angles of Attack," M.S. in Aeronautical Engineering.

Da-Ming Liu, "Effect of Canard Oscillations on the Vortical Flowfield of a X-31A-Like Fighter Aircraft Model," M.S. in Aeronautical Engineering, March 1992.

TRANSONIC FAN CASCADE EVALUATION

R. P. Shreeve, Professor
Department of Aeronautics and Astronautics
Sponsor: Naval Air Systems Command
Funding: Naval Postgraduate School

OBJECTIVE: To modify an existing supersonic blow-down wind tunnel to model the flow through the passages of an advanced engine fan, and to evaluate the use of passive separation alleviation techniques on the passage shock-boundary layer interaction at a relative Mach number

of 1.7.

SUMMARY: Increasing relative Mach numbers are encountered as fan speeds are increased to obtain higher pressure ratios per stage. Separation, as the passage shock interacts with the boundary layer on the blade suction surface, limits the fan performance. The purpose here is to set up a relevant two dimensional experimental model in order to evaluate blade elements designed to incorporate separation control. The design of the test section and model will be based on a pilot experiment developed at M=1.4.

FAN AND COMPRESSOR STALL AND OFF-DESIGN PERFORMANCE IMPROVEMENT

R.P. Shreeve, Professor
G. V. Hobson, Associate Professor
W.B. Roberts, Research Associate
Department of Aeronautics and Astronautics
Sponsor and Funding: Naval Air Warfare Center, Aircraft Division, Trenton

OBJECTIVE: Current tasks aim (1) to validate off-design performance and stall prediction for controlled-diffusion blading and obtain experimental information necessary to enable higher blade loading designs, (2) to develop the means to test shock-boundary layer alleviation devices for transonic fans.

SUMMARY: Previous tasks to measure the effects of tip clearance variation in a multistage compressor and to include secondary flow effects in throughflow code calculations were reported. Laser Doppler Velocimetry measurements in a large subsonic cascade wind tunnel containing controlled-diffusion blades at near-stalling incidence were augmented with laser-sheet flow visualization. New inlet guide vanes and suction for side wall boundary layer thickness control were installed in preparation for tests at stall. A small scale two-passage model simulation of the flow through a transonic fan at M=1.4 was developed in a blow-down wind tunnel. Surface static pressure and wake impact pressure distributions were obtained and shadowgraph and fluid injection methods were applied to visualize the shock-boundary layer interaction. A numerical simulation was also obtained using the RVCQ3D code. The results provide a baseline for the evaluation of separation control techniques.

PUBLICATIONS: Moyle, I.N., Walker, G.W. and Shreeve, R.P., "Stator-Averaged, Rotor Blade-to-Blade Near-Wall Flow in a Multistage Axial Compressor with Tip Clearance Variation", Transactions of the ASME, *Journal of Turbomachinery*, Vol.114, No.3, Jul 1992, pp. 668-674

CONFERENCE PRESENTATION: Ucer, A.S. and Shreeve, R.P.,"A Viscous Axisymmetric Throughflow Prediction Method for Multi-Stage Compressors", ASME Paper 92-GT-293, presented at the International Gas Turbine Congress and Exposition, Cologne, Germany, 1-4 June 1992.

THESES DIRECTED: Golden, W.L., Jr.,"Static Pressure Measurements of the Shock-Boundary Layer Interaction in a Simulated Fan Passage", Master's

Thesis, March 1992.

Myre, D.D., "Fan Passage Flow Model Simulation," Master's Thesis, December 1992.

Wendland, R.A., "Upgrade and Extension of the Data Acquisition System for Propulsion and Gas Dynamic Laboratories," Master's Thesis, June 1992.

AUTONOMOUS LANDING AND TAKEOFF SYSTEMS (ALTOS)

E. R. Wood, Professor
Department of Aeronautics and Astronautics
Sponsor: UAV Joint Project Office,
Naval Air Systems Command
Funding: Naval Air Systems Command

OBJECTIVE: The objective of this project was to evaluate five candidate technologies for an Autonomous Landing and TakeOff System (ALTOS) to guide Unmanned Aerial Vehicles (UAV's) being launched from U. S. Navy surface combatants. The evaluation was divided into four tasks which were: (1) define selection criteria; (2) identify candidate technologies; (3) evaluate the candidate technologies; and (4) recommend technologies to be investigated further.

SUMMARY: The project was carried out by a team comprised of students from the Naval Postgraduate School (as part of course requirements for AE 4306) and a subcontractor, Orion Aviation, Inc. of Palos Verdes, California. Also in order to carry out Task 3 above, the students made use of a flight simulation computer program, FLIGHTLAB II, which was rented from Advanced Rotorcraft Technology, Inc. of Mountain View, California.

For the first task, defining the selection criteria, a total of nineteen different criteria were identified, defined and assigned weighting factors. Representative criteria included Acquisition Range, Air Vehicle Compatibility, Wave-Off Capability, Ground Station/Ship Compatibility, Guidance Accuracy, Landing Accuracy, and Maintainability, Probability of Intercept, etc. These selection criteria were also reviewed by the students as part of task three. Their assessments are documented in Appendix D of part three of the project report.

The second task required the students to identify candidate technologies. The technologies identified were millimeter wave radar, micro wave radar, laser, acoustic, and global positioning system (GPS). Each technology was briefly described along with a recommended math model and performance parameters.

For the third task, evaluating the candidate technologies, several of the selection criteria required the use of a mathematical model to simulate and analyze the inflight performance. For this, the students used a simulation program called FLIGHTLAB II. The millimeter wave radar and GPS technologies were modelled. The micro wave and laser technologies were not modelled because their physical performance parameters are similar to millimeter wave radar. The acoustic technology was not modelled because the perform-

ance parameters were defined as a function of range which FLIGHTLAB is unable to simulate.
Completion of the three tasks resulted in recommendations for further research which was defined in task four. Continued work resulted in successful modelling of the acoustic technology in addition to laser/radar and GPS. The conclusion based upon performance analysis, was that all five technologies are capable of landing a UAV on a surface combatant. However, other selection criteria not related to performance have a large impact on selecting the right technology. The project report concluded that the recommended technology for further research is GPS because it showed favorable performance results and is easily integrated into the UAV system at minimal technical risk.

PUBLICATIONS: Wood, E. R. and Orion Aviation, "Final Report for Autonomous Landing and Takeoff Systems," NPS Technical Report, NPS-AA-92-0003PR, October 1992.

RESEARCH IN HELICOPTER HIGHER HARMONIC CONTROL

E. R. Wood, Professor
Department of Aeronautics and Astronautics
Sponsor: Research Administration Office
Funding: Naval Postgraduate School

OBJECTIVE: Higher Harmonic Control (HHC) is an active control system concept for helicopters that promises a major breakthrough in such important areas as helicopter vibrations, performance, and acoustics. In addition, under this heading has been included other research related to improving helicopter vibra- tions, performance, and acoustics at NPS such as: (1) NOTAR research; (2) scale model helicopter flight research; and (3) flight simulation modelling of helicopters.

SUMMARY: A major goal of HHC research being conducted at NPS is to explain on a theoretical basis the open-loop test results obtained from the NASA/Army/Hughes HHC flight test program conducted in the period 1982-85. This research is made possible in part by McDonnell Douglas Helicopter Company, who has made available for analysis the extensive flight test data taken during the earlier research program.

The data is used as follows. The vibration task requires reduction and analysis of the closed and open-loop data obtained from flight testing the HHC-equipped OH-6A helicopter in Yuma, Arizona. The performance task requires correlating performance flight test data against a theoretical model based upon Garrick's unsteady aerodynamic theory. In addition, it is planned to conduct supporting flight tests using a radio-controlled helicopter model that is being modified for HHC. Modifications are being made to a newly acquired helicopter which has a rotor diameter of 11 feet, a gross weight of 180 lbs, and a 60-lb. payload.

For research on NOTAR a 1/4 scale tailboom which incorporates Coanda circulation control has been designed by the students and is currently being fabricated. The 1/4 scale tailboom is suitable for flight testing on the remotely piloted helicopter. It has also been designed

to be compatible with the NASA-Langley 1/4 scale V/STOL wind tunnel.

Studies continue to be conducted on exploring and developing better methods for conducting scaled rotorcraft flight test research. Areas being investigated include remotely-piloted model and full-scale helicopters. The Robinson R-22 is currently under serious study for full-scale testing. Also under consideration for full scale testing is the whirl tower at Annapolis and the QH-50 coaxial remotely controlled helicopter at China Lake.

In the area of flight simulation modelling, two MS students are currently extending NPS's capability using *FLIGHTLAB*. The *FLIGHTLAB* simulation computer program can be used for real-time flight simulation studies of rotorcraft. A pilot work station can be coupled to the simulator so that the mathematical model can literally be flown in the computer. FLIGHTLAB is presently being used to model both UAV's and full scale helicopters.

THESES DIRECTED: Trainer, W.T., LCDR, USN, "Experimental and Analytical Investigation of the Vibration Characteristics of a Remotely Piloted Helicopter," Master's Thesis, June 1992.

Vandiver, J.L., LT, USN, "RPH Preliminary Design, Trend Analysis and Initial Analysis of the NPS Hummingbird," Master's Thesis, September 1992.

Ransford, K.M., "Baseline Vibration Measurements of Remotely Piloted Helicopters for Higher Harmonic Control Research," Master's Thesis, December 1991.

DEPARTMENT OF AERONAUTICS AND ASTRONAUTICS

1992
Faculty Publications and Presentations

TECHNICAL REPORTS

Lindsey, Gerald H., "Final Report on Aircraft Fatigue Load Spectra Investigation," NPS Technical Report, NPS-AA-92.

Wood, E.R., "Final Report for Autonomous Landing and Takeoff Systems, " NPS Technical Report, NPS-AA-92-003PR, October 1992.

JOURNAL ARTICLES

Ball, Robert E., and Caravasos, N., "Combat Survivability: A Look at the Fundamentals," *Aerospace America*, August 1992, pp 30-33.

Bobbitt, R.B. and Howard, R.M., "Escape Strategies for Turboprop Aircraft in Microburst Windshear," *Journal of Aircraft*, Vol. 29, No. 5, September-October 1992, pp. 745-752.

Hebbar, S.K. and Leedy, D.H., "Wind Tunnel Investigation of a Fighter Model at High Angles of Attack," *Journal of Aircraft*, Vol. 29, No. 6, November-December 1992, p. 1091.

Hebbar, S.K., Platzer, M.F., Park, S.N., and Cavazos, O.V., "A Dynamic Flow Visualization Study of a Two-Percent F/A-18 Fighter Aircraft Model at High Angles of Attack," *High-Angle-of-Attack Technology*, Vol. 1, NASA CP 3149, Part 3, May 1992, P. 1025.

Hebbar, S.K., Platzer, M.F., and Cavazos, O.V., "Pitch Rate/Sideslip Effects on LEX Vortices of an F/A-18 Aircraft Model," *Journal of Aircraft*, Vol. 29, No. 4, July-August 1992, p. 720.

Hobson, G.V. and Lakshminarayana, "Full Elliptic Incompressible Flow Calculations on a Regular Grid," *AIAA Journal*, Vol 30, No. 11, pp. 2783-2785, November 1992.

Howard, R.M., "Design of a High-Lift Airfoil for Hang-Glider Applications," *Technical Soaring*, Vol. 16, No. 1, January 1992, pp. 27-32.

Johnson, D.K., Howard, R.M., and Ilacqua, P.N., "Data Analysis for Unsteady Turbulence Measurements over Airfoils," *Journal of Aircraft*, Vol. 29, No. 3, May-June 1992, pp. 308-313.

Kolar, Ramesh and Moura, G.A.M., "Approach for Analysis and Design of Composite Rotor Blades," *AIAA Journal of Aircraft*, Vol. 29, No. 4, July-August 1992.

Rogers, W.L. and Collins, D.J., "X-29 H Controller Synthesis," *Journal of Guidance, Control and Dynamics*, Vol. 15, No. 4, pp 962-967, July-August 1992.

CONFERENCE PUBLICATIONS

Agrawal, B.N., Bang, H., and Jones, E.S., "Application of Piezoelectric Actuators and Sensors in the Vibrations Control of Flexible Spacecraft Structures," IAF-92-0319, World Space Congress, Washington, D.C., 28 August - 5 September 1992.

Bertrand, J.S., Denis, R., and Collins, D.J., "Neural Network Controllers for the X-29 Aircraft," IJCNN, Vol. 1, Baltimore, Maryland, I321-326, 7-11 June 1992.

Bray, R.M., Lyons, D.F., and Howard, R.M., "Aerodynamic Analysis of the Pioneer Unmanned Air Vehicle," AIAA 92-4635, AIAA Atmospheric Flight Mechanics Conference, Hilton Head, S.C., 10-12 August 1992.

Cricelli, A.S., Ekaterinaris, J.A., and Platzer, M.F., "Unsteady Airfoil Flow Solutions on Moving Zonal Grids," AIAA Paper 92-0543, 30th Aerospace Sciences Meeting, Reno, Nevada, 6-9 January 1992.

Hebbar, S.K., Platzer, M.F., and Kim, C.H., "Water Tunnel Visualization of Dynamic Effects during Sideslipping of a Canard-Configured Fighter Model," Proceedings of the Fifth Asian Congress of Fluid Mechanics, Vol. 2, August 1992, p. 1161.

Hobson, G.V., "A Navier-Stokes Analysis of a Controlled-Diffusion Compressor Cascade at Very High Incidence," AIAA 92-3313, AIAA/SAE/ASME/ASEE 28th Joint Propulsion Conference, Nashville, 1992.

Hobson, G.V. and Wang, C-W., "A Turbulence Model Based on RNG for Quasi-three-Dimensional Cascade Flows," AIAA 92-3312, AIAA/SAE/ ASME/ASEE 28th Joint Propulsion Conference, Nashville, 1992.

Hobson, G.V. and Lakshminarayana, "Fully Elliptic Incompressible Flow Calculations on a Regular Grid," AIAA Journal, Vol. 30, No. 11, pp. 2783-2785, November 1992.

Howard, R.M. and Bray, R.M., "Flight Test and Wind Tunnel Study of a Scaled Unmanned Air Vehicle, "AIAA 92-4075, AIAA 6th Biennial Flight Test Conference, Hilton Head, S.C. 24-26 August 1992.

Howard, R.M., Salmons, J.D., Aitcheson, and Koch, P.A., "Flying-Qualities Flight Test of a Half-Scale Unmanned Air Vehicle," Proceedings of the Society of Flight Test Engineers 23rd Annual Symposium, Hauppauge, NY, 3-7 August 1992, pp. 5-41 5-49.

Shipley, M. and Collins, D.J., "Classification of Acoustic Transients by Means of Neural Networks," Third Annual R&D Conference, Naval Surface Warfare Center, Silver Spring, Maryland, 8-10 April 1992.

Small, J.F., Hebbar, S.K., and Platzer, M.F., "Flow Visualization and Wake Analysis for Complex Three-Dimensional Bluff Bodies at Subcritical Through Critical Reynolds Numbers," AIAA-92-0155, January 1992.

CONFERENCE PRESENTATIONS

Biblarz, O., "Clusters" Seminar, NAWC, China Lake, 2 February 1992.

Biblarz, O., "Thermionic Arc Initiation," IEEE International Conference on Plasma Science, Tampa, Florida, June 1992.

Biblarz, O., "Plasma Sheath Approximate Solutions for Cylindrical Probes," APS 45th Gaseous Electronics Conference, Boston, Massachusetts, 27-30 October 1992.

Bray, R.M., Lyons, D.F., and Howard, R.M., "Aerodynamic Analysis of the Pioneer Unmanned Air Vehicle," AIAA 92-4635, AIAA Atmospheric Flight Mechanics Conference, Hilton Head, S.C., 10-12 August 1992.

Cebeci, T., Platzer, M.F., Jang, H.M., and Chen, H.H., "A Viscous Inviscid Interaction Approach to the Calculation of Dynamic Stall Initiation on Airfoils," ASME Paper 92-GT-128, International Gas Turbine and Aeroengine Congress, Cologne," Germany, 1-4 June 1992.

Cebici, T., Platzer, M.F., Jang, H.M., and Chen, H.H., "A Viscous-Inviscid Interaction Approach to the Calculation of Airfoil Dynamic Stall Initiation on Airfoils," ASME 92-GT-128, International Gas Turbine Aeroengine Congress, Cologne, Germany, 1-4 June 1992.

Cricelli, A.S., Ekaterinaris, J.A., and Platzer, M.F., "Unsteady Airfoil Flow Solutions on Moving Zonal Grids, "AIAA 92-0543, 30th Aerospace Sciences Meeting, Reno, Nevada, 6-9 January 1992.

Cricelli, A.S., Ekaterinaris, J.A., and Plazer, M.F., "Unsteady Airfoil Flow Solutions on Moving Zonal Grids," AIAA 92-0543, 30th Aerospace Sciences Meeting, Reno, Nevada, 6-9 January 1992.

Ekaterinaris, J.A., Platzer, M.F., and Chandrasekhara, M.S., "Low Reynolds Number Airfoil Productions, "45th Applied Physics Society Meeting, Tallahassee, Florida, 22-24 November 1992.

Hobson, G.V. and Wang, C-W, "A Turbulence Model Based on RNG for Quasi-Three-Dimensional Cascade Flows," AIAA 92-3312, AIAA/SAE/ ASME/ASEE 28th Joint Propulsion Conference, Nashville, TN, 1992.

Hobson, G.V., "A Navier-Stokes Analysis of a Controlled-Diffusion Compressor Cascade at Very High Incidence," AIAA 92-3313, AIAA/SAE/ ASME/ASEE 28th Joint Propulsion Conference, Nashville, TN, 1992.

Howard, R.M., "Scaled Research for UAVs: Short, Close-Maritime, Endurance," Civilian and Military Needs for Automated Instrument Platforms, Association for Unmanned Vehicle Systems Workshop, Menlo Park, CA, 28-30 June 1992.

Howard, R.M. and Bray, R.M., "Flight Test and Wind Tunnel Study of a Scaled Unmanned Air Vehicle," AIAA 92-4075, AIAA 6th Biennial Flight Test Conference, Hilton Head, S.C., 24-26 August 1992.

Platzer, M.F., Chandrasekhara, Ekaterinaris, J.A., and Carr, L.W., "Dynamic Airfoil Stall Investigations, "5th Symposium on Numerical and Physical Aspects of Aerodynamic Flows, Long Beach, CA, 13-15 January 1992.

Platzer, M.F., Chandrasekhara, M.S., Ekaterinaris, J.A., and Carr, L.W., "Dynamic Airfoil Stall Investigations," 5th Symposium on Numerical and Physical Aspects of Aerodynamic Flows, Long Beach, CA, 13-15 January 1992.

Reuter, W., Buning, P., and Hobson, G.V., Invited Seminar, "Water Tunnel Investigation of a Canard-Configured Aircraft Model in Dynamic Motion," National Aeronautical Laboratory, Aerodynamics Division, Bangalore, India.

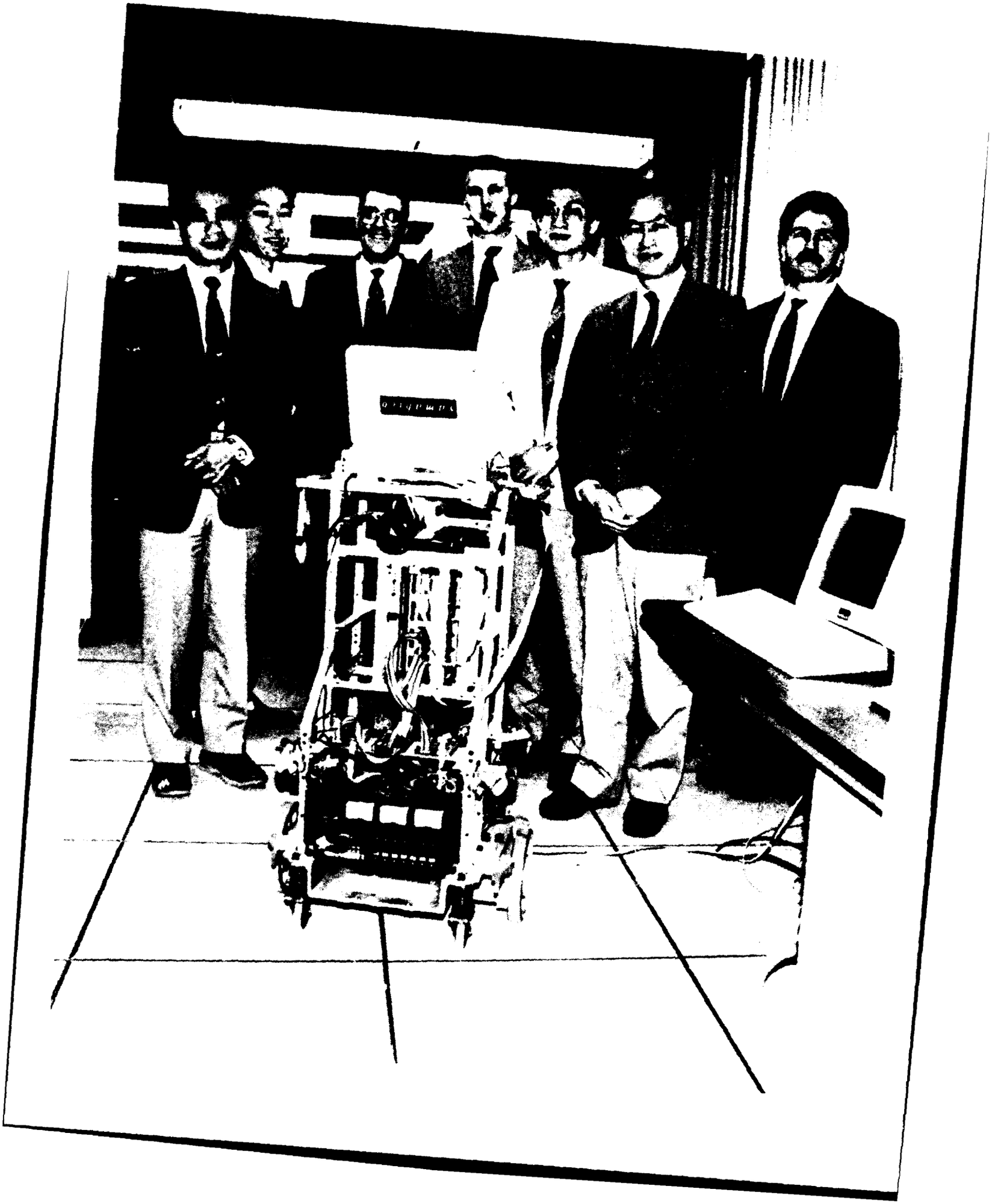
Small, J.F., Hebbar, S.K., and Platzer, M.F., "Flow Visualization and Wake Analysis for Complex Three-Dimensional Bluff Bodies at Subcritical Through Critical Reynolds Numbers," AIAA 92-0155, 30th Aerospace Sciences Meeting, Reno, Nevada, 6-9 January 1992.

Spriesterbach, T.P. and Ross, I.M., "Effect of Heating Rate on the Fuel Efficiency of Aerocruise and Aerobang Maneuvers," AIAA 92-4642, pp. 700-708, AIAA Atmospheric Flight Mechanics Conference, Hilton Head, S.C., 10-12 August 1992.

Wood, E.R., Invited Guest Lecture, "On the Potential for Higher Harmonic Control for Helicopters," Department of Mechanical and Aerospace Engineering, Arizona State University, Tempe, Arizona, 4 December 1992.

DEPARTMENT OF COMPUTER SCIENCE

Professor R.B. McGhee
Chairman



DEPARTMENT OF COMPUTER SCIENCE

The research program in the Department of Computer Science is directed in five areas: Artificial Intelligence and Robotics, Computer Graphics and Visual Simulation, Computer Systems and Architectures, Database and Data Engineering, and Software Engineering. The mission of the Computer Science curriculum is to provide selected officers with the knowledge and skills necessary to specify, evaluate, and manage computer systems and to provide technical guidance in computer applications ranging from non-tactical to tactical areas. In addition to supporting our departmental mission, our research programs contribute heavily to the mission of DoN and DoD agencies. The following is a brief summarization of the Department of Computer Sciences' five research program areas.

ARTIFICIAL INTELLIGENCE AND ROBOTICS

In the area of Artificial Intelligence and Robotics, a major research effort is underway in the area of autonomous vehicles (both underwater and above ground) is carried out. Topics such as path planning, sonar data interpretation, graphics simulation, motion coordination, and image understanding are studied. A knowledge-based approaches to the path planning of missile routes that maximize concealment and minimize energy cost is pursued. Also, investigation in the area of intelligent computer assisted military training (e.g. training systems for helicopter recognition and Ada programming) is performed.

COMPUTER GRAPHICS AND VISUAL SIMULATION

In the Computer Graphics and Visual Simulation area, the research work is focused on the NPSNET system, a low-cost, commercially available workstation-based version of the DARPA SIMNET system. A terrain visualization and reasoning for developing an inexpensive 3D visual simulation for the command and control workstation of the future is investigated. A SIMNET-compatible, non-line-of-sight 3D visual simulator and line-of-sight moving platform simulator are developed.

COMPUTER SYSTEMS AND ARCHITECTURE

In the Computer Systems and Architecture area, the research is performed in the areas of network communication protocols and VLIW architectures for the next generation of high performance workstations. A progress is made on modeling VSAT networks for communications satellites and on applications of very high speed networks to improve the Navy AEGIS combat system.

DATABASE AND DATA ENGINEERING

In the Database and Data Engineering area, a research effort is made in the

areas of interoperable, federated database system, multimedia database system, and universal database front-end system. Prototype systems (some using object-oriented development tools) are being developed.

SOFTWARE ENGINEERING

Fundamental research in intelligent processing of complex queries, optimizing performance of accessing data from heterogeneous databases, visual query languages, and efficient handling of multimedia data are pursued. In the Software Engineering area, the research on Computer-Aaided Prototyping System (CAPS) for real-time software, general semantic model for merging changes to software systems, model for the safety-critical multiprocessing aspects of control systems, and model for prototypes of dynamic systems are performed. Fundamental theory and practicing algorithms for the development and management of software systems are actively pursued. A prototype for a low-cost combat direction system was produced by utilizing the CAPS.

As evident from the above descriptions, the Department of Computer Sciences' research program is highly relevant to the mission of DoN/DoD. Our external funding sources include Naval Research Laboratory, Naval Sea Systems Command, Naval Surface Warfare Center, Naval Weapons Center, NOSC Hawaii, Pacific Missile Test Center, US Army Research Office, US Army Artificial Intelligence Center, US Army Project Manager Training Devices, US Army Test and Experiment Command, US Army AI Center. The prototype systems developed under the research programs are actively used in teaching the department's courses and in supporting MS and Ph.D. theses works.

SYNTHESIZING PROGRAMS FROM SPECIFICATIONS

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

OBJECTIVE: Development of reliable programs is a central problem in software engineering. We are investigating automated techniques for generating executable Ada programs from functional specifications. Applications of the resulting technology include software tools for automatic generation of Ada programs, for direct execution of specifications, and for automatically determining whether test results for programs conform to specified functional requirements. 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 are investigating mechanisms for making black-box specifications expressed in logic executable, both via simulation and via translation into conventional programming languages such as Ada. Our initial effort is focused on automatically generating the scaffolding code needed to automatically test programs containing abstract data types relative to formal specifications. When complete, this should lead to the capability to run arbitrarily large sets of automatically constructed test cases without human intervention except for analyzing failures that have been detected automatically. This work should make it practical to achieve software failure rates that are orders of magnitude lower than is possible using current software development techniques.

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 investigated the underlying technology needed create the necessary software tool support for the proposed software development methodology and have developed a specification of an embedded control system to demonstrate that the facilities for describing real-time constraints in the Spec language are adequate for designing realistic systems.

OTHER: We have extended a previously developed software tool that generates Ada specification modules

from behavioral specifications in the Spec language to handle machines, data types, and tasks. We also developed a software tool for pretty printing a formal specification expressed in the Spec language in a way that illustrates its logical structure. This tool was generated using attribute grammar technology, according to uniform policies that can be applied to other formal languages as well.

AUTOMATICALLY COMBINING CHANGES TO SOFTWARE SYSTEMS

V. Berzins, Professor
Department of Computer Science
Sponsor and Funding: U.S. Army Research Office

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 development and maintenance of large software systems. Combining changes to software is a fundamental problem in software engineering. This process is important in all phases of developing large software systems, where multiple changes must be developed concurrently and then combined. This work has potential applications to software maintenance, view integration in specifications, version control in design databases, and multiple inheritance in specification or programming languages.

SUMMARY: We have investigated change merging for specifications and for software prototypes of real-time systems. We integrated a change merging mechanism for specifications with an inheritance mechanism and investigated both applications and formal properties of the resulting structure. We are currently addressing problems associated with merging changes to PSDL prototypes. We have been working on an analog of the program slicing method for the PSDL language.

Program slicing has been previously applied to change merging for while-programs and we believe that a method applicable to PSDL can be developed based on similar principles despite the fact that PSDL presents new problems because it includes explicit real-time constraints and parallel operations. Concurrency makes PSDL programs potentially nondeterministic, which requires a substantial rethinking of the previous work that was done in the context of deterministic sequential programs. We have been developing a proof that a slice will exhibit the same behavior regardless of what program it is embedded in. In parallel, we are working out the details of an algorithm for merging changes to PSDL programs whose correctness depends on the behavior invariance theorem. We have also done a preliminary functional specification for an automated design management and job assignment system. The main advance provided by this system is automated scheduling and job assignment for teams of engineers in an environment where plans are uncertain, partially known, and subject to change while the work is in progress.

FEDERATED DATABASES AND SYSTEMS

David K. Hsiao, Professor
Department of Computer Science
Sponsor and Funding: The Naval Pacific Missile Test Center

OBJECTIVE: The goal of this project is to provide solutions to heterogeneous databases scattered at two different sites (NPMTC and SanFranShip) and at different locations (within NPMTC).

SUMMARY: At our project, we have developed a solution for federated databases and systems. By federated databases and systems we mean these heterogeneous databases and systems may form a federation without compromising their local application specificities, integrity system. constraints, and security requirements. With the federation, the user can access any heterogeneous database as if it is homogeneous to the user. In other words, the user can continue to write the transaction in the user's favorite data language for the purpose of accessing the user's (homogeneous) databases and the other (heterogeneous) databases. The accessing and sharing among commercial (heterogeneous) databases and systems are not technically feasible at the present time. Our experimental work on federated databases and systems represents the only solution to data accessing and sharing of heterogeneous databases and systems at the present time.

IMAGE UNDERSTANDING FOR AUTONOMOUS ROBOTS

Yutaka Kanayama, Professor
Department of Computer Science
Sponsor: Research Council
Funding: Naval Postgraduate School

OBJECTIVES: The goal of this project was to investigate the effectiveness and limitation of the use of the image understanding technique in navigation, guidance and spatial learning of an autonomous mobile robot. This project is a part of the research initiation program for the principal investigator.

SUMMARY: We have finished the following major tasks in this research. (In the last year's budget, a color CCD camera and image grabbing hardware system had been already acquired. (1) We were successfully able to do linear feature extraction from gray scale images. This task is an important part of image understanding in an indoor environment. This is the thesis work of LT Kevin Peterson. (2) A three dimensional geometric model was designed and constructed for the fifth floor environment of Spanagel Hall and was successfully implemented. (3) Combining these two tasks, we invented an and precise algorithm of matching extracted features and the 3D model to make camera position identification. (4) Shortest and safe planning research had several successful results. (5) As a new motion control algorithm for Yamabico, I invented an algorithm for path tracking. A patent is being applied for based on this algorithm is being applied. (6) Mainly because of this new motion control algorithm, software development task for new MML

(Model-based Mobile robot Language) for the Yamabico robot was started.

(7) Improvement of Yamabico's sonar system.

SIMULATION AND CONTROL OF AUTONOMOUS UNDERWATER WALKING ROBOTS

Yutaka Kanayama, Professor
Robert B. McGhee, Professor
Department of Computer Science
Sponsor and Funding: National Science Foundation (BCS-9109989)

OBJECTIVE: This is a proposal for a three year cooperative research program related to autonomous underwater walking robots involving the Naval Postgraduate School and the Port and Harbor Research Institute(PHRI) in Japan. The purpose of this project is to investigate fast gait control, vehicle dynamics, the effects of ocean currents, and other topics using computer simulation and control of the real walking robot. This project was funded in February 1992.

SUMMARY: We started research work right after the NSF decided to fund us. We started weekly research meetings with both PI's, two MS students and one CS staff member, which continues to this day. In March and April of 1992, Profs. Kanayama and McGhee visited PHRI in Japan to discuss on the important topics like goals, schedule, budgets, robot hardware, computer support, robot specifications and other matters related to this research. Prof. Kanayama visited PHRI in July again in this year to continue discussions mainly on software development tasks. Prof. McGhee is on the Doctoral Committee of Scott McMillan in the Department of Electrical Engineering at the Ohio State University, who take this underwater walking robot research as his dissertation topic area. The dissertation title is "Parallel Real-Time Dynamic Simulation of an Underwater Legged Robot." The research activities are making steady progress. We are expecting publications to come out soon when the current activities produce some concrete results in the second year.

USE OF THE 3D-1M RESOLUTION DATABASE FOR THE JANUS MODEL

Se-Hung Kwak, Adjunct Professor
Department of Computer Science
David R. Pratt, Adjunct Instructor
Department of Computer Science
Sponsor amnmd Funding: TRADOC Analysis Command, Monterey

OBJECTIVE: The goal of this project was to investigate and improve a JANUS simulation system by utilizing 3D-1M resolution database of PEGASUS.

SUMMARY: Currently, a JANUS simulation system uses 50M resolution database. This resolution is not adequate to accurately simulate combat models. If 3D-1M resolution database from a PEGASUS system is utilized, much more accurate and realistic results can be achieved. However, as the resolution is

increased, more computation power is required in order to maintain reasonable response time from JANUS. Especially, line-of-sight(LOS) calculation, which is the major part of detection process, needs much higher computational power. Roughly speaking, about 2000 times of computational power is necessary to maintain the same performance as utilizing a 50M resolution database. This computationally demanding problem can be handled by Transputers. This is one of the inexpensive and reliable approaches to such a highly computational demanding task. The progress for this reporting period has included major effort to study 3D-1M resolution database of PEGASUS and investigate Transputer interface to JANUS as well as PEGASUS database. Study on existing sequential algorithm for LOS was performed, and theoretical studies in the design of parallel algorithm for LOS is initiated.

EVALUATION AND IMPROVEMENT OF THE ASW SYSTEMS EVALUATION TOOL (ASSET)

J. Eagle, Professor
Department of Operations Research
Y. Lee, Assistant Professor
Department of Computer Science
Sponsor and Funding: Antisubmarine Warfare Division, Office of the Chief of Naval Operations

OBJECTIVE: ASSET is a Monte Carlo antisubmarine warfare campaign model. It is an integrated analysis tool with submodels for C3I, undersea and overhead surveillance, submarine operations, MPA operations, and mine warfare. Although it was well-designed, some shortcomings were noted. The primary purpose of this project was to analyze and implement the improvements suggested in previous evaluations of various sub-areas of ASSET.

SUMMARY: The glimpse rate model for submarine detection used in the original ASSET has been replaced with compound Lambda-Sigma jump model. There is a different target radiated frequency in each environmental region. Each target will have its own detection rate to reflect the differences in its operating characteristics. Multiple engagements between platforms are used to eliminate the limitations of interaction between opponent platforms. The glimpse rate model is used to determine detection opportunities of maritime patrol aircraft (MPA) and to approximate a continuous looking sensor pattern. A different criterion of selecting search probability area (SPA) and MPA pairs using the ratio of MPA's time on-station over the SPA size has been implemented. In addition, we have designed and implemented a prototype user interface for porting ASSET to a Sun Sparcstation running X windows.

RAPID PROTOTYPING OF HARD REAL-TIME SYSTEMS

Luqi, Associate Professor
Department of Computer Science
Sponsor and 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 system (CAPS). CAPS is based on a prototyping language with module specifications for modeling real-time systems and combining reusable software. These tools make it possible for prototypes to be designed quickly and to be executed for validating the requirements. The research focuses on automated methods for retrieving, adapting, and combining reusable components based on normalized module specifications; establishing feasibility of real-time constraints via scheduling algorithms; simulating unavailable components via algebraic specifications; automatically generating translators and real-time schedules for supporting execution; constructing a prototyping project database using derived mathematical models; providing automated design completion and error checking facilities in a designer 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 production version of the software 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 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.

A COMPUTER AIDED PROTOTYPING SYSTEM FOR EMBEDDED SOFTWARE

Luqi, Associate Professor
Department of Computer Science
Sponsor and Funding: DoD Ada Joint Program Office

OBJECTIVE: Requirements for modern embedded software systems include the capability to respond in real-time to data inputs from multiple interfaces such as commands from end users, multiple sensors, multiple weapons interfaces, electronic warfare and multiple tactical data link systems. The demands for efficient computation, lucid display, strict

real-time deadlines and ability to deal with sporadic input data and hardware interrupts in such sophisticated systems have greatly increased the development cost. Experimentation with a Computer Aided Prototyping System (CAPS) for systematic development of Ada embedded software on commercial workstations with existing system software has demonstrated a high technology and low cost approach to providing state of the art software development tools for real-time Ada programs in the 1990's. This project seeks to design and develop a CAPS system for DoD use. The initial feasibility study for the development of CAPS system has been completed, and prototype versions of some of the CAPS tools have been validated by using them to generate an executable Ada prototype of the essential features of a C3I system. The initial pilot study has demonstrated that Ada prototypes of real-time systems can be generated rapidly and at low cost. The objective of this project is to develop these tools to the point where they can be used by DoD.

SUMMARY: Many of the software tools in the previous version of CAPS were developed before there was a complete version of CAPS. Consequently, these tools were originally patched to operate somehow even though they needed to interact with parts of CAPS that did not exist at the time. This project is redesigning and redeveloping these tools to extend and integrate the existing capabilities of CAPS in a form that is practically usable. We have developed a new user interface for CAPS that better integrates the tools, substantially simplifies the interactions between the designer and the system, and makes the structure of the interface correspond better to the structure of the prototyping process. We have designed and developed a new graphical editor for CAPS, and designed a new syntax-directed editor. The new design provides a tight coupling between these tools which will allow information and automatic constraint propagation actions to readily cross the boundary between the two tools in both directions, thus substantially increasing the level of automated assistance the tools can provide. The new graphical editor also provides better user-friendly features, such as an undo command, and visual representations of more aspects of a prototype design, such as whether or not an operator has been decomposed into a lower level network and whether or not a data stream represents a state variable with a predefined initial value. We have also developed a tool to instantiate and adapt components retrieved from the software base to conform to the interface required by the conventions of the CAPS runtime architecture and have started to collect, develop, and test reusable software components to populate the CAPS software base. The effectiveness of CAPS in practice is influenced by the extent to which common operations in the problem domain of the prototype are covered by these reusable components.

OTHER: The project has produced approximately 27,000 lines of program code for components of the CAPS system: new graphical editor 6k loc, new syntax directed editor 7k loc, new software base tools 10.3k loc, new caps shell 2k loc, reusable component 1.6k loc. This initial version of the computer-aided prototyping system for semi-automated Ada real-time program development established the feasibility of the CAPS system. We used the initial version of CAPS to develop several real-time embedded Ada control

software systems, including. Patriot missile control software Fish farm control software C3 system. Robot control software. Track processing software. A total of 16k lines of code were developed for the applications.

LOW COST COMBAT DIRECTION SYSTEM

Luqi, Associate Professor
Department of Computer Science
Sponsor and Funding: Naval Sea Systems Command

OBJECTIVE: The objective of the project is to show the feasibility of using commercial workstations, off-the-shelf software packages, and Navy Ada for creating low-cost CDS prototypes. 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 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 via the Navy Ada Compiler. We have explored the CDS capabilities that can be provided by contemporary commercial workstations with suitable Ada software. The project will demonstrate a low cost approach to providing state of the art software for shipboard use. We have addressed the feasibility of translating the Ada CDS prototypes containing the basic features of a Combat Direction System to target AN/UYK code.

SUMMARY: We have completed implementation of a prototype 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.

OTHER: Approximately 20,000 lines of executable on-line Ada code have been produced under the project. The programs run on several types of machines, including Dec vax and Sun workstations. Program source tapes and demo tapes have been delivered to the sponsor in Computer Aided Prototyping of Real-time Systems.

COMPUTER AIDED PROTOTYPING OF REAL-TIME SYSTEMS

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

OTHER: Approximately 25,000 lines of executable on-line Ada and C++ code implementing CAPS tools have been produced under the project. We have also developed approximately 16,000 lines of prototype code using CAPS to validate the tools and the process: C3I 10k loc, patriot missile 1.9k loc, robot control 1.6k loc, fish farm control 2k loc.

MODELS FOR PROTOTYPES OF DYNAMIC SYSTEMS

Luqi, Associate Professor
Department of Computer Science
Sponsor and Funding: Naval Surface Warfare Center

OBJECTIVE: This project addresses the development of analytical models of dynamic software systems to support rapid prototyping, computer-aided analysis of hard real-time constraints, and new real-time scheduling methods for dynamic systems. The objective of the proposed research is to enable the design of flexible real-time systems that consist of variable numbers of subsystems whose connection patterns can change with time. Potential applications include distributed C3I systems and damage-tolerant systems that can automatically reconfigure themselves in response to component failures. The results of this research support tools for analyzing hard real-time constraints and synthesizing executable software prototypes.

SUMMARY: The set of subsystems comprising a dynamic system can change with time. Such changes can be due to subsystems physically crossing the boundaries of the dynamic system, such as aircraft entering and leaving a controlled airspace, or due to subsystems failing and coming back on-line after repairs, such as automatically reconfigurable systems designed to survive damage to subcomponents. Embedded software systems are typically subject to hard real-time constraints. However, current approaches to designing real-time systems depend on the assumption that the system structure is static. Our work is developing the basis for removing this restriction.

MODELING OF REAL-TIME SYSTEMS NAVAL RESEARCH LABORATORY

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

OBJECTIVE: This project involves the design and development of the methodology and computer-aided software tools for building hard real-time systems. The primary goals of the project are to develop suitable methodology and software tools for building complex hard real-time systems and to provide training for the software engineers at NRL to use such methodology and tools.

SUMMARY: Most engineers at NRL developed system specifications from discussion with the sponsors. They then used their programming experience to determine the system requirements and module designs, which were reviewed either in-house or with the sponsors to see if they meet the functional and operational specifications of the users. Prototypes for the design were then developed and tested with test cases that were either developed in-house or provided by the sponsors. In order to meet the real-time constraints, engineers usually designed and developed their systems to run as fast as possible, without formal assurance that performance will meet

the requirements or formal analysis to determine the range of operating conditions under which all deadlines can be met. Given the fact that most engineers at NRL have neither experience nor training for any structured design methods, we recommend that NRL adopt the Hatley-Pirbhai extension of the informal Yourdon method now and switch to a more powerful method when stable tools are available and the engineers have gained some experience with systematic design methods and some more formal training.

OTHER: Training materials on real-time software development and a report based on a survey of NRL and a technology survey on the state of the art of real-time software development were developed and presented at NRL. A general survey with many questions was given to NRL workers, and the results were analyzed. More than 100 pages of materials were developed to support the task. In three trips to NRL a total of 24 hours of training was given.

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

R.B. McGhee, Professor
J. R. Clynch, Professor
S.H. Kwak, Professor
Department of Computer Science
Sponsor and Funding: Naval Research and Development, Hawaii

OBJECTIVE: The goal of this project was to collect performance data and select components for a breadboard SANS system, including both a GPS receiver and inertial sensors, to order parts and start construction of a breadboard system, and to construct a land-based dynamic test facility.

SUMMARY: The SANS package is a self-contained unit suitable for accurately determining the location of an autonomous underwater vehicle (AUV) using a combination of GPS, inertial, depth, and magnetic sensors. It also incorporates a computer to provide control signals to guide the AUV to a mission area, to record mission data, and to return the AUV to its launch point. It is designed for either internal or external mounting on any AUV. Design studies and experimental investigations described in the publications listed below have lead to the conclusion that the location of objects detected by an AUV operating in shallow waters can be determined to an accuracy of approximately 10 meters rms, worldwide, by an navigation and mission control package occupying not more than 120 cu.in., and requiring not more than 10 watts average power.

During 1992, a golf cart was purchased and provided with the instrumentation needed to evaluate the accuracy of a breadboard SANS system while driving on a calibrated track. All components were purchased and some software modules were completed. Completion of the breadboard system and land-based testing is anticipated in 1993. Wet testing of an integrated SANS package using the NPS AUV is also planned, contingent on an adequate level of funding.

PUBLICATIONS: McGhee, R.B, Jr., Clynch, J.R., Kwak, S.H., and Mckeon,

J.B., "Technology Survey and Preliminary Design For a Small AUV Navigation System, NPS Technical Report, NPS-CS-92-001, March 1992.

Kwak, S.H., McKeon, J.B., Clynch, J.R., and McGhee, R.B., "Incorporation of Global Positioning System into Autonomous Underwater Vehicle Navigation," Proceedings of 1992 IEEE Symposium on Autonomous Underwater Vehicle Technology, Washington, D.C., June 1992, pp. 291-297.

THESIS DIRECTED: McKeon, J.B., LCDR, USN, "Integration of GPS INS Capability into a Small AUV, Master's Thesis, March 1992.

USE OF SOFTWARE FAILURE REGION ANALYSIS TO ENHANCE REGRESSION TESTING

T. J. Shimeall, Assistant Professor
Department of Computer Science
Sponsor and Funding: Naval Weapons Center

OBJECTIVE: The goal of this research was the development of a technique for formulation of regression testing adequacy criteria, based on the properties of software failure regions.

SUMMARY: The problem of regression testing is widely recognized as a difficult one in the field of software testing. This research has analyzed a series of software faults and produced a series of recommendations on how these faults (and other factors) may be exploited in the conduct of software testing. By viewing the software process as aniterative process, regression testing is viewed as drawing on previously-constructed groups of information. That information is then exploited to develop detailed regression test criteria and managerial recommendations.

PUBLICATIONS: Shimeall, T.J. and Shimeall, S.C., "Iterative Software Testing," NPS Technical Report, NPS-CS-92-008, 1992.

INTER-REGION ANALYSIS OF SOFTWARE FAILURE REGIONS

T. J. Shimeall, Assistant Professor
Department of Computer Science
Sponsor: Naval Weapons Center
Funding: NPS Merit Funding

OBJECTIVE: The goal of this research was the analysis of relationships among the failure regions generated by a selection of known faults in a particular piece of software.

SUMMARY: This research examined characteristics of software faults and the application of the properties of these faults to the task of software testing. This examination was curtailed due to extensive purchasing delays of required equipment (equipment was finally received in Dec., 1992, after a purchasing delay of 23 months). Despite this limiting effect, the research established that faults may

cluster in the input space, but this clustering appears to be limited in scope to small groups of faults forming each cluster, rather than all of the faults of a particular program forming one large cluster. Research in this area is ongoing in student thesis work and in journal paper presentation with the aid of the now-available computation resources.

PUBLICATION: Shimeall, T.J., "An Exploration of the Failure Behavior of Software Faults," Portland State University, May 1992, Distinguished Lecture.

FORMAL METHODS FOR THE DESIGN OF INTERACTIVE TUTORIAL SOFTWARE

T. J. Shimeall, Assistant Professor
Department of Computer Science
Sponsor and Funding: Space and Naval Warfare Systems Command

OBJECTIVE: The goal of this research was the development of a method for the design and construction of efficient computerized tutorials.

SUMMARY: This research has developed a design method for CAI. Concept-flow diagrams, analogous to the conventionally-used data-flow and control-flow diagrams, were defined. Criteria for the review of such diagrams were developed. A computer program automating these diagrams was produced and is in use at two other sites.

THESIS DIRECTED: Maskell, D.M., "Concept-Flow Diagrams: Method for Design of Computer-Aided-Instruction," Master's Thesis, March 1992.

OTHER: INTERP, A Concept-Flow Diagram Interpreter delived to SPAWAR and The University of Texas at Austin (Software).

A NEW PROGRAMMING LANGUAGE NAD ITS ENVIRONMENT

Dennis M. Volpano, Professor
Department of Computer Science
Funding: Naval Postgraduate School
David Gries, Department of Computer Science
Cornell University
Funding: ARPA ISTO

OBJECTIVE: The goal of this project is to design and implement a new programming language Polya and its environment. Polya supports a new notion of encapsulation that will allow scientists to write programs at a higher level and with less effort.

SUMMARY: A critical component of Polya is a new type discipline that offers more flexibility than those of existing prototype languages and does not compromise the security of traditional strong typing. Type inference must be performed incrementally in the context of overloading, subtyping, and ad-hoc polymorphic recursion. New results for type inference in the context of overloading have been obtained. More flexible restrictions on a type basis were identified under which the

typability problem is decidable. It was shown that constraint-set satisfiability under the new restrictions can be done in low-order polynomial time. These results show that more natural overloadings can be expressed without an attendant rise in computational complexity.

DESIGN AND IMPLEMENTATION OF CD-ROM BASED DATABASED MANAGEMENT SYSTEM

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

OBJECTIVE: In this research, we propose to extend our prototype to incorporate a CD-ROM device where the relational database will reside. We will explore the issues related to accessing CD-ROM devices connected to a network from various machines such as PC, Macintosh, and UNIX workstations.

SUMMARY: We studied the issues of converting a data storage format of the existing prototype (which is in the HyperCard's internal format) to the relational format. This step is the necessary step toward utilizing external physical storage device such as CD-ROM. Media characteristics of CD-ROM for storing documents are explored. We also studied the use of object-oriented programming tools that allow faster prototyping.

PUBLICATIONS: Wu, T.C., "Faster Program Development with Actor's WDL and Action Methods," *Journal of Object-Oriented Programming*," Vol. 4, No. 9, February 1992, pp. 54-60.

Wu, T.C., "Improving Reusability with Actor's Protocol Mechanism," *Journal of Object-Oriented Programming*," Vol. 5, No.1, March/April 1992, pp. 49-51.

THESES DIRECTED: Hale, LT R. J., "The Development of a Scheduling Application in Support of the Paperless Ship, Master's Thesis, March 1992.

Chelouche, Major Evyatar, "Using Object-Oriented Databases for Implementation of Interactive Electronic Technical Manuals," Master's Thesis, March 1992.

QUERY PROCESSING IN MULTIMEDIA DATABASE SYSTEMS

C. Thomas Wu, Associate Professor
Vincent Y. Lum, Professor
Neil C. Rowe, Associate Professor
Department of Computer Science
Sponsor and Funding: Naval Command, Control, and Ocean Surveillance Center

OBJECTIVE: This research explores the issues related to querying processing in multimedia database systems. A visual query language will be proposed and our earlier natural language query processing will be explored further.

SUMMARY: A visual query language called DFQL was developed. The first prototype that supports the proposed language DFQL was implemented. The current prototype generates a sequence of SQL statements from the given DFQL query. The parser for natural language processing was improved to incorporate a better capability in understanding domain-dependent semantic information. We also studied the issues of query processing in the object-oriented databases.

PUBLICATIONS: Wu, C.T., "Protocol vs. Multiple Inheritance," *Journal of Object-Oriented Programming*, Vol. 5, No. 4, July/August 1992, pp. 72-75.

Wu, C.T., "Visual Query Language for Relational Databases," Proceedings of DS-5 Conference on Semantics of Interoperable Database Systems, Vol. 2, November 1992, Lorne, Australia, pp. 46-59.

Wu, C.T., Gugliemo, E., Ntoka, N., and Rowe, N., "A Protoptype Decision Support System and Multimedia Database for Command and Control, 9th Annual Decision Aids Conference, Monterey, CA, June 1992.

Wu, C.T., Gugliemo, E., and Rowe, N., "Natural Language Processing of Captions for Retrieving Multimedia Data," Conference on Applied Natural Language Processing, Trento, Italy, April 1992.

CONFERENCE PRESENTATION: Wu, C.T., "Dataflow Query Language, Presenation at International Federation for Information Processing Working Group 2.6 Meeting, Moneterey, CA, 6-8 July 1992.

THESES DIRECTED: Li, Captain, T.C., "User Interface of DFQL: An Object-Oriented Approach," Master's Thesis, March 1992.

Filippi, LT S.C., "Implementing Relational Operations in an Object-Oriented database," Master's Thesis, March 1992.

Balci, LTJG, M. and Saridogan, LTJG Erhan, "Design ands Implementation of a Graphical User Interface for a Multimedia Database Management System, Masters' Theses, September 1992.

Spear, CPT Ronald L., "A Relational/Object-Oriented Database Management System: R/OODBMS, Master's Thesis, June 1992.

OTHER: Working prototypes were developed by the students as part of their theses. One paper was submitted to a journal.

ESTABLISHMENT OF INFOSEC CENTER OF EXCELLENCE

C. Thomas Wu, Associate Professor
Roger Stemp, Adjunct Instructor
Department of Computer Science
Sponsor and Funding: National Security Agency

OBJECTIVE: An INFOSEC Center of Excellence is a formal, cooperative partnership between the National Security Agency (NSA) and a Department of Defense (DOD) educational institution that provides mutual benefit to each partner. We will develop an information security track that provides students with fundamental concepts of trusted

systems and where appropriate, exposes the students to the advanced concepts required to support current research endeavors.

SUMMARY: The status reports on INFOSEC Trusted System Laboratory, INFOSEC Reference Library, and INFOSEC Funding Allocation were produced. Course syllabus for CS 4601 Introduction to Computer Security and CS4602 Advanced Computer Security was developed. Course matrices for both CS and ITM Computer Security Track were developed and reported to the appropriate committees.

COMPILE TIME TECHNIQUES TO ENHANCE THE PERFORMANCE OF THE AN/UYS-2 MULTIPROCESSOR

Amr Zaky, Assistant Professpr
Department of Computer Science
Sponsor and Funding: Naval Sea Systems Command

OBJECTIVE: To investigate and experiment with different mechanisms to improve certain performance measures for the AN/USY-2 signal processing multiprocessor.

SUMMARY: The AN/USY-2 is employed by USN for the purpose of real-time (RADAR/SONAR) signal processing on board ships. As the AN/USY-2 employs a Large Grain Data Flow (LGDF) processing methodology, an application is treated as a Data Flow Graph (DFG) of nodes - each of which represents a signal processing primitive. In order to increase the utilization of the processors, and to ensure the production of output data at regular time intervals (a very important requirement for this class of real-time applications), some control has to be exerted on the scheduling of the DFG nodes. AN/USY-2 run-time mechanisms dispatch ready nodes in a quasi-arbitrary manner which can yield artificial data memory congestion, lack of computation-communication overlap, and production of outputs at irregular time intervals. The goal of this project is to identify the mechanisms of AN/USY-2 that can be used in controlling the dispatch times of the DFG nodes. This work (jointly with Professor S. Shukl the ECE Department), has resulte the introduction of a framew (Revolving Cylinder Scheduling) for compile time analysis and restructuring of DFGs so as to avoid the potential shortcomings - which are discussed above - of arbitrary node dispatching. Tools have been developed to restructure DFGs in the way of realizing the Revolving Cylinder Scheduling Framework. Also, a real-time LGDF multiprocessor has been developed to evaluate the relative performance of the restructured graphs as compared to the original graphs. Currently, two faculty and several students in both the Computer Science and Electrical and Computer Engineering Departments are involved in this project.

PUBLICATION: Shukla, S.B. and Zaky, A., "A Compile-Time Technique for Controlling Real-Time Data-Flow Graphs," in Proceedings of the 1992 International Conference on Parallel Processing, Chicago, Illinois, 1992.

CONFERENCE PRESENTATION: Shukla, S.B. and Zaky, A. "A Compile-Time Technique for Controlling Real-Time Data-Flow Graphs," in Internation Conference of Parallel Processing,

Chicago, Illinois, 1992. This paper won the outstanding paper award at International Conference on Parallel Processing.

NPSNET

Michael J. Zyda, Professor
David R. Pratt, Assistant Professor
Department of Computer Science
Sponsors and Funding: Advanced Research Project Agency, Army AI Center, U.S. Army Training and Doctrine Command, Naval Ocean Systems Center, U.S. Army Test and Experimentation Command

OBJECTIVE: NPSNET is a three-dimensional, workstation-based, visual simulator being developed by researchers at the Graphics and Video Laboratory of the Department of Computer Science at the Naval Postgraduate School. The project centers on the development of graphics simulations software, and is expanding to include many related facets of virtual reality.

Research is being conducted entirely within the Department of Computer Science at NPS as part of the MS and Ph.D. programs. The research is directly supported by the teaching efforts of the Computer Graphics and Visual Simulation Track, established at the school this past year. This track (one of five in the department) has a real-time, interactive, three dimensional slant that is particularly conducive to work in the virtual worlds field.

In addition to the general requirements of the department, the track offers five classes designed to give the MS candidates an understanding of real-time, interactive three-dimensional graphics and simulation. With the knowledge obtained in these courses, the candidates are singularly prepared to design and work with computer graphics simulations. Many choose to write their theses on work with NPSNET, as do students from other tracks. Without the contributions made by the MS students, the NPSNET project would be impossible to maintain and continue.

The goal of the project has been to create a low-cost, government owned, workstation based visual simulator that utilizes SIMNET databases and SIMNET and DIS networking formats. In the last year, this goal has been accomplished. The next stop being taken is to build an extension to NPSNET that would lower the entry cost for other researchers wanting to work with both SIMNET and other simulators. We want to expand NPSNET as a family of simulators that can function as an easily adaptable core through which more modern simulators can be linked to SIMNET and follow on systems.

The NPSNET project focuses on the application of virtual world systems in an attempt to find useful, cost-efficient uses for this new technology. Because of the nature of this focus, the emphasis of the project is on software development. While many researchers work with the hardware of virtual reality, often repeating the work done by others, the NPSNET project is developing the software to go with the technology. This software includes hardware drivers, interfaces, graphics, and functions determined by the particular use of the simulation.

Thus, our goal is to build worlds that are useful to inhabit instead of building the hardware to enter them.

SUMMARY: We are currently involved in a myriad developmental aspects for NPSNET. The last year has seen the completion of several projects, as well as the initial forays into new work. The projects are diverse in content, but all have the same goals of developing a fully-interactive, believable environment. The diversity of direction can be attributed to the many students who work on the project, each choosing the aspect of development most interesting to themselves, or that most closely suited to their course of study. These directions include:

a. The Object-Oriented Programming Paradigm.

b. Physically-Based Modeling

c. Dynamic Terrain

d. Autonomous Forces

e. Real-Time Scene Management

f. Aural Cues

g. Collision Detection

h. NPSNET Stealth

i. Live Tests

j. DIS Integration

k. Department of Defense Simulation Internet Maneuvers

PUBLICATIONS: Zyda, Michael J., Osborne, William D., Monahan, James G. and Pratt, David R.. "NPSNET: Real-Time Collision Detection and Response," *The Journal of Visualization and Computer Animation*, special issue on Simulation and Motion Control, Vol. 4, No. 1, August 1992.

Zyda, Michael J., Monahan, James G. and Pratt, David R. "NPSNET: Physically-Based Modeling Enhancements to an Object File Format," chapter in Creating and Animating the Virtual World, Editors: Nadia Magnenat Thalmann and Daniel Thalmann, Publisher: Springer-Verlag Tokyo, 1992, pp. 35-52.

CONFERENCE PRESENTATIONS: Wilson, Kalin P., Zyda, Michael J., and Pratt, David R. "NPSGDL: An Object Oriented Graphics Description Language for Virtual World Application Support," proceedings of the Third Eurographics Workshop on Object-Oriented Graphics, Champery, Switzerland, 28 - 30 October 1992.

Pratt, David r., Zyda, Michael J., Mackey, Randy L., and Falby, John S. "NPSNET: A Networked Vehicle Simulator with Hierarchical Data Structures," in the Proceeding of the Image VI Conference, Scottsdale, Arizona, 14 - 17 July 1992.

Zyda, Michael J., Pratt, David R., Monahan, James G. and Wilson, Kalin P. "NPSNET: Constructing a 3D Virtual World," in Computer Graphics, special Issue on the 1992 Symposium on Interactive 3D Graphics, MIT Media Laboratory, 29 March - 1 April 1992, pp. 147-156.

Brutzman, Donald P., Kanayama, Yutaka and Zyda, Michael J. "Integrated Simulation for Rapid Development of Autonomous Underwater Vehicles," Proceedings of the 1992 Symposium on Autonomous Underwater Vehicle Technology, Washington, DC, June 2-3, 1992, pp 3-10.

Falby, John S., Zyda, Michael J.,

Pratt, David R. and Wilson, Kalin P. "Educational and Technological Foundations for the Construction of a 3D Virtual World," in the Proceedings of Virtual Reality '92, San Jose, 23-25 September 1992.

Zyda, Michael J., and Pratt, David R. "NPSNET Digest: A Look at A 3D Visual Simulator for Virtual World Exploration and Experimentation," in the Proceedings of the 1992 EFDPMA Conference on Virtual Reality, Washington, DC, June 1-2, 1992.

THESES DIRECTED: Dahl, Leif "NPSNET: Aural Cues for Virtual World Immersion," Master's Thesis, September 1992.

Nash, Dave "NPSNET: Modeling the In-Flight and Terminal Properties of Ballistic Munitions," Master's Thesis, September 1992.

Warren, Pat and Walter, Jon "NPSNET: JANUS-3D - providing a 3D Display for a Traditional Combat Model," Joint Master's Thesis, September 1992.

Walters, Alan "NPSNET: Dynamic Terrain & Cultural Features," Master's Thesis, September 1992.

Weigeshoff, William "NPSNET-SAF: Automated Terrain Analysis for Route Planning and Fields of Fire," Master's Thesis, September 1992.

Wilson, Kalin P. "NPSGDL: An Object Oriented Graphics Description Language for Virtual World Application Support," Master's Thesis, September 1992.

Brutzman, Donald P. "NPS AUV Integrated Simulator," Master's Thesis, March 1992.

Cooke, Joseph M. "NPSNET: Flight Simulation Dynamic Modeling Using Quaternions," Master's Thesis, March 1992.

Daley, John A. "HYPER-NPSNET: A Virtual World with An Integrated 3D Hypertext," Master's Thesis, March 1992.

Park, Hyun Kyoo "NPSNET: Real-Time 3-D Ground-Based Vehicle Dynamics," Master's Thesis, March 1992.

OTHER: Zyda, Michael J. and Pratt, David R. "NPSNET: LHD-1 Landing Script," on ACM SIGGRAPH Video Review, Vol. 70, July 1992, entitled "Visualization Software: The State of the Art,". The video segment shows a brief clip of NPSNET animating the landing of an LHD-1.

DEPARTMENT OF COMPUTER SCIENCE

1992 Faculty Publications and Presentations

TECHNICAL REPORTS

Kwak, S.H., McGhee, R.B., and Bihari, T.E., Rational Behavioral Model: A Tri-Level Multiple Paradigm Architecture for Robot Vehicle Control Software, NPS Technical Report, NPSCS-92-003, March 1992.

Lee, Y., "Improving the ASW System Evaluation Tool," NPS Technical Report, NPS-CS-92-015, October 1992.

McGhee, R.B., Clynch, J.R., Kwak, S.H., and McKeon, J.B., Technology Survey and Preliminary Design for a Small AUV Navigation System, NPS Technical Report, NPS-CS-92-001, March 1992.

Rowe, N., "Obtaining Optimal Mobile-Robot Paths with Non-Smooth Anisotropic Cost Functions Using Qualitative-State Reasoning," NPS Technical Report, NPS-CS-92-012, September 1992.

Rowe, N. and Kanayama, Y., "Near-Minimum-Energy Paths on a Vertical-Axis Cone with Anistropic Friction and Gravity Effects: The Details, NPS Technical Report, NPS-CS-92-013, September 1992.

Shimeall, T.J., Shimeall, S.C., "Iterative Software Testing," NPS Technical Report, NPSCS-92-008, 1992.

JOURNAL ARTICLES

DeHaemer,M.J., Zyda, M.J., "Simplication of Objects Rendered by Polygonal Approximations," *Computers & Graphics*, Vol. 15, No. 2, pp. 175-184, 1991, Great Britain: Pergamon Press. Paper received "Best Paper 1991" award from an international selection committee appointed by the editor of Computers & Graphics, 29 Sep 92.

Healey, A.J., McGhee, R.B., Cristi, R., Papoulias, F.A., Kwak, S.H., Kanayama, Y., Lee, Y., Shukla, S., and Zaky, A., "Research on Autonomous Underwater Vehicles at the Naval Postgraduate School," *Naval Research Reviews*, Vol. XLIV, No. 1, pp. 43-51, 1992.

Hsiao, D. K., "Federated Databases and Systems: A Tutorial on Their Data Sharing," *The International Journal on Very Large Data Bases* (VLDB Journal), Vol. 1, No. 1, July 1992.

Hsiao, D. K., "Federated Databases and Systems: A Tutorial on Their Resource Consolidation," *The International Journal on Very Large Data Bases* (VLDB Journal), Vol. 1, No. 2, October 1992.

Lundy, G.M., "Formal Model of a High Speed Transport Protocol," in *Protocol Specification, Testing and Verification*, XII, North-Holland. (with R.C. McArthur).

Lundy, G.M., "Specification and Analysis of the FDDI MAC Protocol Using Systems of Communicating Machines," in *Computer Communications*, Vol. 15, No. 5, June 1992. (with I. F. Akyildiz).

Steed, A., Rowe, N., and Carter, E., "Using Artificial Intelligence for Hydrographic Survey Planning," *The Hydrographic Journal*, Vol. 64, April 1992, supported by direct funding, sponsor the Naval Ocean Systems Center, San Diego.

Wu, T., "Faster Program Development with Actor's WDL and Action Methods," *Journal of Object-Oriented Programming*, Vol. 4, No. 9, pp. 54 - 60, Feb 1992.

Wu, T., "Improving Reusability with Actor's Protocol Mechanism," *Journal of Object-Oriented Programming*, Vol. 5, No. 1, pp. 49 - 51, March/April, 1992.

Wu, T., "Protocol vs. Multiple Inheritance," *Journal of Object-Oriented Programming*, Vol. 5, No. 4, pp. 72 - 75, July/August 1992.

Zyda, M.J., Pratt, D.R., Falby, J.S., and Mackey, R.L., "NPSNET: Hierarchical Data Structures for Real-Time Three-Dimensional Visual Simulation," *Journal of Computers & Graphics*, Vol. 17, No. 1, 1993.

Zyda, M.J., Osborne, W.D., Monahan, J.G., and Pratt, D.R., "NPSNET: Real-Time Collision Detection and Response," *Journal of Visualization and Computer Animation*, special issue on Simulation and Motion Control, Vol. 4, No. 1, pp., August 1992.

Zyda, M.J., "The Software Required for the Computer Generation of Virtual Environments," abstract in the *Journal of the Acoustical Society of America*, Vol. 92, No. 4, Pt. 2, pp. 2345-2346, October 1992.

CONFERENCE PROCEEDINGS

Berzins, V., Luqi, and Lee, Y., "Applications and Meaning of Inheritance in Software Specifications," in Proceedings of the 25th Hawaii International Conference on System Sciences, Kauai, Hawaii, pp. 64-73, 7-10 January 1992.

Brutzman, D.P., Kanayama, Y, and Zyda, M.J., 1992b. "Integrated Simulation for Rapid Development of Autonomous Underwater Vehicles," in Proceedings of the IEEE Oceanic Engineering Society Conference AUV 92, Washington, D.C., pp. 3-10, 2-3 June 1992.

Brutzman, D.P., Compton, M.A., and Kanayama, Y., 1992c"Autonomous Sonar Classification Using Expert Systems," in Proceedings of the IEEE Oceanic Engineering Society Conference OCEANS 92, Newport, R.I., October 26-29, 1992.

Brutzman, D.P., Kanayama, Y. and Zyda, M.J., "Integrated Simulation for Rapid Development of Autonomous Underwater Vehicles," Proceedings of the 1992 Symposium on Autonomous Underwater Vehicle Technology, Washington, DC, pp. 3-10, 2-3 June 1992.

Byrnes, R.B., MacPherson, D.L., Kwak, S.H., Nelson, M.L., and McGhee, R.B., "An Experimental Comparison of Hierarchical and Subsumption Software Architectures for Control of an Autonomous Underwater Vehicle," Proceedings of 1992 IEEE Symposium on Autonomous Underwater Vehicle Technology, Washington, DC, pp. 135-141, 2-3 June 1992.

Falby, J.S., Zyda, M.J., Pratt, D.R., and Wilson, K.P., "Educational and Technological Foundations for the Construction of a 3D Virtual World," in the Proceedings of Virtual Reality '92, San Jose, 23-25 September 1992.

Hsiao, D.K., "The Object-Oriented Database Management," Proceedings of the Second Far-East Workshop on Database Systems, Kyoto, Japan, April 1992.

Kanayama, Y., "Architectural Consideration for Real-Time Control System and Simulator," Workshop on Architectures for Intelligent Control Systems, IEEE International Conference on Robotics and Automation, Nice, France, pp. 30-31, 10 May 1992.

Kwak, S.H., McKeon, J.B., Clynch, J.R., and McGhee, R.B., "Incorporation of Global Positioning System into Autonomous Underwater Vehicle Navigation," Proceedings of 1992 IEEE Symposium on Autonomous Underwater Vehicle Technology, Washington, DC, pp. 291-297, 2-3 June 1992.

Lee, Y. and Bonsignore, J., "Underwater Multi-Dimensional Path Planning, in Proceedings of the Tenth Annual National Conference on Ada Technology, Arlington, Virginia, pp. 357-360, 24-27 February 1992.

Lee, Y. and Luqi, "Controlling an Autonomous Underwater Vehicle Using an Expert System," in Proceedings of the Second International Conference on Automation, Robotics and Computer Vision, Singapore, pp. AI-3.6.1-6, 15-18 September 1992.

Lundy, G.M., "Design of High Speed Transport Protocols," in Proceedings, IEEE Military Communications Conference, San Diego, CA, 4-7 November 1991. (with R.C. McArthur).

Lundy, G.M., "An Algorithm for Improving Security in FDDI," in Proceedings, Optical Engineers/Fibers 92, Boston, Mass.

Luqi and Lee, Y., "Towards Automated Retrieval of Reusable Software Components," in Workshop Notes of AAAI-92 Workshop on Artificial Intelligence and Automated Program Understanding, San Jose, California, pp. 85-88, 13 July 1992.

Pratt, D.R., Zyda, M.J., Mackey, Randy, L., and Falby, J.S., "NPSNET: A Net-worked Vehicle Simulator with Hierarchical Data Structures," in the Proceedings of the IMAGE VI Conference, Scottsdale, Arizona, 14-17 July 1992.

Stascavage, J.F. and Lee, Y., "BOILERMODEL: A Qualitative Model-Based Reasoning System Implemented in Ada," in Proceedings of the Tenth Annual National Conference on Ada Technology, pp. 337-356, Arlington, Virginia, 24-27 February 1992.

Volpano, D.M., "A New Programming Language," in the Proceedings of the DARPA Software Technology Conference, Los Angeles, CA, pp. 97-101, April 1992, (with D. Gries).

Wilson, Kalin, P., Zyda, M.J., and Pratt, D.R., "NPSGDL: An Object Oriented Graphics Description Language for Virtual World Application Support," in the Proceedings of the Third Eurographics Workshop on Object-Oriented Graphics, Champery, Switzerland, 28-30 October 1992.

Wu, T., "Visual Query Language for Relational Databases," Proceedings of DS-5 Conference on Semantics of Inter-Operable Database Systems, Lorne, Australia, Vol. 2, pp. 46-59, November 1992.

Zyda, M.J., Pratt, D.R., Monahan, J.G., and Wilson, K.P., "NPSNET: Constructing a 3D Virtual World," in Computer Graphics, Special Issue on the 1992 Symposium on Interactive 3D Graphics, MIT Media Laboratory, pp. 147-156, 29 March - 1 April 1992.

Zyda, M.J., "NPSNET Digest: A Look at a 3D Visual Simulator for Virtual World Exploration and Experimentation," in The 1992 EFDPMA Conference on Virtual Reality, Washington, DC, 1-2 June 1992.

CONFERENCE PRESENTATIONS

Berzins, V., Luqi, and Lee, Y., "Applications and Meaning of Inheritance in Software Specifications," in Proceedings of the 25th Hawaii International Conference on System Sciences, Kauai, Hawaii, pp. 64-73, 7-10 January 1992.

Brutzman, D.P., Compton, M.A., and Kanayama, Y., 1992c"Autonomous Sonar Classification Using Expert Systems," in Proceedings of the IEEE Oceanic Engineering Society Conference OCEANS 92, Newport, Rhode Island, 26-29 October 1992.

Guglielmo, E. and Rowe, N., "Natural Language Processing of Captions for Retrieving Multimedia Data, Conference on Applied Natural Language Processing, Trento, Italy, April 1992, an extended form was published as Naval Weapons Center (now Naval Air Warfare Center, Weapons Division) Technical Publication NWC TP 7203, December 1991.

Guglielmo, E., Ntoka, N., and Rowe, N., "A Prototype Decision Support System and Multimedia Database for Command and Control, 9th Annual Decision Aids Conference, Monterey, CA, June 1992.

Hsiao, D. K., a talk on "A Brief History of Research and Development of Database Machines," Daejeon, South Korea, April and June 1992.

Hsiao, D.K., a talk on "A Recent Advances in Database Software and Hardware Technologies," Tokyo, Japan, April and June 1992.

Hsiao, D.K., a talk on "Conceptual Designs for Database Applications," Kyoto, Japan, April and July 1992.

Hsiao, D.K., a talk on "The Object-Oriented Database Management - A Tutorial on Its Fundamentals," Kyoto, Japan, April and June 1992.

Hsiao, D.K., a talk on "Database Security - A Tutorial on Its Fundamentals," Kyoto, Japan, April and June 1992.

Hsiao, D.K., "An Object-Oriented Approach to Security Policies and Their Access Controls for Database Management," Proceedings of the Second Far-East Workshop on Future Database Systems, Kyoto, Japan, April 1992.

Hsiao, D.K., "The Object-Oriented Database Management," Proceedings of the Second Far-East Workshop on Database Systems, Kyoto, Japan, April 1992.

Hsiao, D.K., a talk on "Federated Databases and Systems - A Tutorial," Tokyo, Japan; Daejeon, South Korea, April and June 1992.

Kanayama, Y., "Architectural Consideration for Real-Time Control System and Simulator," Workshop on Architectures for Intelligent Control Systems, IEEE International Conference on Robotics and Automation, Nice, France, pp. 30-31, May 10, 1992.

Kwak, S.H., McKeon, J.B., Clynch, J.R., and McGhee, R.B., "Incorporation of Global Positioning System into Autonomous Underwater Vehicle Navigation," Proceedings of 1992 IEEE Symposium on Autonomous Underwater Vehicle Technology, Washington, DC, pp. 291-297, 2-3 June 1992.

Lee, Y. and Bonsignore, J., "Underwater Multi-Dimensional Path Planning, in Proceedings of the Tenth Annual National Conference on Ada Technology, Arlington, Virginia, pp. 357-360, 24-27 February 1992.

Lee, Y. and Luqi, "Controlling an Autonomous Underwater Vehicle Using an Expert System," in Proceedings of the Second International Conference on Automation, Robotics and Computer Vision, Singapore, pp. AI-3.6.1-6, 15-18 September 1992.

Lee, Y. and Bonsignore, J., "Imprecise Orientation for Multi-Dimensional Path Planning," in the First International Conference on Fuzzy Theory & Technology, Durham, North Carolina, 14-18 October 1992.

Locke, J., Pratt, D.R., and Zyda, M.J., "Integrating SIMNET with NPS Using a Mix of Silicon Graphics and Sun Workstations," working paper to Conference on the Interoperability of Defense Simulators, Orlando, Florida, 17 - 19 March 1992.

Lundy, G.M., "An Algorithm for Improving Security in FDDI," in Proceedings, Optical Engineers/Fibers 92, Boston, Mass.

Luqi and Lee, Y., "Towards Automated Retrieval of Reusable Software Components," in Workshop Notes of AAAI-92 Workshop on Artificial Intelligence and Automated Program Understanding, San Jose, California, pp. 85-88, 13 July 1992.

Pratt, D.R., Zyda, M.J., Mackey, Randy, L., and Falby, J.S., "NPSNET: A Net-worked Vehicle Simulator with Hierarchical Data Structures," in the Proceedings of the IMAGE VI Conference, Scottsdale, Arizona, 14-17 July 1992.

Shimeall, T.J., "The Use of Self-checks and Voting in Software Error Detection: A View from Experimentation," Oregon Graduate Center, 22 May 1992, distinguished lecture.

Shimeall, T.J., "An Exploration of the Failure Behavior of Software Faults," Portland State University, May 25, 1992, distinguished lecture.

Stascavage, J.F. and Lee, Y., "BOILERMODEL: A Qualitative Model-Based Reasoning System Implemented in Ada," in Proceedings of the Tenth Annual National Conference on Ada Technology, pp. 337-356, Arlington, Virginia, 24-27 February 1992.

Volpano, D.M., "A New Programming Language," in the Proceedings of the DARPA Software Technology Conference, Los Angeles, CA, pp. 97-101, April 1992, with D. Gries.

Volpano, D.M., "Basic Polymorphic Type Inference with Overloading," Formal Aspects of Computing, British Computer Society, August 1992.

Volpano, D.M., "Parametic Polymorphism and Overloading in Programming Languages," University of North Texas, Denton, TX, 13 April 1992.

Volpano, D.M., "Type Inference in Polya," Cornell University, Ithaca, NY, 19 July 1992.

Wilson, Kalin, P., Zyda, M.J., and Pratt, D.R., "NPSGDL: An Object Oriented Graphics Description Language for Virtual World Application Support," in the Proceedings of the Third Eurographics Workshop on Object-Oriented Graphics, Champery, Switzerland, 28-30 October 1992.

Wu, T., "Dataflow Query Language," Presentation at International Federation for Information Processing Working Group 2.6 Meeting, Monterey, CA, 6-8 July 1992.

Wu, T., "Visual Query Language for Relational Databases," Proceedings of DS-5 Conference on Semantics of Inter-Operable Database Systems, Lorne, Australia, Vol. 2, pp. 46-59, November 1992.

Zyda, M.J. and Pratt, D.R., "NPSNET: LHD-1 Landing Script," on an ACM SIGGRAPH Video Review, Vol. 70, July 1992, entitled "Visualization Software: The State of the Art."

Zyda, M.J., Pratt, D.R., Monahan, J.G., and Wilson, K.P., "NPSNET: Constructing a 3D Virtual World," in Computer Graphics, Special Issue on the 1992 Symposium on Interactive 3D Graphics, MIT Media Laboratory, pp. 147-156, 29 March - 1 April 1992.

Zyda, M.J., "The Software Required for the Computer Generation of Virtual Environments," in The 1992 Virtual Reality Conference, Washington, DC, 1-2 December 1992.

Zyda, M.J., "The Software Required for the Computer Generation of Virtual Environments," The 124th Meeting of the Acoustical Society of America, New Orleands, Session 5aPP on "Psychological and Physiological Acoustics and Architectural Acoustics: Virtual Environments VI - Multichannel Considerations, 31 October - 4 November 1992.

Zyda, M.J., Attended SIGGRAPH '92, Chicago, participated in course entitled "Immersive Virtual Environments," 26-31 July 1992.

Zyda, M.J., "NPSNET: Terrain Visualization Year 4," given at the HQDA AI Proponency Conference, Rockville, MD, 3-4 June 1992.

Zyda, M.J., "NPSNET Digest: A Look at a 3D Visual Simulator for Virtual World Exploration and Experimentation," in The 1992 EFDPMA Conference on Virtual Reality, Washington, DC, 1-2 June 1992.

Zyda, M.J., "NPSNET: Physically-Based Modeling Enhancements to an Object File Format," presentation with Dave Pratt at Computer Animation '92, Geneva, Switzerland, 18 May - 23 May 1992.

Zyda, M.J., "Local Arrangements Chair for SIGHI '92, Monterey, 30 April - 8 May 1992.

Zyda, M.J., "NPSNET: Constructing a 3D Virtual World," Presentation at the 1992 Symposium on Interactive 3D Graphics, 29 March - 1 April 1992.

Zyda, M.J., "NPSGDL: An Object Oriented Graphics Description Language for Virtual World Application Support," Third Eurographics Workshop on Object-Oriented Graphics, Champery, Switzerland, 28-30 October 1992.

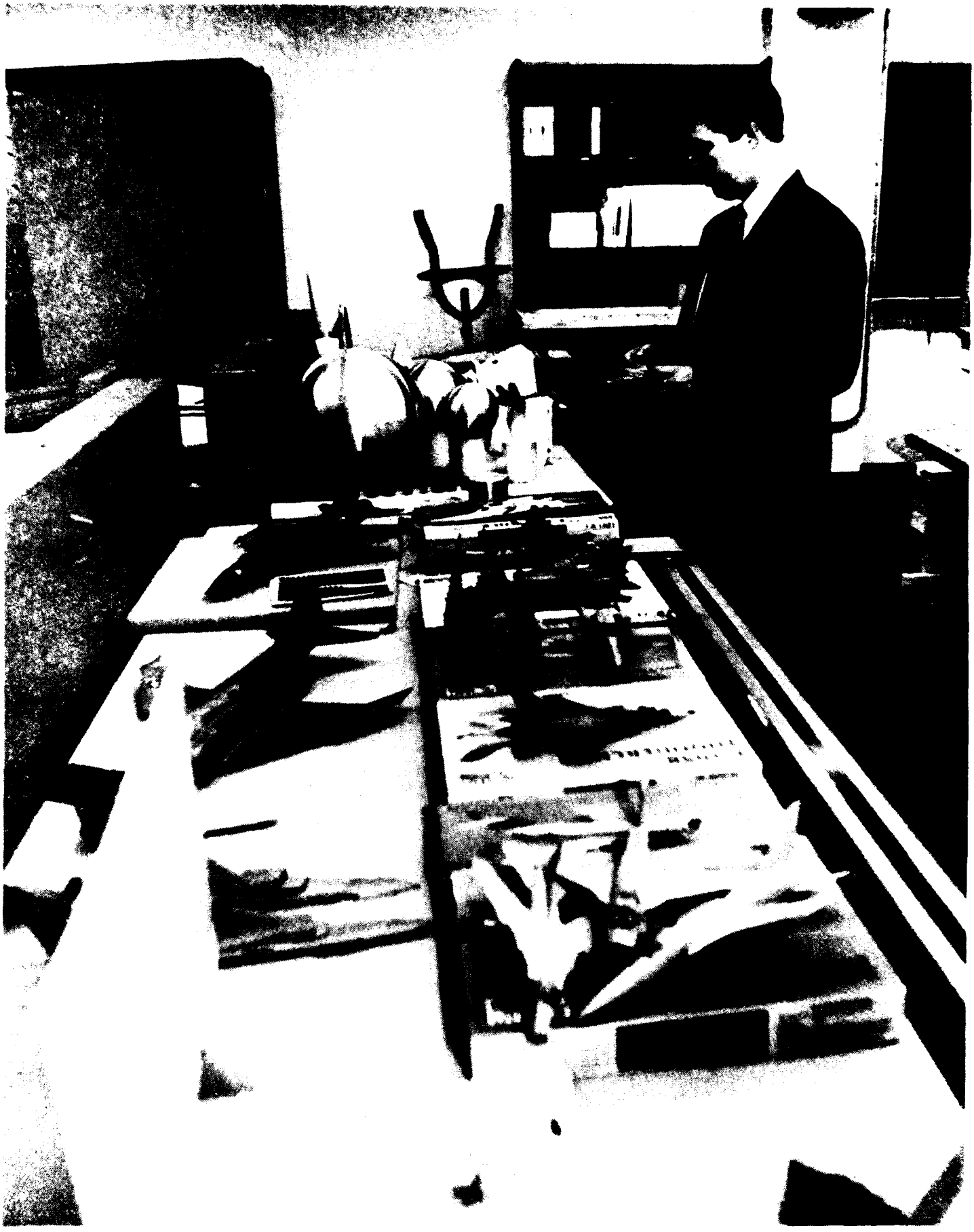
Zyda, M.J., "NPSNET: Latest Progress," Sixth Workshop on the Interoperability of Defense Simulations, Orlando, Florida, 17-19 March 1992.

BOOK CONTRIBUTIONS

Zyda, M.J., Monahan, J.G., and Pratt, D.R., "NPSNET: Physically-Based Modeling Enhancements to an Object File Format," chapter in Creating and Animating the Virtual World, Editors: Nadia Magnenat Thalmann and Daniel Thalmann, Publisher: Springer-Verlag Tokyo, pp. 35-52., 1992.

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

Professor M.A. Morgan
Chairman



DEPARTMENT OF
ELECTRICAL AND COMPUTER ENGINEERING

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

Research topics span the following areas: Communications, Computer Engineering, Electromagnetics, ElectroOptics, Electronic Systems, Power Systems, Radar and Electronic Warfare, Signal Processing, Systems and Controls, and Underwater Acoustics. The following compendium categorizes each research project into one of the above areas. Some research projects involve one or more of these areas, although they are listed here in only one category. Where projects are externally or partially externally funded, that is noted in the summary. There is a strong interaction between the department's teaching and research programs, both by the incorporation of the latest research into courses and by the involvement of graduate students in the projects, as indicated by the numbers of theses completed.

COMMUNICATIONS

Professor Tri Ha is working on a multi-year project to study the performance of various types of frequency-hopped spread spectrum receivers suitable for satellite communication in low earth orbits. The work has resulted in two presentations to MILCOM 92.

Professor Alex Lam is investigating M-ary optical code-division multiple-access (CDMA) communications with avalanche photodiode detectors. This research has resulted in two journal papers and one conference paper.

Professor Lam is also involved in a project whose goal is to investigate wavelet transforms and time-frequency analysis of signals. This project has received funding from SPAWAR 40. The work has resulted in two MS theses.

Professor Lam has also been working with Sawasd Tantaratana, of the Univ. of Mass. in an investigation of fast sequential acquisition schemes and system performance of spread-spectrum systems with complex signature sequences. This project has produced one journal paper, two conference papers, and one MS thesis.

Professor Paul Moose is pursuing the accreditation of one or more numerical computer models to assess the effects of nuclear bursts on the satellite communications links between ground stations and the UHF Follow-On Satellite Stations. The work is funded by OPTEVFOR and has produced one MS thesis.

Professor Clark Robertson is engaged in a project whose goal is to determine the Electronic Counter-Counter Measures (ECCM) potential of various FFH/MFSK communications systems under conditions of worst case hostile Electronic Counter Measures (ECM) and fading channels. Three papers, three conference papers, and one MS thesis have resulted from this work.

Professors Robertson and **Ha** are working on a project funded by the U. S. Coast Guard Research and Development Center to determine what Open System Interconnection (OSI) data communication protocols can be used to provide effective and efficient data communications for radio-based maritime mobile services (including satellite systems).

Professor Richard W. Adler is continuing in the fourth year of an extramurally funded project to conduct numerical analysis and experimental research in support of the Navy's requirement to site VLF through UHF communication antenna systems and support equipment in non-ideal locations such as polar and equatorial regions containing rugged terrain. In addition, a program of support for investigating the radiowave propagation characteristics of the polar (high-latitude) and the equatorial ionosphere was initiated in 1990 and continued in 1992.

Professor Adler is also engaged in an externally funded project to evaluate the viability of using active (amplified) antennas to receive weak signals in the strong-signal environment at Navy HF SIGINT sites worldwide.

Professor Adler is engaged in another externally funded project to develop techniques and methodology for identifying and locating radio noise sources at Navy HFDF receiving sites worldwide. An automated Performance Evaluation Technique (PET) was initiated for improving the efficiency of HFDF site surveys that are conducted. A method of predicting the signal environment that can be expected at HFDF sites is under development and will reduce the labor-intensive measurements that are currently required for site performance surveys.

COMPUTER ENGINEERING

Professors Jon Butler and **Chyan Yang** have been working jointly on a project to 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. This work has resulted in the porting of a computer-aided design (CAD) method for multiple-valued circuits developed in the previous two years of this project to a parallel computer, IPSC/2 (Intel Personal Supercomputer). Also, a new minimization approach to the design of multiple-valued programmable logic arrays has been produced. This project has resulted in the production of one journal paper and three conference papers, as well as two theses.

Professor Douglas Fouts is studying design principles for very high-speed digital circuits in this NPS funded Research Initiation Project. Gallium arsenide (GaAs) digital integrated circuits (ICs) have the potential to increase the speed of computers and digital systems by up to half an order of magnitude. However,

GaAs-implemented systems lose much of their raw speed in the interconnections between ICs and subsystems. This research proposes to study both high-speed chip-to-chip interconnection networks and networks for interconnecting high-speed digital subsystems, and to develop new circuits, implementation techniques, and design guidelines that will allow systems to take full advantage of the inherent speed of GaAs logic. This work has produced one journal paper, one conference paper, and one MS thesis.

Professor Fouts is also engaged in a newly funded project by SPAWAR 40, the first phase of which is to test existing GaAs dynamic logic circuits, especially Two-Phase Dynamic Logic (TDFL), for susceptibility to radiation-induced single event upsets (SEUs). With this information, predictions can be made about the number of SEUs that might occur in a specified amount of time for a circuit exposed to a specified level of radiation. Based on the information gained, it will be possible to estimate the amount of redundancy required to make a circuit or system tolerant of SEUs for a specified level of radiation. The preferred method for providing SEU tolerance is to add redundancy at the circuit level, thus freeing the logic designer and the system architect from having to worry about SEUs. Therefore, the second part of the proposed research is to develop dynamic logic circuits that are tolerant of SEUs. The simulation of a new circuit is not a sufficient test before using the circuit in a system, especially if the system is in space. Therefore, the third part of this research will be to lay out, fabricate, and radiation test circuits that simulate successfully. The work has resulted in one conference paper, two presentations and three MS theses.

Professor Herschel Loomis, Mr. Ray Bernstein and **Visiting Professor Michael Melich** (Space Systems) have been conducting externally funded research into computer algorithms and architectures for the processing of tactical information. A major activity was the participation in the data collection experiment on commercial shipping in a "Chokepoint," the English Channel. This project has produced four MS theses.

Professor Shridhar Shukla has been working on a two-year project to develop a framework for mapping hard real-time applications on loosely coupled multiprocessors to guarantee performance. The emphasis is on task allocation to minimize contention-based communication cost and on contention-free message routing. This project has produced one paper which is currently undergoing revision.

Professors Shukla, Yang, and **Amr Zaky** (Computer Science) have been working on a NAVSEA funded project on compile-time support for the processing graph methodology on the AN/UYS-2 parallel signal processor. The goal of this continuing project is to develop a methodology for determining the optimal chains of primitives in processing graph methodology (PGM) applications running on the AN/UYS-2. The project has resulted in two MS theses and in one conference paper.

Professor Shukla is also involved in a research project which deals with the design and implementation of the primitives required to manage the communication and reconfiguration in robust distributed, real-time combat platforms. This work has resulted in one MS thesis.

ELECTROMAGNETICS

Professor Jeffrey Knorr has been engaged in a continuation of research on circuit modeling for microwave computer-aided-design. The objective of this project is to complete the development of a circuit model for the inductive strip in homogeneous finline, to begin development of a circuit model for the inductive strip in inhomogeneous finline and to conduct experiments to validate the models.

Professor Ramakrishna Janaswamy is investigating new techniques for widebanding VHF wire antennas over the frequency range 30--90MHz for digital radio applications. The project is funded by the U. S. Army CECOM and has resulted in the preparation of a technical report and one MS thesis.

Professor Janaswamy is also working on a project to develop a computer model for predicting HF wave propagation over two and three dimensional terrain for siting antenna systems under varying terrain situations. The work is supported by the Naval Security Group Command and has produced two journal articles and one conference presentation and abstract.

Professor David Jenn is performing research to develop accurate analytical models and computer codes for various complex microwave antennas and scatterers. The models are used in the design and evaluation of high performance radar, communication and EW systems. All aspects of electromagnetic design are considered: radiation from antennas, electromagnetic compatibility between system components, and radar cross section prediction and control. One journal paper is in press and two conference presentations and five MS theses have resulted from this work.

Professor Hung-Mou Lee is investigating 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. His research has produced two conference papers.

Professor Hung-Mou Lee is also improving the execution speed and accuracy of the m-Layer program. The m-Layer program developed by NCCOSC predicts ducting effects of over-the-horizon EM propagation when the mean atmospheric profile over the propagation path can be considered as vertically stratified. This project converted the extended precision algorithm for the representation of large numbers into complex logarithmic format and improved the Airy function evaluation algorithm. A consistency checking procedure was also implemented to reduce the precision requirement on the eigenvalues and to assure the accuracy of the mode eigenfunctions. The execution speed of the program is also improved substantially. The work is funded by NCCOSC and has resulted in one accepted journal article, one conference presentation, one technical report and two MS theses.

Professor Hung-Mou Lee is also working to produce an accurate computer program for validating other numerical electromagnetic computation codes in work funded by NCCOSC. The electromagnetic scattering from a zero-thickness, perfectly conducting, circular, tubular cylinder of finite length with different anisotropic coatings on its inside and outside surfaces will be investigated. The

principal axes of the surface impedance tensors lie along the axial and the circumferential directions of the cylinder. The induced electric and magnetic surface current densities and the far field will be obtained. Analytical expressions of the double series expansion coefficients of the kernels of the integral-differential equations of this problem will be obtained and utilized to assure that extremely accurate numerical results can be obtained. These results will be used as a standard for valfdating numerical electromagnetic computation codes. One conference presentation has been accepted relating to this work.

Professor Michael A. Morgan is evaluating the viability for radar cross section reduction using active counter-EMF cancellation. The concept is based upon the electromagnetic equivalence theorem wh.'ch indicates that a surface current distribution can be found which ideally cancels the scattered radar signal in all directions. Implementation of this concept is limited to use of discrete approximations to the ideal distribution. This project seeks to quantify approach and its performance in the real world through initial computer modelling with some experimentation in the second-year.

Professors Morgan and **Robertson** are conducting an engineering antenna design study as well as fabricating and testing of a prototype ultra-wideband impulse receiving antenna. The unique antenna has low pulse dispersion and a relative bandwidth exceeding 100:1. This work is funded by the U.S. Army CECOM Signals Warfare Directorate. The design is complete and fabrication of an initial prototype is on schedule for completion in early 1993.

Professor Robertson is also working on a project funded by NAVMIC whose purpose is to develop a set of user friendly mathematical applications capable of computing the radiation pattern and other pertinent antenna parameters of an antenna or antenna system based on available information. The work has resulted in one MS thesis.

ELECTRO-OPTICS

Professor John Powers is studying the predicted propagation properties of transient acoustic and optical waves in an effort to understand the propagation of very short duration waves and to use such waves in imaging applications. One presentation and two MS theses have been produced by this work.

Professor Ron Pieper is working to analyze the depth-of-focus for incoherent periodic sources using the optical visibility as a criterion. The original direction of this work has been shifted from the theoretical to somewhat more practical considerations in which the visibility concept is applied to generate a performance measure for thermal imaging systems. The research has produced one journal paper and one conference paper.

ELECTRONIC SYSTEMS

Professor Alan Kraus is working on a project funded by the Commanding Officer, Aviation Supply Office to assure the reliability, operability and

maintainability of the electronic boxes in the C2 aircraft by performing detailed thermal analyses to obtain temperature maps of the components in each box.

Professor Kraus is also engaged in a project to investigate the range of skin temperatures of the PANSAT Vehicle between the sunlight and shadow orbit zones. A finite difference model was constructed, the analysis was completed and a report was written. The work was supported by SPAWAR.

Professor Murali Tummala is working on the modernization of Coast Guard's LORAN-C tube transmitters by developing techniques for automatic pulse shaping and monitoring. The project is funded by the Electronics Engineering Center of the Coast Guard and has resulted in one conference paper and one MS thesis.

Professor Sherif Michael is developing the process for On-Orbit Annealing of Satellite Solar Panels in this externally funded project. 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 Photovoltaic current annealing processes and other related topics of radiation effects on GaAs, InP, and Si devices. The research has produced one conference paper and one MS thesis.

Professor Michael is also studying radiation insensitive semiconductor networks with the objective of applying the new Composite OPAMP techniques for radiation hardening of analog networks using the NPS Linear Accelerator. One conference paper and presentation and one MS thesis have been produced by this work.

Professor Michael is also conducting research on the design and development of low-sensitivity analog building blocks to be utilized in switched capacitor network implementations.

POWER SYSTEMS

Professor Robert Ashton is working to implement a computer controlled system which at least in part can actively compensate for harmonics in a power system with only the knowledge of the bus voltage. The work has resulted in one conference paper.

Professor Sherif Michael is involved in a project to investigate and develop a hybrid power system utilizing solar systems, wind generator systems, and thermo-electric generator systems to power remote communication stations in Alaska.

Professors Michael and **Ashton** are working to design and modify a power distribution panel of an existing communication system to provide the capability of uninterruptable operation when switching between different power sources.

Professor Stephen Williams is beginning work on a project to develop a set of metrics for evaluating power system detailed waveform analysis tools funded

by Advanmced Research Projects Agency (ARPA). The scope of shipboard electrical system problems must be defined. From this class of problems, a set of applicable analytic methods for estimating system electrical performance are identified. During the period of research, one such tool will be parametrically evaluated for its potential usefulness in predicting the performance of shipboard electrical systems. The work has produced a technical report and an MS thesis.

Professor Williams is also working to assess the importance of load input impedances on the shipboard 155 VDC combat power bus. The objectives are to develop a criterion for establishing system stability based upon a minimum knowledge of system parameters and to formulate a control approach which ensures system stability under widely varying conditions. The project is funded by Naval Surface Warfare Center and has produced a technical report.

Professor Williams is also doing research to verify component design in a proposed new shipboard electric plant scheme. The project is funded by Naval Surface Warfare Center and has produced one technical report to the sponsor.

RADAR AND ELECTRONIC WARFARE

Professor Phillip Pace is conducting research to theoretically and experimentally investigate a new modified residue preprocessing architecture to enhance the resolution performance of high speed analog-to-digital converters (ADCs). This is the first part of a continuing project that is expected to continue for one or more years. One journal publication and one conference presentation has resulted from this work.

SIGNAL PROCESSING

Professor Jeffrey Burl is conducting research on dynamic image processing in the spatial frequency domain using the extended kalman filter. The processing of image sequences containing a moving object was investigated in this research. An algorithm based on the extended Kalman filter was proposed. The algorithm was developed and applied to some sample image sequences to evaluate its performance. This performance was compared with that of other algorithms found in the literature. As part of this research project, he and his students developed software for implementing all of the major image motion analysis algorithms currently available.

Professor Monique Fargues is conducting research into tracking sources using the rank revealing QR factorization. The goal of this project is to investigate the application of the Rank Revealing QR (RRQR) factorization to compute the signal information, and to take advantage of the simplicity of the QR update to track moving sources. Two conference papers and one MS thesis have been published.

Professors Fargues and **Cristi** are engaged in a project whose goal is to investigate the applications of reduced-rank autoregressive (AR) modeling techniques to identification of biological underwater sounds. The work has

produced one MS thesis.

Professors Fargues and **Hippenstiel** are investigating the properties of wavelets as they relate to underwater surveillance detection and identification problems. The research has produced UWB detection software and one MS thesis.

Professors Fargues and **Hippenstiel** are also investigating advanced processing techniques to automatically detect and classify certain short duration signals in a new study funded by the U. S. Army CECOM and just begun in October 1992.

Professor Ralph Hippenstiel is investigating the use of the Instantaneous Power Spectrum (IPS) and a cumulant based modification of IPS to extract detection/classification clues from time-frequency representations. The research is funded by NCCOSC and has produced a technical report, usable detection software and one MS thesis.

Professor Chin-Hwa Lee has been working on computer aided VLSI design for tactical image processing. In this research, image processing algorithms have been implemented directly onto ASIC chips using programmable gate arrays. Nonlinear algorithms such as dynamic programming and simulated annealing are studied and implemented. Emphasis is concentrated on an integrated CAD environment using the VHDL for ASIC chip design and modeling. Particular interests are in the behavioral modeling of programmable VLSI chips with timing elements. This research has resulted in one conference presentation, and one MS thesis.

Professor Chin-Hwa Lee is also studying the application of image processing to sensor data in this externally funded research. In this research, image processing techniques applied to sensor data are being studied. The dynamic programming and simulated annealing techniques for image processing have already been studied. 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 be compared. One conference presentation and one MS thesis have been produced.

Professors Therrien and **Tummala** are doing research in multidimensional signal processing, investigating the development of iterative algorithms for block matrix equation solution for multidimensional spectral analysis and other applications and studying transient signal modeling and classification. The research has generated two journal papers and one MS thesis.

Professor Tummala is also working on the application of time series modeling techniques to aircraft EMP test data for data compression and storage, and synthesis of strength waveforms by combining several test point responses. The project is funded by the Naval Air Warfare Center, Patuxent River, MD, and has produced one MS thesis.

Professors Herschel Loomis and **M. Soderstrand** (Visiting) and **R. Bernstein** have been performing advanced signal processing studies funded by the Secretary of the Air Force. They have been investigating advanced signal processing algo-

rithms and architectures for the detection and characterization of broadband communications signals in noise and interference. A workshop on cyclostationary signals and processing was held at NPS in April 1992. One journal paper (in press), two conference papers, and three theses were produced.

SYSTEMS AND CONTROL

Professor Jeffrey Burl is studying sensor and actuator placement for large space structure control. An H controller was synthesized for a simulated space station. Simulated annealing, gradient descent, and an algorithm based on the influence coefficients of the Karhunen-Loeve transform were investigated as methods of optimizing actuator placement. The signal processing software for the LACE dynamics experiment was completed. This experiment measured the structural dynamics of a satellite on orbit. This experiment provides valuable data on the accuracy of large space structure models which has an important influence on the design of LSS controllers and their sensitivity to actuator placement.

Professor Roberto Cristi is pursuing a project which aims at the design of a control system for rapid pointing of an antenna for EHF satellite communication. Primary objective is the estimation of offsets due to installation and construction tolerances, which affect the extremely tight pointing tolerance of two degrees. This the first part of a two year project, to be completed in FY 1993. The project is funded by NISE West, Vallejo, CA, and has produced a technical report which is in preparation.

Professor Hal Titus is conducting research on the use of an Extended Kalman Filter to track the fence data. It will be compared with the present batch processing results and against targets of known orbit. Maneuver and atmospheric sensing and glitch rejection algorithms will be developed. Real time tracks with their own covariance ellipsoids will be displayed. This project is being funded by NAVSPASUR.

Professor Titus is also developing a Kalman filter torpedo tracking program under NUWES funding which incorporates the acoustic data and the torpedo's INS data as well. The work has generated one MS thesis.

Professor Titus is also conducting research with funding from the U.S. Army and Space Intelligence Center whose purpose is to support the Crossbow Committee and several of their intelligence teams. He studied and simulated several Soviet missiles and attempted to develop techniques to counter them.

UNDERWATER ACOUSTICS

Professor James H. Miller is working with Professors Ching-Sang Chiu and Robert Bourke of Oceanography analyzing the results of the Barents Sea experiment. The goal of this experiment was to determine the feasibility of conducting tomography in the Barents Sea and to investigate space-time coherence of the acoustic field. In August 1992, NPS and Woods Hole Oceanographic Institution deployed a set of acoustic sources and receivers including the NPS

vertical array to tomographically image the Barents Sea Polar Front. In addition to the scientific goals, the Barents Sea is a Navy-relevant geographical area and understanding the acoustic propagation is important to ASW activities. The project has resulted in one journal paper and two MS theses.

Professors Miller and **Chiu** are also working on a project whose goal is the determination of source range and depth in an ocean acoustic waveguide given a time domain representation of a source-generated signal. The research has produced one journal article, one conference presentation and two MS theses.

Professor Charles Therrien is developing new technology for modeling and classifying passive sonar signals in this project funded by NUSC. The work has resulted in one PhD Dissertation, two MS theses, one technical report and a workshop presentation.

Professor Therrien is also conducting research whose aim is to develop ARMA signal models for some specific sonar data sets of interest to ARPA contractor ORINCON and to transfer the modeling technology to ORINCON and ARPA for their possible use in the DANTES program.

Professor Lawrence Ziomek is engaged in research to generalize the Recursive Ray Acoustics (RRA) Algorithm, which is funded by NAVSEA. The RRA Algorithm is a simple, fast, and accurate algorithm that can be used to compute the position, angles of propagation, travel time, and path length along a ray path and to draw ray trace plots for speeds of sound that are functions of all three spatial variables. Investigation of the possibility of performing sound-pressure level calculations using the RRA Algorithm is also being undertaken. The work has resulted in a paper, a conference presentation and a half-day tutorial.

AN ADAPTIVE ESTIMATION TECHNIQUE FOR CONTROLLING ACTIVE POWER LINE CONDITIONERS

Robert W. Ashton, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Research Initiation Program
Funding: Naval Postgraduate School

OBJECTIVE: To implement a computer controlled system which at least in part can actively compensate for harmonics in a power system with only the knowledge of the bus voltage.

SUMMARY: Due to the proliferation of power electronics devices in recent years, the amount of harmonic current injected into the power system is on the increase causing undesirable voltage waveform distortion. This distortion can cause additional losses in switchgear, rotating machines and transformers. Induction machines may vibrate due to parasitic torques or not develop sufficient starting torque. Capacitors will age faster due to excessive dielectric losses and stress The goal of this research is to implement a system which can at least in part cancel harmonic currents in a power system with only the knowledge of the distorted bus voltage. The power system characteristics are established through an adaptive estimation technique which feeds and Active Power Line Conditioner with the proper control information through an iterative process. The adaptive estimation system could also be used to supply power to a number of DC loads while at the same time compensating harmonics on a source AC bus. The whole system is controlled using a personal computer making it flexible to the needs of a particular power system.

PUBLICATIONS: R.W. Ashton, and A.E. Emanuel, "An Adaptive Estimation Method for Harmonic Voltage Minimization by Means of Line Conditioners," IEEE-PES, Summer Meeting, Paper 91 SM 307-9 PWRD, San Diego, CA, July 1991.

ON THE USE OF MULTIPLE-VALUED LOGIC IN THE DESIGN OF DIGITAL SYSTEMS

Jon T. Butler, Professor
Chyan Yang, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Research Laboratory
Funding: Naval Postgraduate School

OBJECTIVE: Development of 1) design techniques for compact multiple-valued circuits, and 2) parallel techniques for use on parallel computers in the design and analysis of multiple-valued programmable logic devices.

SUMMARY: At the point of this writing, no salaries have been expended on this project. However, we have succeeded in implementing a parallel version of a simulated annealing minimization algorithm produced nine months ago on a serial machine. Specifically, we have implemented the algorithm on eight SUN workstations configured as a

multiprocessor with one processor as the master. This particular implementation could use such a system, since there is little coupling between processes. Our results are preliminary, but we have shown that eight processors are beyond the point of diminishing returns for the quality of the solution as it depends on the number of processors.

PUBLICATIONS: Schueller, K.A. and J.T. Butler, "On the Design of Cost-Tables for Realizing Multiple-Valued Circuits," *IEEE Transactions on Computers*, February 1992, pp. 178--189; this is an extended version of K.A. Schueller, P.P. Tirumalai, and J.T. Butler, "Analysis of the Cost Table Approach to the Design of Multiple-Valued Circuits," Proceedings of the 1986 International Symposium on Multiple-Valued Logic, May 1986, pp. 42--50.

Dueck, G.W., R.C. Earle, P.P. Tirumalai, and J.T. Butler, "Multiple-Valued Programmable Logic Array Minimization by Simulated Annealing," Proceedings of the International Symposium on Multiple-Valued Logic, May 1992, pp. 66--74.

Sasao, T. and J.T. Butler, "On the Analysis of an FPGA Architecture," Proceedings of the International Symposium on Logic Synthesis and Microprocessor Architecture, July 1992, pp. 162--168.

Yang, C. and O. Oral, "Experiences of Parallel Processing with Direct Cover Algorithms for Multiple-Valued Logic Minimization," Proceedings of the International Symposium on Multiple-Valued Logic, May 1992, pp. 66-74.

CONFERENCE PRESENTATIONS: Butler, J.T., "Multiple-Valued Programmable Logic Arrays," California State University -- Fresno, March 6, 1992. J.T. Butler, "Multiple-Valued Programmable Logic Array Minimization by Simulated Annealing," International Symposium on Multiple-Valued Logic, May 27, 1992.

Butler, J.T. and S.W. Butler, "Profiles of Topics and Authors of the International Symposium on Multiple-Valued Logic for 1971--1991," International Symposium on Multiple-Valued Logic, May 28, 1992.

Butler, J.T., "Experiences of Parallel Processing with Direct Cover Algorithms for Multiple-Valued Logic Minimization," International Symposium on Multiple-Valued Logic, May 27, 1992.

Butler, J.T., "On the Analysis of an FPGA Architecture," International Symposium on Logic Synthesis and Microprocessor Architecture, July 15, 1992.

Butler, J.T., "CAD Tools for Multiple-Valued Circuits," International Workshop on Post-Binary ULSI Systems, May 30, 1992.

SEMINAR PRESENTATIONS: Butler, J.T., "Multiple-Valued Programmable Logic Arrays," Naval Postgraduate School, Monterey, CA, March 11, 1992 (as part of a class taught by C. Yang).

Butler, J.T., "Multiple-Valued Programmable Logic Arrays," Kyushu Institute of Technology, Iizuka, Kyushu, Japan, July 6, 1992.

THESES DIRECTED: Earle, R.C., LT, USN, "Minimization of Multiple-Valued Programmable Logic Array Using Simulated Annealing," Master's

Thesis, December 1991.

Yildirim, C., LT, Turkish Navy, "Multiple-Valued Programmable Logic Array Minimization by Concurrent Multiple and Mixed Simulated Annealing," Master's Thesis, December 1992.

AUTOMATIC CONTROL OF AN EXTREMELY HIGH FREQUENCY ANTENNA

Roberto Cristi, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: NISE West (formerly NAVELEX), Vallejo, CA
Funding: NISE West

OBJECTIVE: This project aims at the design of a control system for rapid pointing of an antenna for EHF satellite communication. Primary objective is the estimation of offsets due to installation and construction tolerances, which affect the extremely tight pointing tolerance of two degrees. This the first part of a two year project, to be completed in FY 1993.

SUMMARY: A mathematical model for the effects of the offsets in installation has been devised, based on Euler parameter approach. It turns out that this approach allows the application of standard linear algebra technique for the estimation and correction of the various errors. Computer programs have been written for simulation and analysis, and are in the process of being tested on real data. Problems of ill conditioning call for particular solution techniques least sensitive to computational errors.

PUBLICATIONS: Cristi, R., and W.D. Riling, "The Application of Euler Parameter Techniques to the Estimation and Correction of Offset Errors in an Extremely High Frequency (EHF) Antenna," Technical Report in preparation.

TRACKING SOURCES USING THE RANK-REVEALING QR FACTORIZATION

Monique P. Fargues, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: NCCOSC, San Diego, CA
Funding: Unfunded

OBJECTIVE: The goal of this on-going project is to investigate the application of the Rank-Revealing QR (RRQR) factorization to compute the signal information, and to take advantage of the simplicity of the QR update to track moving sources.

SUMMARY: Subspace decomposition methods are a powerful tool used in different areas of Signal Processing in which the signal information is usually obtained via eigen-based or SVD-based methods. These techniques are numerically very stable but expensive to update. The RRQR factorization provides an attractive alternative to accomplish subspace selection. Last year we proposed to add an updating capability to the RRQR factorization, and applied it to the Direction Of Arrival (DOA)

problem. During 1992 we have refined the original algorithm and have improved its tracking capabilities. Simulations show the performance of the "refined" adaptive RRQR-based technique is similar to that obtained using classical eigen-based techniques.

CONFERENCE PUBLICATIONS: Fargues, M.P., "Tracking Moving Sources Using The Rank Revealing QR Factorization," 25th Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, 4-6 November 1991.

Fargues, M.P. and M.P. Ferreira, "Adaptive RRQR-Based Factorization: Improving the Algorithm Tracking Capabilities," 26th Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, 26-28 October, 1992.

THESIS DIRECTED: Ferreira, M.P., LCDR, Brazilian Navy, "Fast High-Resolution Techniques Applied to the Direction-Of-Arrival Problem," Master's Thesis, September 1992.

MODELING, DETECTION, AND RECOGNITION TECHNIQUES FOR UNDERWATER BIOLOGICAL DATA

Monique P. Fargues, Assistant Professor
Roberto Cristi, Associate Professor
Department of Electrical and Computer Engineering

OBJECTIVE: The goal of this project is to investigate the applications of reduced-rank Autoregressive (AR) modeling techniques to identification of biological underwater sounds.

SUMMARY: We have been involved in preliminary work designed to familiarize ourselves with the area. The work covered during 1992 was divided into two parts. The first part of the research investigated the use of backpropagation neural networks and reduced-rank AR models to identify biological sounds (such as humpack whale or killer whale sounds, for example). The second part of the study investigated the use of spectral distances (such as the Symmetrized Itakura distance) for biological sound classification. The digitized acoustic data used for the research was obtained from audio tapes provided by the Hopkins Marine Station of Stanford University, Pacific Grove, CA. Preliminary results have shown reduced-rank AR models to be a promising tool for biological sound classification.

THESIS DIRECTED: Vanderkamp, M., LT, USN, "Modeling and Classification of Biological Signals," Master's Thesis, December 1992, co-advisor.

DESIGN PRINCIPLES FOR VERY HIGH-SPEED DIGITAL CIRCUITS AND SYSTEMS

Douglas J. Fouts, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Research Initiative Program
Funding: Naval Postgraduate School

OBJECTIVE: Gallium arsenide (GaAs) digital integrated circuits (ICs) have the potential to increase the speed of computers and digital systems by up to half an order of magnitude. However, GaAs-implemented systems lose much of their raw speed in the interconnections between ICs and subsystems. This research proposes to study both high-speed chip-to-chip interconnection networks and networks for interconnecting high-speed digital subsystems, and to develop new circuits, implementation techniques, and design guidelines that will allow systems to take full advantage of the inherent speed of GaAs logic.

SUMMARY: New, high-speed, low-power, output driver and input receiver, bus driver and receiver, and bus transceiver circuits have been designed for interconnecting GaAs digital ICs. Simulations have shown that the use of the new circuits will increase the system speed of computers and digital systems that are implemented with GaAs logic. Full characterization of the new circuits requires fabrication and testing, but fabrication can not be accomplished at the NPS. A cooperative research and development agreement (CRDA) was being negotiated with an industrial partner who was willing to fabricate the new circuits. However, the CRDA was unsuccessful. The principle investigator is currently attempting to find alternate fabrication services. Systems applications for the new, high-speed, GaAs circuit shave been studied. The inherent radiation hardness of GaAs, together with its high speed and low power consumption, make it ideal for use in space-born systems. Recent efforts to further improve the speed-power consumption product of GaAs logic for use in space systems has focussed on dynamic logic circuits. The results of this work are very promising, and have lead to a new research grant from the Naval Research Laboratory.

PUBLICATIONS: Fouts, D.J., "A Gallium Arsenide Digital Phase Shifter for Clock and Control Signal Distribution in High-Speed Digital Systems," *IEEE Journal of Solid State Circuits*, Vol. 27, No. 5, May 1992, pp. 802--809.

Fouts, D.J. and T.C. Gonter, "A Microprocessor Interface for Ferroelectric Capacitor Memory", 26th Annual Asilomar Conference on Signals, Systems, and Computers, October 26--28, 1992.

CONFERENCE PRESENTATIONS: Fouts, D.J. and T.C. Gonter, "A Microprocessor Interface forerroelectric Capacitor Memory", 26th Annual Asilomar Conference on Signals, Systems, and Computers, October 1992.

THESIS DIRECTED: Gonter, T.C., CAPT, USMA, "A Microprocessor Interface for the NM24CF04 Serial-Access Ferroelectric Memory", Master's Thesis, December 1991.

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

Douglas J. Fouts, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Research Laboratory
Funding: SPAWAR

OBJECTIVE: The first phase of this research project is to test existing GaAs dynamic logic circuits, especially Two-Phase Dynamic Logic (TDFL), for susceptibility to radiation-induced single event upsets (SEUs). With this information, predictions can be made about the number of SEUs that might occur in a specified amount of time for a circuit exposed to a specified level of radiation. Based on the information gained, it will be possible to estimate the amount of redundancy required to make a circuit or system tolerant of SEUs for a specified level of radiation. The preferred method for providing SEU tolerance is to add redundancy at the circuit level, thus freeing the logic designer and the system architect from having to worry about SEUs. Therefore, the second part of the proposed research is to develop dynamic logic circuits that are tolerant of SEUs. The simulation of a new circuit is not a sufficient test before using the circuit in a system, especially if the system is in space. Therefore, the third part of this research will be to lay out, fabricate, and radiation test circuits that simulate successfully.

SUMMARY: Prototype Two-Phase Dynamic Logic (TDFL) test circuits have been obtained for radiation testing. All equipment necessary to perform the tests has been ordered, although not all of the equipment has been received. Interface circuitry for operating the TDFL circuits has been designed. All components necessary for constructing the interface circuitry has been ordered and received. The interface circuitry is currently under construction.

PUBLICATIONS: Billingsly, A.B., D.J. Fouts, and R. Hamming, "Memory Latency Reduction Using an Address Prediction Buffer," 26th Asilomar Conference on Signals, Systems, and Computers, 26-28 October 1992.

CONFERENCE PRESENTATIONS: Fouts, D.J., "Testing High-speed Digital Integrated Circuits," presentation at a workshop on testing high-speed integrated circuits at the University of California at Santa Barbara, October 1992.

Billingsly, A.B., D.J. Fouts, and R. Hamming, "Memory Latency Reduction Using an Address Prediction Buffer," 26th Asilomar Conference on Signals, Systems, and Computers, October 1992.

THESES DIRECTED: Vagts, C.B., LT, USN, "A Single-Transistor Memory Cell and Sense Amplifier for a Gallium Arsenide Dynamic Random Access Memory," Master's Thesis, December 1992. Received Armed Forces Communications and Electronics Association Award.

Nowickey, G.J., LT, USN, "A Read Prediction Buffer for Dynamic Random Access Memory," Master's Thesis, December 1992.

Billingsly, A.B., LT, USN, "An Investigation of Memory Latency Reduction Using an Address Prediction Buffer," Master's Thesis, December 1992.

RESEARCH IN LOW-ALTITUDE SATELLITE COMMUNICATIONS AND NETWORKS

Tri T. Ha, Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Ocean Systems Center
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this multi-year project was to investigate the performance of various types of frequency-hopped spread spectrum receivers suitable for satellite communications in low earth orbits.

SUMMARY: Four types of frequency-hopped spread spectrum receivers were investigated. These were the noise-normalization receivers, the self-normalization receivers, the ratio-statistic receivers, and the simultaneous frequency-hopped sequence receivers. For this reporting period, error-correction coding was added to the performance analysis of the ratio-statistic receivers and the linear combining receivers. Convolutional codes with hard-decision Viterbi decoding were employed for the ratio-statistic receivers. The linear combining receivers employed convolutional codes with soft-decision Viterbi decoding. Doppler effects were included in the analysis of the linear combining receivers.

PUBLICATIONS: Robertson, R.C., J.F. Riley, and T.T. Ha, "Error Probabilities of Fast Frequency-hopped FSK with Ration-statistic Combining in a fading channel with partial-band interference," MILCOM 92, San Diego, CA.

Robertson, R.C., T.W. Vece, and T.T. Ha, "Performance of a Fast Frequency-hopped DFT-based MFSK Receiver with Noise-normalization Combining in a Fading Channel with Partial-band Interference," MILCOM 92, San Diego, CA.

INVESTIGATION OF TIME AND FREQUENCY TECHNIQUES FOR DETECTION OF WIDEBAND TRANSIENT SIGNALS IN NOISE ENVIRONMENTS

Ralph D. Hippenstiel, Associate Professor
Monique P. Fargues, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor and Funding: U.S. Army CECOM Center for Signals Warfare

OBJECTIVE: To investigate advanced processing techniques to automatically detect and classify certain short duration signals.

SUMMARY: A computational investigation of various time and frequency techniques designed to detect wide band transient signals in noise was proposed. The first phase of the study involved the design and comparisons of detection procedures using synthetic transient data. The second phase applied the detection schemes to the data provided by the sponsoring organization. Finally, in the third phase Fortran code of the detection scheme best suited to detect the wide band transient signals will be provided to the sponsor.

CHARACTERIZATION/FEATURE EXTRACTION FROM NON-STATIONARY SIGNALS

Ralph D. Hippenstiel, Associate Professor
Department of Electrical and Computer Engineering
Sponsor and Funding: Naval Command, Control and Ocean Surveillance Center

OBJECTIVE: To investigate the use of the Instantaneous Power Spectrum (IPS) and a cumulant based modification of IPS to extract detection/classification clues from time-frequency representations.

SUMMARY: The principal accomplishment this year has been the development and demonstration of the Instantaneous Power Spectrum (IPS) and a cumulant based modification based on IPS. Synthetic and real underwater signals with a non-stationary character have been processed. These signals are transient or dynamic in nature. That is they exist only for short periods of time, or their parameters are functions of time. The Wigner Ville Distribution (WD) and the Instantaneous Power Spectrum (IPS) have been shown to applicable to non-stationary signals. Cumulant type processing minimizes the noise degradation caused by Gaussian noise. In the context of detection /identification this property helps to improve the performance since the noise effects are some what minimized.

PUBLICATIONS: Hippenstiel, R., "Progress report: Characterization /Feature Extraction from Non-Stationary Signals," July 9, 1992.

Hippenstiel, R., "Characterization /Feature Extraction from non-stationary signals," NPS Technical Report, NPSEC-93-004, 9 December 1992.

THESIS DIRECTED: Hagerman, K.A., LT, USN, "Instantaneous Power Spectrum and 1 1/2D Instantaneous Power Spectrum Techniques," Master's Thesis, June 1992.

OTHER: Software to implement the different processing algorithms was provided to the sponsor as part of the research task.

BASIC RESEARCH INTO WAVELETS AND THEIR APPLICATION TO UNDERWATER SURVEILLANCE PROBLEMS

Ralph D. Hippenstiel, Associate Professor
Monique P. Fargues, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor and Funding: Naval Postgraduate School

OBJECTIVE: To investigate the properties of wavelets as they relate to underwater surveillance detection and identification problems.

SUMMARY: The study of the spectrum of signals, usually imbedded in additive noise, is important in SONAR/RADAR target detection and target identification. Many diverse techniqués have been used to obtain a frequency versus time description. The Affine Wavelet Transform has been introduced in the last decade. This

transform offers the potential advantage of zooming in some details or getting the most important features of the signal under study.

This research served in many ways to foster understanding of time-frequency representations. Single and multiple tonal signals with narrow band characterizations have been examined using the wavelet transform type representation. Pulsed sinusoids and transients have also been processed using a Morlet derived wavelet, as well as in using the Mallat and the "a trous" algorithms.

THESIS DIRECTED: Brooks, W.A., LT, USN, "Ultra-Wideband Radar Transient Signal Detection using Time-Frequency and Wavelet Transforms," Masters Thesis in Electrical Engineering, December 1992.

OTHER: Wavelet transform software designed to detect UWB transient in the presence of non-stationary noise and RFI interference provided to the Radar Branch of NCCOSC, San Diego, CA, December 1992. Computer codes in Matlab language are also available.

STUDY OF WIDEBANDING TECHNIQUES FOR VHF ANTENNAS

Ramakrishna Janaswamy, Associate Professor
Department of Electrical and Computer Engineering
Sponsor and Funding: U.S. Army CECOM

OBJECTIVE: To investigate new techniques for widebanding VHF wire antennas over the frequency range 30--90MHz for digital radio applications.

SUMMARY: In the first phase of the project we have designed abroadband wire antenna to operate over the frequency range 30--90 MHz. A simple whip consisting of a 1m high resistively loaded monopole antenna was considered. A lossless tuning network was designed to render the input impedance as well as the radiation pattern of the antenna relatively insensitive to frequency. The antenna is cheap to fabricate, light-weight, and can be easily mounted on moving vehicles or back-packs. FORTRAN programs were developed to facilitate computer aided design on a PC.

PUBLICATIONS: Janaswamy, R., "Widebanding Techniques for VHF Antennas-I," NPS Technical Report, NPS-EC-92-010, 1992.

THESIS DIRECTED: J. Park, LT, USN, "Design of Matching Network for Dipole Antennas," Masters Thesis in Electrical Engineering, September 1992.

DEVELOPMENT OF 3D MODEL FOR PROPAGATION OVER IRREGULAR TERRAIN

Ramakrishna Janaswamy, Associate Professor
Department of Electrical and Computer Engineering
Sponsor and Funding: Naval Security Group Command

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

SUMMARY: In the first year of the project we have developed a full wave model that automatically takes into account the important contributions of surface wave and backscattering for waves propagating over a two dimensional terrain profile. The model is based on the combination of a Fredholm integral equation and radiation boundary conditions. A computer code was developed that predicts ground wave attenuation as well as sky-wave patterns for a given set of terrain and ground data. Extensive comparision has been made with existing models and with measurements to validate the model. In the next fiscal year we will develop a model to handle the case of propagation over finite 3D obstacles.

PUBLICATIONS: R. Janaswamy, "2-D Radiation Boundary Conditions on an Arbitrary Outer Boundary," *Microwave and Optical Technology Letters*, Vol. 5, No. 8, pp. 393--395, July 1992.

R. Janaswamy, "A Fredholm Integral Equation Approach to Propagation Predictions Over Small Terrain Irregularities," *IEEE Transactions Antennas Propagation*, Vol. 40, No. 11, November 1992.

R. Janaswamy, "A Fredholm integral equation approach for wave propagation over irregular terrain," *1992 IEEE AP-S/URSI Meeting Digest*, Session TA05, Vol. 2, pp. 765-768, Chicago, IL, 1992.

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 of this research was to develop accurate analytical models and computer codes for various complex microwave antennas and scatterers. The models are used in the design and evaluation of high performance radar, communication and EW systems. All aspects of electromagnetic design are considered: radiation from antennas, electromagnetic compatibility between system components, and radar cross section prediction and control.

SUMMARY: During the past year research has been conducted in four areas. A brief description of each follows:

(1) Design of small, efficient dual reflector antennas: A computer code has been developed to analyze axially symmetric displaced-axis antennas. Research has shown that this type of

antenna has superior gain performance compared a classical cassegrain configuration of the same size. This will result in potentially smaller and lighter antennas for manpack and satellite communication systems.

(2) Analysis of curved radome effects: Verification and testing of a computer code to model aircraft radomes has been completed. A method of moments solution is used to evaluate the defocusing and depolarization effects of curved radomes on microwave scanning antennas. This type of radome is frequently used in fighter aircraft and missile applications, and its presence may adversely affect the radar's performance. This solution is unique in that it allows the radome to be in the near field of the antenna. This situation is commonly encountered in practice, and cannot be handled by the usual radome models.

(3) Radar cross section synthesis: A synthesis procedure was developed to determine the material properties of an arbitrary target so that a specified radar cross section is obtained. The method can be used in the design of low observable targets, and can be extended to handle the treatment of isolated areas of a target's surface to reduce hot spots. The synthesis procedure has been demonstrated on simple shapes such as strips and plates.

(4) Radar cross section reduction of indirect-file projectiles: Weapons locating radars have the ability to detect and track incoming shells and extrapolate back to determine the coordinates of the firing mechanism. As a counter to these radars, the cross section of artillery and mortar rounds was computed and reduced using the method of passive cancellation. Significant reduction was achieved by simply adding two shallow slots to the round.

PRESENTATIONS: Jenn, D.C., "Solution of Inverse Scattering Problems Using a Method of Moments Approach," Applied Computational Electromagnetics Society, The Eigth Annual Review of Progress in Applied Computational Electromagnetics, March 1992.

Jenn, D.C., "Radar Cross Section Synthesis Using the Method of Moments," North American Radio Science Meeting, June 1992.

THESES DIRECTED: Benden, C.P., CAPT, USMC, "Radar Cross Section of Indirect-fire Projectiles, Master's Thesis, December, 1992.

Fletcher, J.E., CAPT, USMC, "Radar Cross Section of Reflector Antennas," Master's Thesis, June, 1992.

Ordonez, M.V., LT, USN, "Method of Moments Analysis of Symmetric Dual Reflector Antennas With Feeds," Masters Thesis, June, 1992.

Vered, N., LCDR, Israeli Navy, "Method of Moments Analysis of Displaced-Axis Dual Reflector Antennas," Master's Thesis, March, 1992.

Francis, R.M., LT, USN, "A Computer Model for the Transmission Characteristics of Dielectric Radomes," Master's Thesis, March, 1992.

THERMO-ACOUSTIC COOLING OF C2 ELECTRONICS

Allan D. Kraus, Senior Lecturer
Department of Electrical and Computer Engineering
Sponsor: Naval Air Station, San Diego
Funding: Aviation Supply Office

OBJECTIVE: The goal of this project was to assure the reliability, operability and maintainability of the electronic boxes in the C2 aircraft by performing detailed thermal analyses to obtain temperature maps of the components in each box.

SUMMARY: Analysis of one box was conducted and a report was written. Additional work forthcoming.

THERMAL ANALYSIS OF PANSAT VEHICLE

Allan D. Kraus, Senior Lecturer
Department of Electrical and Computer Engineering
Sponsor and Funding: NRL/SPAWAR

OBJECTIVE: The goal of this project was to investigate the range of skin temperatures of the PANSAT Vehicle between the sunlight and shadow orbit zones.

SUMMARY: A finite difference model was constructed, the analysis was completed and a report was written.

M-ARY OPTICAL CDMA COMMUNICATIONS

Alex W. Lam, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Research Initiation Program
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project was to investigate M-ary optical code-division multiple-access (CDMA) communications with avalanche photodiode detectors.

SUMMARY: Arbitrarily tight upper and lower bounds on the probability of bit error (p.b.e.) for optical CDMA systems were developed. These bounds were necessary because the exact evaluation of the p.b.e. was intractable and computer simulation would require formidable amounts of computation time. The techniques could be applied to general multiple-access systems. The simple modified Chernoff upper bound as well as the Gaussian approximation results could therefore be calibrated using these computational efficient bounds.

PUBLICATIONS: Lamm, A.W. and A.M. Hussain, "Performance Analysis of Direct-Detection Optical CDMA Communication Systems with Avalanche Photodiodes," *IEEE Transactions on Communications*, Vol. COM-40, No. 4, pp. 810--820, April 1992.
A.W. Lam, "Arbitrary Tight PBE Bounds for Optical CDMA Communications," *IEE Electronics Letters*, Vol. 28, No. 12, pp. 1139--1140, June 1992.

CONFERENCE PRESENTATION: A.W. Lam, "Error Probability Bounds for APD Based Optical CDMA Communications," Proceedings of the 1992 Conference on Information Sciences and Systems, Princeton University, p. 107, March 1992.

WAVELETS AND TIME-FREQUENCY ANALYSIS

Alex W. Lam, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Research Initiation Program
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project was to investigate wavelets and time-frequency analysis of signals.

SUMMARY: We proposed wavelet-based time-frequency analytical techniques for transient and general classes of signals. Problems of particular interests were the detection and classification of multiple signals and chirped waveforms in additive noise. Impulsive and 1/f noise processes would be considered. The results would be applicable to important problems in radar and sonar systems and digital communications.

THESES DIRECTED: Kalmbach, M.R., CAPT, USMC, "Wavelet-based Multiresolution Analyses of Signals," Master's Thesis, June 1992.

Legaspi, J.E., LT, USN, "One and Two Dimensional Discrete Wavelet Transforms," Master's Thesis, September 1992.

SEQUENTIAL ACQUISITION SCHEMES FOR SSMA SYSTEMS WITH GENERALIZED SIGNATURE SEQUENCES

Alex W. Lam, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor and Funding: Army Research Office

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

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

PUBLICATION: Lam, A.W. and F.M. Ozluturk, "Performance Analysis of Direct-Sequence Spread-Spectrum Communications with Complex Signature Sequences," *IEEE Transactions on*

Communications, Vol. COM-40, No. 10, pp. 1607--1614, October 1992.

CONFERENCE PRESENTATIONS: Lam, A.W., S. Tantaratana, and P. Vincent, "Effects of Fading and Modulation on Noncoherent PN Sequence Sequential Acquisition Schemes," Proceedings IEEE Military Communications Conference, San Diego, pp. 17.1.1--17.1.5, October 1992.

Ozluturk, F.M., S. Tantaratana, and A.W. Lam, "Probability of Bit Error of DS/SSMA Systems with MPSK Signaling and Complex Signature Sequences," Proceedings IEEE Military Communications Conference, San Diego, pp. 35.5.1--35.5.5, October 1992.

THESIS DIRECTED: Vincent, P.J., LT, USN, "Effects of Fading and Data Modulation on Noncoherent m-sequence Acquisition Schemes," Master's Thesis, March 1992.

OTHER: Ozluturk, F.M., S. Tantaratana, and A.W. Lam, "Performance Bounds for DS/SSMA Systems with Noncoherent Signaling Schemes," invited paper to be presented at IEEE MILCOM '93.

COMPUTER AIDED VLSI DESIGN FOR TACTICAL IMAGE PROCESSING

Chin-Hwa Lee, Professor
Department of Electrical and Computer Engineering
Sponsor: Research Initiation Program
Funding: Naval Postgraduate School

OBJECTIVE: In this research, image processing algorithms will be inplemented directly into ASIC chips using programmable gate arrays. Nonlinear algorithms such as dynamic programming and simulated annealing will be studied and implemented. Emphasis is concentrated on an integrated CAD environment using the VHDL for ASIC chip design and modeling. Particular interests will be the behavioral modeling of programmable VLSI chips with timing elements.

SUMMARY: Our confidence to start with a VHDL behavior model and push it through the intermediate design levels to an actual chip implementation is increased to a large extent in the FY92 effort. The algorithm development of the simulated annealing algorithm was continued. Modeling and system implementation were directed to a FPGA chip demonstration. This experience and capability in NPS should be interesting to other operations in the Navy.

PUBLICATION: Lee, C.-H., "Simulated Annealing Applied to Acoustic Signal Tracking," SPIE/IS&T Symposium on Electronic Imaging Science and Technology, San Jose, February 14, 1992.

THESIS DIRECTED: Loeblein, J., LT, USN, "Digital Logic Testing: Incorporating the Design Simulation File into a Hardware Test System Analysis," Master's Thesis, December 1992.

IMAGE PROCESSING APPLIED TO SENSOR DATA

Chin-Hwa Lee, Professor
Department of Electrical and Computer Engineering
Sponsor and Funding: Naval Research Laboratory

OBJECTIVE: In this research, image processing techniques applied to sensor data will be studied. The simulated annealing techniques for image processing is of particular interest. Specific experiments are planned to use a DSP environment, Ptolemy. The goal is to achieve programming on parallel computer systems through graphics presentation.

SUMMARY: The FY92 effort was concentrated on studying the simulated annealing technique. A series of experiments involving artifically generated lofargrams were tested in the prototype algorithms. Test cases are divided into three categories, (1) single tonal tracking, (2) multitonal tracking, and (3) sweep tonal tracking. The signals are buried in white noise with signal to noise ratios (SNR) of3 db, 0 db, -3 db, -6 db, -9 db, -12 db, and -18 db. The prototype algorithm can achieve successful tracking in a -18 db signal to noise ratio environment. These remarkable results cannot be paralleled by any known algorithm at this point in time. The Ptolemy environment does provide a graphics environment to simulate DSP algorithms. The documentation is not at the stage to be self explanatory. There is no tutorial available to help the users. Therefore, the learning curve to use this tool is very high initially.

PUBLICATION: Lee, C.-H., "Simulated Annealing Applied to Acoustic Signal Tracking," SPIE/IS&T Symposium on Electronic Imaging Science and Technology, San Jose, CA, February 14, 1992.

THESIS DIRECTED: *Brahosky, V.A., LT, USN, "A Combinatorial Approach to Automated Lofargram Analysis," Master's Thesis, June 1992.*

SYSTEM DESIGN SYNTHESIS

Chin-Hwa Lee, Professor
Department of Electrical and Computer Engineering
Sponsor and Funding: Naval Surface Warfare Center

OBJECTIVES: This proposal will develop a subset of the MIM library in VHDL. Guidelines of development and design with the MIM will be developed. Whenever possible, commercial tool sets will be used. Special attention will be paid to provide an easy interface between the VHDL MIM and custom tool environment such as ADAS. The study of complexity measurement will be conducted. Several algorithms including FFT, Fir filtering, and network communications will be used as prototype efforts to demonstrate the results of this work.

SUMMARY: Two study reports entitled: "Massively Interconnected Module Resource Library" and "Complexity Analysis for Massively Interconnected Modules" have been delivered to the sponsor. The first report established the VHDL library modules

that are necessary to model complicated systems. Modules working for FFT and FIR filters have been tested out. The second report deals with the complexity analysis in a massively connected system. In particular the parallel computation systems that can handle DOD applications are of particular interest.

PUBLICATIONS: Szu, H., C. Yeh, G. Rogers, M. Jenkins, A. Farsaie, and C.-H. Lee, "Speed Up Performances on MIMD Machines," International Conference on Neural Networks, Baltimore, MD, June 1992.

Lee, C.-H., "Massively Interconnected Models for a Beamformer," Proceedings of the 1992 Complex System Engineering Synthesis Architecture Workshop, NSWC, July 20--23, 1992.

THESIS DIRECTED: Sullivan, D.T., LT, USN, "Computer Simulation Studies of Two-Dimenional Beamforming for Linear Arrays Using a Parallel Computer System," Master's Thesis, December 1992.

SHORT RANGE ANTI-AIR RADAR PROPAGATION

H.-M. Lee, Associate Professor
Department of Electrical and Computer Engineering
Sponsor and Funding: Office of the Chief of Naval Operations

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. It was shown that this approach reproduced the formulation by Fock when restricted to a homogeneous atmosphere. During this investigation, it was discovered that the residue integral of Fock's formulation did not converge. Thus the residue series is asymptotic at best.

PUBLICATION: Lee, H.-M., "Earth-Flattening: A New Approximation," in preparation for *Journal of Applied Physics*.

CONFERENCE PRESENTATIONS: Lee, H.-M., "Earth Flattening Approximation and Fock's Theory for Low Altitude em Propagation over the Ocean," Proceedings of the 1992 International Symposium on Antennas and Propagation, Sapporo, Japan, pp. 513--516, September 1992.

Lee, H.-M., "From Mie Solution to Fock's Theory for Short Range Propagation," Proceedings of the 1992 URSI International Symposium on Electromagnetic Theory, Sydney, Australia, 351--353, August 1992.

Lee, H.-M., "Creeping Wave Over a Flattened Earth," Abstract of the National Radio Science Meeting, 74, Boulder, Colorado, January 7--10, 1992.

M-LAYER IMPROVEMENT AND EXTENSION

H.-M. Lee, Associate Professor
Department of Electrical and Computer Engineering
Sponsor and Funding: Naval Command, Control and Ocean Surveillance Center

OBJECTIVE: To improve the execution speed and accuracy of the m-Layer program.

SUMMARY: The m-Layer program developed by NCCOSC predicts ducting effects of over-the-horizon EM propagation when the mean atmospheric profile over the propagation path can be considered as vertically stratified. This project converted the extended precision algorithm for the representation of large numbers into complex logarithmic format and improved the Airy function evaluation algorithm. A consistency checking procedure was also implemented to reduce the precision requirement on the eigenvalues and to assure the accuracy of the mode eigenfunctions. The execution speed of the program is also improved substantially.

PUBLICATIONS: Lee, H.-M., "Consistency Checking for Mode Function Computation of a Multilayered Dielectric Waveguide," submitted to *Journal of Electromagnetic Waves and Applications*.

Lee, H.M. and Y.Y. Han, "M-Layer: NPS Version," accepted for publication in *IEEE Transactions on Magnetics*, Vol. 29, No. 3, 1993.

CONFERENCE PRESENTATIONS: Lee, H.-M. and Y.Y. Han, "Improvement of M-Layer: A Tropospheric Propagation Program," Digests of the Fifth Biennial IEEE Conference on Electromagnetic Field Computation, Claremont, California, August 1992.

TECHNICAL REPORT: Lee, H.-M. and Y.Y. Han, "Exponential Representation and Consistency Checking for M-Layer," NPS Technical Report, NPSEC-92-005, March 1992.

THESES DIRECTED: Han, Y.Y., LT, Taiwanese Navy, "Complex Exponent Representations of Large Numbers for M-Layer," Master's Thesis, March 1992.

Che, J.P., LT, Taiwanese Navy, "A New Root Search Strategy for M-Layer," Master's Thesis, September 1992.

EM SCATTERING FROM A TUBULAR CYLINDER OF ANISOTROPIC SURFACE IMPEDANCES

H.-M. Lee, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Sandia National Laboratories
Funding: Naval Command, Control and Ocean Surveillance Center

OBJECTIVE: To produce an accurate computer program for validating other numerical electromagnetic computation codes.

SUMMARY: The electromagnetic scattering from a zero-thickness, perfectly conducting, circular, tubular cylinder of finite length

with different anisotropic coatings on its inside and outside surfaces will be investigated. The principal axes of the surface impedance tensors lie along the axial and the circumferential directions of the cylinder. The induced electric and magnetic surface current densities and the far field will be obtained. Analytical expressions of the double series expansion coefficients of the kernels of the integral-differential equations of this problem will be obtained and utilized to assure that extremely accurate numerical results can be obtained. These results will be used as a standard for validating numerical electromagnetic computation codes.

ADVANCED SIGNAL PROCESSING TECHNIQUES

Herschel H. Loomis, Jr., Professor
Department of Electrical and Computer Engineering
and Space Systems Academic Group
M. Soderstrand, Professor
University of California-Davis
Raymond Bernstein, Visiting Instructor
Department of Electrical and Computer Engineering
Sponsor and Funding: Secretary of the Air Force

OBJECTIVE: To investigate advanced signal processing algorithms and architectures for the detection and characterization of broadband communications signals in noise and interference.

SUMMARY: My principal accomplishment this year has been in the development and realization of algorithms for the detection and characterization of cyclostationary signals, such as Binary Phase Shift Keyed signals. This work has resulted in one paper in press and two submitted, two conference presentations and a technical report. I have been aided in this research by the thesis students and particularly by a visiting colleague, M. Soderstrand, who developed jointly with a student and me, some important results on filtering of narrowband signals prior to processing signals for their cyclostationarity. The group conducted an experiment involving the collection of live data and the application of spectral correlation algorithms to that data; analysis of the data is proceding. Also as a part of this project, a special workshop in "Quadratic Signal Processing" was organized and held at NPS in April of 1992. Currently, the fifth annual such workshop is being organized for April 1993 at NPS.

PRESENTATIONS: Loomis, H.H., Jr. and R. Bernstein, Jr., "Realization of TDOA Estimation Architectures," Poster paper presented at the NSF Workshop of Cyclostationarity, W.A. Gardner, organizer, Yountville, CA, August 1992.

Loomis, H.H., Jr., "Digital Implementations of Cyclic Spectrum Analyzers," Presented to the Governmnent Only Spread Spectrum Conference (GOSC), National Security Agency, May 1992.

THESES DIRECTED: Lancaster, F.D., LCDR, USN, "Test Plan for a Special Collection Experiment," Master's Thesis, September 1992.

Benson, T.A., LT, USN, "Geolocation

using a Cyclostationary Time Difference of Arrival Technique," Master's Thesis, December 1992.

Carter, N., LT, USN, "Design of Spectral Correlation Analyzer Software," Master's Thesis, December 1992.

WORKSHOP: Loomis, H.H., Jr., Organizer, Quadratic Signal Processing, Representatives of SPAWAR 44, Naval Security Group Command, Naval Postgraduate School and Contractors, NPS, April 1992.

PROJECT GUSTY ORIOLE

Herschel H. Loomis, Jr., Professor
Department of Electrical and Computer Engineering
and Space Systems Academic Group
Raymond Bernstein, Visiting Instructor
Department of Electrical and Computer Engineering
Sponsor and Funding: Secretary of the Air Force

OBJECTIVE: To conduct research into computer algorithms and architectures for the processing of tactical information. To provide support for the course Space Systems 3001, Military Applications of Space.

SUMMARY: Investigated Algorithms and architectures of systems for the production, distribution and analysis of tactical information. Investigated architectures of spaceborne computer systems. Investigated operational problems concerned with the employment of tactical information for decision making and targeting. Participated in the data collection experiment on commercial shipping in a "Chokepoint," the English Channel. Four thesis students have completed theses analyzing the data from the experiment.

THESES DIRECTED: Hendrickson, P., LT, USNR, "Frequency Modulation on Pulse (FMOP) and other Non-Conventional Radar Parameters; Can They Separate the Wheat from the Chaff?" Master's Thesis, June 1992.

Barber, G.P., CAPT, USA, "Space Systems Analysis and Design Tool Kit," Master of Science in Systems Technology (Space Systems Operations), September 1992.

de Beaumont, C., LT, USN, "A Proposal for Improved Merchant Ship Surveillance Involving Maritime Patrol Forces and Additional Ocean Surveillance Systems," Master's Thesis, September 1992.

Habermehl, S., LT, USN, "Correlation of Emitter Parametric Data and Active Radar Tracking Information in the Dover Strait," Master's Thesis, September 1992.

Vandenberg, D.J., LT, USN, "Collection Systems Correlation Study," Master's Thesis, September 1992.

ON-ORBIT ANNEALING OF SATELLITE SOLAR PANELS

Sherif Michael, Associate Professor
Department of Electrical and Computer Engineering
Sponsor and Funding: Space and Naval Warfare Command

OBJECTIVE: The goal of this project is to 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 FY90 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: Michael, S., "Analysis of Radiation Damage and Annealing Process in Advanced Solar Cells Using DLTS Techniques," 11th International Photovoltaic Solar Energy Conference, October 1992.

Walters, R.J., G.P. Summers, and J. Bruening, "A Detailed Study of the Photo-Injection Annealing of InP Solar Cells," Proceedings of the 12th Space Photovoltaic Research and Technology Conference," NASA Lewis Research Center, Cleveland, OH, October 20--22, 1992.

CONFERENCE PRESENTATIONS: Michael, S., "Analysis of Radiation Damage and Annealing Process in Advanced Solar Cells Using DLTS Techniques," 11th International Photovoltaic Solar Energy Conference, October 1922.

Walters, R.J., "A Detailed Study of the Photo-Injection Annealing of InP Solar Cells," Proceedings of the 12th Space Photovoltaic Research and Technology Conference, NASA Lewis Research Center, Cleveland, OH, October 20--22, 1992.

RADIATION INSENSITIVE SEMICONDUCTOR NETWORKS

Sherif Michael, Associate Professor
Department of Electrical and Computer Engineering
Sponsor and Funding: Space and Naval Warfare Command

OBJECTIVE: The goal of this project is to 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 application in the investigation of current ORION satellite hardware survivability in space.

THESIS DIRECTED: Mayfield, T.E., LT, USN, "Computerized Diagnostic Analyzer fo SSBN Class Low Voltage DC Weapon Power System," Master's Thesis, March 1992.

ANALOG VLSI AND THEIR APPLICATIONS TO NEURAL NETWORKS IMPLEMENTATION

Sherif Michael, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Weapons Center
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project is to investigate the design and developments of low-sensitivity analog building blocks to be utilized in switched-capacitor networks implementations.

SUMMARY: In this research a novel technique for designing high performance, low sensitivity analog VLSI building blocks is investigated. The new designs are based on the composite amplifiers, previously introduced by the investigator. The research goal is to develop stray-insensitive switched-capacitor analog building blocks that would be instrumental in the design of high performance analog VLSI circuits. The availablility of such novel designs would play a key role in the practical implementations of neural networks.

OTHER: A conference paper for publication at the Midwest Symposium on Circuits and Systems is forthcoming.

HYBRID POWER SYSTEM FOR REMOTE COMMUNICATION STATIONS

Sherif Michael, Associate Professor
Department of Electrical and Computer Engineering
Sponsor and Funding: U.S. Coast Guard

OBJECTIVE: The goal of this project is to investigate and develop a hybrid power system utilizing solar systems, wind generator systems, and thermo-electric generator systems to power remote communication stations in Alaska.

SUMMARY: In this research the possibility of incorporating different power systems to provide electrical power to Alaska's Coastal Voice Distress Network, operated by the U.S. Coast Guard is studied. research tasks include investigating the performance of Thermo-Electric Generators (TEG) providing power to the current systems; investigating present and new power sources technologies; investigating different energy resources available at the proposed station sites, including seasonal change studies; developing and designing reliable hybrid power systems capable of utilizing available energy sources at these

sites. These systems would probably incorporate wind power, solar power, and TEG systems.

OTHER: A final report on the results of this project is forthcoming.

UNINTERRUPTABLE POWER SUPPLY DESIGN FOR COMMUNICATIONS SYSTEMS

Sherif Michael, Associate Professor
Robert Ashton, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor and Funding: U.S. Coast Guard

OBJECTIVE: The goal of this project distribution panel of an existing communication system to provide the capability of uninterruptable operation when switching between different power sources.

SUMMARY: This research is proposed to design and develop a protogype uninterruptable power supply. The result would be an improved power distribution panel that will provide the capability to manually switch between two AC sources, to the HMMWV DC battery/alternator or other DC sources. This would be accomplished with no interruption in the AN/MRC-142 communications systems operation.

OTHER: The prototype is forthcoming.

BARENTS SEA POLAR FRONT EXPERIMENT: Signal Processing

James H. Miller, Associate Professor
Department of Electrical and Computer Engineering
Ching-Sang Chiu, Associate Professor
Department of Oceanography
Robert Bourke, Professor
Department of Oceanography
Sponsor and Funding: Office of Naval Research

OBJECTIVE: The goal of this experiment was to determine the feasibility of conducting tomography in the Barents Sea and to investigate space-time coherence of the acoustic field.

SUMMARY: In August, 1992, NPS and Woods Hole Oceanographic Institution deployed a set of acoustic sources and receivers including the NPS vertical array to tomographically image the Barents Sea Polar Front. In addition to the scientific goals, the Barents Sea is a Navy-relevant geographical area and understanding the acoustic propagation is important to ASW activities.

PUBLICATION: Bourke, R.H., C.-S. Chiu, J.F. Lynch, J.H. Miller, R.D. Muench, and A.J. Plueddemann, "Initial Results from the Barents Sea Polar Front Experiment," Eos, *Transactions, American Geophysical Union*, Vol. 73, No. 43, p. 289, 1992.

THESES DIRECTED: Omans, G.A., LT, USN, "Broadband Modal Beamforming of Acoustic Tomography Signals Acquired by a Vertical Array, Master's Thesis,

September 1992.

Elliott, M., LT, USN, "Simulation of Acoustic Multipath Arrival Structure in the Barents Sea," Masters Thesis, June 1992.

TIME DOMAIN LOCALIZATION

James H. Miller, Associate Professor
Department of Electrical and Computer Engineering
Ching-Sang Chiu, Associate Professor
Department of Oceanography
Sponsor: Naval Underwater Warfare Center, New London
Funding: Naval Postgraduate School Direct Funds

OBJECTIVE: The goal of this work is the determination of source range and depth in an ocean acoustic waveguide given a time domain representation of a source-generated signal.

SUMMARY: One of the spin-offs of the Monterey Bay Tomography Experiment was a capability to model broadband pulse propagation in a complicated environment such as the Bay. Using a broadband parabolic equation model, we have successfully explained the time domain characteristics of received signal and interpreted the propagation in terms of coupled normal modes using the source and receiver locations, bathymetry, and sound speed profile. This success leads naturally to the inverse problem for solving for the source location given the received signal. We are interfacing with NUWC New London to determine the feasibility of this technique using actual platform data.

PUBLICATIONS: Miller, J.H. and C.-S. Chiu, "Localization of the Sources of Short Duration Acoustic Signals," *Journal of the Acoustical Society of America*, Vol. 92, No. 5, pp. 2997--2999, 1992.

Miller, J.H. and C.-S. Chiu, "Localization of the Sources of Short Duration Acoustic Signals in a Coastal Ocean Environment," 124th Meeting of the Acoustical Society of America, New Orleans, October 31--November 4, 1992.

THESES DIRECTED: Nicholson, C.L., LCDR, USN, "Localization of Acoustic Transients in Shallow Water Environments," Master's Thesis, December 1992. LCDR Nicholson was selected for the Space and Naval Warfare Systems Command Award in Electronic Systems Engineering.

Schultz, J.L., LT, USN, "Implementation of a Time Domain Localization Algorithm in the AN/SQR-10 Tactical Towed Array Sonar System," Master's Thesis, December 1992.

EVALUATION OF UHF F/O SATELLITE SYSTEM MODELS

Paul H. Moose, Associate Professor
David Jenn, Associate Professor
Department of Electrical and Computer Engineering
Sponsor and Funding: Operational Test and Evaluation Force

OBJECTIVE: The objective of this project is to accredit one or numerical computer models to assess the effects of nuclear bursts on the satellite communications links between ground stations and the UHF Follow-On satellite stations.

SUMMARY: Funding for this project arrived late in the fourth quarter of FY92. Our progress to date consists of obtaining copies of computer codes for predicting plasma contributions associated with high altitude nuclear bursts and codes for predicting parameters associated with electromagnetic propagation between earth stations and satellites through the plasmas. Four codes are being evaluated: SCENARIO, PRPSIM, SPACECEM, and SKYMAP. The first two have been licensed to us by the Defense Nuclear Agency (DNA). The latter two belong to the Air Force. Documentation is being assembled at NPS on the technical characteristics of the UHF Follow-On satellite communications package, on the Navy's requirements for nuclear survivability of the links and on the various computer codes.

THESIS DIRECTED: Godeaux, A., CAPT, USMC, "An Evaluation of Models Simulating the Effects of a Nuclear Explosion on the Communication Links of the UHF Follow-On Satellite (U)," Master's Thesis, September 1992.

FIELD CANCELLATION USING A COUNTER-EMF APPROACH

Michael A. Morgan, Professor
Department of Electrical and Computer Engineering
Sponsor: Chief of Naval Operations, EW/C3I/Space Warfare
Funding: Naval Postgraduate School

OBJECTIVE: This two-year project investigates the practical viability for reducing bistatic wideband radar scattering signatures using distributed active cancellation.

SUMMARY: The counter-EMF technique appears most promising from a practical perspective at radar frequencies below which passive measures such as shaping and absorbing materials are inoperative. Thus the active approach may dovetail in frequency with the more conventional methods to provide ultra-wideband RCS reduction against future radar designs, including impulse radars. The first year is being devoted to analytical studies and numerical simulations to consider tradeoffs of RCS reduction vs. frequency range for number and placement of canceler modules on air and surface platforms. The second year will provide numerical and scale model experimental validations as well as address issues for full scale implementation.

ULTRA-WIDEBAND IMPULSE ANTENNA DESIGN

Michael A. Morgan, Professor
R. Clark Robertson, Associate Professor
Department of Electrical and Computer Engineering
Sponsor and Funding: U.S. Army CECOM Signals Warfare Directorate

OBJECTIVE: The goal of this project is to perform an engineering design study, develop a test plan, and to construct and test an initial prototype for an ultra-wideband impulse receiving antenna.

SUMMARY: Impulse antennas are antennas that are intended to either transmit or receive very short pulses of electromagnetic energy. As is well known, short pulses have extremely wide bandwidths; hence, impulse antennas by their very nature must be wideband. However, in order to maintain signal fidelity, it is also very important that the impulse antenna not introduce significant phase distortion into the signal. What is required is a wideband antenna with not only a constant magnitude response across the bandwidth but also linear phase shift resulting in minimal dispersion of the signal. Research into impulse antennas has been very intense for a number of years now, with a major application being the measurement of EMP signals resulting from nuclear explosions. A TEM horn antenna for receiving impulse signals with a theoretical bandwidth of 100MHz--5GHz was designed.

RESOLUTION ENHANCEMENT TECHNIQUES FOR HIGH SPEED ANALOG-TO-DIGITAL CONVERTERS

Phillip E. Pace, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Research Initiation Program
Funding: Naval Postgraduate School

OBJECTIVE: To theoretically and experimentally investigate a new modified residue preprocessing architecture to enhance the resolution performance of high speed analog-to-digital converters (ADCs). This is the first part of a continuing project that is expected to continue for one or more years.

SUMMARY: Electro-optical and video ADC circuits that incorporate the new preprocessing were designed to verify the concept and detail the advantages and disadvantages of such an approach. Theoretical studies were also conducted to extend the understanding of the modified residue formalism. The goal of this research was to study the modified residue architecture and evaluate its effectiveness as an ADC preprocessing solution. ADC circuits which use the modified residue preprocessing demonstrate a clear advantage over ADCs that use the conventional folding approach.

PUBLICATIONS: Pace, P.E., P.A. Ramamoorthy, and D. Styer, "High-Resolution Techniques for Guided-Wave Analog-to-Digital Converters," *Electronics Letters*, Vol 28, pp. 2174--2175, November 1992.

CONFERENCE PRESENTATIONS: Pace, P.E.,

P.A. Ramamoorthy, D. Styer, "Resolution Enhancement Technique for Guided-Wave Analog-to-Digital Converters," IEEE Lasers and Electro-Optics '92 Annual Proceedings, EOS2.2, November 1992.

A VISIBILITY-DEPENDENT DEPTH-OF-FOCUS FOR INCOHERENT PERIODIC SOURCES

Ron J. Pieper, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Research Initiation Program
Funding: Naval Postgraduate School

OBJECTIVE: Analyze the depth-of-focus for incoherent periodic sources using the optical visibility as a criterion. The original direction of this work has been shifted from the theoretical to somewhat more practical considerations in which the visibility concept is applied to generate a performance measure for thermal imaging systems.

SUMMARY: During this period the final adjustments on the analysis dealing with incoherent sinusoidal sources were completed. The shift in the direction of the research was to apply visibility as a criterion for evaluation of thermal imaging systems, for which incoherent optical analysis applies. This has led to what appears to be a more realistic model for predicting the minimum resolvable temperature difference (MRTD).

PUBLICATIONS: Pieper, R.J., K. Raj, and T.-C. Poon, "A Visibility Dependent Depth of Focus for Incoherent Sinusoidal Sources," *Applied Optics*, Vol. 31, No. 7, pp. 977--986, March 1992.

Ugarte, A.R. and R.J. Pieper, "A New Model for Predicting the MRTD Curve for Thermal Imagers," 24th IEEE Southeastern Symposium on System Theory, pp. 231-234, March 1992.

CONFERENCE PRESENTATION: Ugarte, A.R. and R.J. Pieper, "A New Model for Predicting the MRTD Curve for Thermal Imagers", presented at the Southeastern Symposium on System Theory, March 1992.

PROPAGATION OF TRANSIENT WAVES

John Powers, Professor
Department of Electrical and Computer Engineering
Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: To study the predicted propagation properties of transient acoustic and optical waves in an effort to under-stand the propagation of very short duration waves and to use such waves in imaging applications.

SUMMARY: With the ability to generate short-duration sound and light pulses comes the requirement to be able to model and understand the propagation of these waves. Unlike most line-integral techniques presently available, these models should be computationally efficient.

We have developed a method of simulating acoustic propagation in linear homogene-ous media based on Fourier transform techniques. The propagation transfer function represents a time-varying spatial filter that increasingly attenuates the higher spatial frequencies of the wave as time increases. This method allows use of the FFT to appreciably reduce computation time. The technique is modular and allows elements of the model to be cascaded as complexity is increased. The technique, originally developed for modeling acoustic wave propagation has been extended to include optical wave propagation in the past year. Effort focussed on implementing the model on a large-memory microcomputer using the commercial program, MATLAB, and in using visualization tools to display the calculated four-dimensional wave (three space dimensions and time). In this year's effort, we are constructing a high-frequency experimental data collection system that operates under computer control to measure experimental acoustic data fields to confirm the technique.

THESES DIRECTED: Upton, J., Lt. Col., USMC, "Microcomputer Simulation of a Fourier Approach to Optical Wave Propagation," Master's Thesis, June 1992.

Reid, W., LT, USN, "Microcomputer Simulation of a Fourier Approach to Acoustical Wave Propagation, Master's Thesis, December 1992.

PRESENTATIONS: Powers, J., "Modelling Diffraction of Pulsed Ultrasonic and Optical Waves," Department Seminar, Electrical and Computer Engineering Department, Naval Postgraduate School, Monterey, CA, November 19, 1992.

DEVELOPMENT OF PROTOCOLS FOR MARITIME MOBILE COMMUNICATIONS

R. Clark Robertson, Associate Professor
Tri T. Ha, Professor
Department of Electrical and Computer Engineering
Sponsor and Funding: U.S. Coast Guard Research and Development Center

OBJECTIVE: The purpose of this research program is to determine what Open System Interconnection (OSI) data communication protocols can be used to provide effective and efficient data communications for radio-based maritime mobile services (including satellite systems).

SUMMARY: Data communications are becoming more extensively used in the maritime mobile services. At present, there is no general protocol profile that can be used as a building block for data communications between maritime mobile services. As computer and computer-based equipment become more prevalent in maritime applications, ships will have increased requirements to transmit data to and from the multiple computer /computer-based equipment. Implementation of a maritime OSI data communications standard will allow multiple shipboard equipment (Loran-C, GPS receiver, Vessel Traffic System communications, etc.) to communicate via a shipborne network and then transmit the data to a shore based network in an effective and efficient manner. In addition to

the investigation of data communication protocols, a preliminary investigation of the technical and operational requirements for effective and efficient data communications for radio-based maritime mobile services will be made. This project is in its initial stage.

PERFORMANCE OF FAST FREQUENCY-HOPPED *M*-ary FREQUENCY-SHIFT KEYING SYSTEMS OVER FADING CHANNELS WITH PARTIAL-BAND INTERFERENCE

R. Clark Robertson, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Research Initiation Program
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project is to determine the Electronic Counter-Counter Measures (ECCM) potential of various FFH/MFSK communications systems under conditions of worst case hostile Electronic Counter Measures (ECM) and fading channels.

SUMMARY: To date the uncoded performance of three fast frequency-hopped *M*-ary orthogonal frequency-shift keying (FFH/MFSK) communication systems with noncoherent detection have been evaluated: systems with linear combining, noise-normalization (also referred to as adaptive gain control) combining, and self-normalization combining. In addition, the performance of FFH, binary FSK communication systems with ratio-statistic combining has also been evaluated. All of these receivers have been examined assuming worst case hostile Electronic Counter Measures (ECM) are operational during communications. Finally, the effect of Doppler shift of the received signal on the noise-normalization receiver has been evaluated.

There are three primary areas for further research that are currently under investigation. First, the performance of the nonideal noise-normalized demodulator is of particular interest since the ideal noise-normalized demodulator is so robust under conditions of worst case hostile ECM. The effectiveness of the noise-normalized receiver requires an accurate measurement of the noise power present in each hop, and the effect of inaccurately measuring noise power must be examined in order to determine how graceful receiver degradation is as noise power measurement inaccuracy increases. Second, the performance under conditions of worst case hostile ECM and fading has been obtained for three of the four FFH/MFSK systems initially proposed for investigation, but to date the ratio-statistic combining receiver has been examined only for the binary case. Since the binary ratio-statistic combining demodulator is somewhat more robust than the binary self-normalized combining demodulator under conditions of worst case hostile ECM and fading, the performance of the FFH/MFSK ratio-statistic combining receiver will be evaluated and compared to that of the FFH/MFSK self-normalized combining receiver. Third, all results obtained thus far have assumed a fading information signal and a nonfading jamming signal. This yields worst case performance and may be overly pessimistic. Hence, the final phase of the research is to extend previous

results to account for fading of the jamming signal as well as the information signal.

PUBLICATIONS: Robertson, R.C. and K.Y. Lee, "Performance of fast frequency-hopped MFSK receivers with linear and self-normalization combining in a Rician fading channel with partial-band interference," *IEEE Journal on Selected Areas in Communications*, Vol. 10, No. 4, pp. 731--741, May 1992.

Robertson, R.C. and T.T. Ha, "Error Probabilities of Fast Frequency-hopped FSK with Self-normalization Combining in a Fading Channel with Partial-band Interference," *IEEE Journal on Selected Areas in Communications*, Vol. 10, No. 4, pp. 714-723, May 1992.

Robertson, R.C. and T.T. Ha, "Error Probabilities of Fast Frequency-hopped MFSK with Noise-normalization Combining in a Fading Channel with Partial-band Interference," *IEEE Transactions on Communications*, Vol. 40, No. 2, pp. 404-412, February 1992.

PRESENTATIONS: Robertson, R.C., T.W. Vece, and T.T. Ha, "Performance of a Fast Frequency-hopped DFT-based MFSK Receiver with Noise-normalization Combining in a Fading Channel with Partial-band Interference, "Proceedings of 1992 IEEE Military Communications Conference, Vol. 1, pp. 48-52, 1992.

R.C. Robertson, J.F. Riley, and T.T. Ha, "Error Probabilities of Fast Frequency-hopped FSK with Ratio-statistic Combining in a Fading Channel with Partial-band Interference," Proceedings of 1992 IEEE Military Communications Conference, Vol. 3, pp. 865-869, 1992.

Robertson, R.C. and K.Y. Lee, "Performance of Fast Frequency-hopped MFSK Receivers with Linear Combining in a Rician fading channel with Partial-band Interference," Proceedings of 25th Asilomar Conference on Signals, Systems, and Computers, Vol. 2, pp. 851--855, 1991.

THESIS DIRECTED: Betancourt, M.A., Major, Venezuelan Air Force, "Coded Performance of a Fast Frequency-hopped Noncoherent BFSK Ratio-statistic Receiver over a Rician Fading Channel with Partial-band Interference," Master's Thesis, September 1992, co-advisor.

EVALUATION OF ANTENNA CHARACTERISTICS BASED ON AVAILABLE INFORMATION

R. Clark Robertson, Associate Professor
Department of Electrical and Computer Engineering
Sponsor and Funding: Naval Maritime Intelligence Center

OBJECTIVE: The purpose of this research program is to develop a set of user friendly mathematical applications capable of computing the radiation pattern and other pertinent antenna parameters of an antenna or antenna system based available information.

SUMMARY: It is important to be able to obtain as specific an idea as possible of the capabilities,

limitations, and vulnerabilities of a particular antenna or antenna system. Oftentimes, the only information available is that of a photograph of the system under investigation and the physical size of the system. Generally, this will primarily be information obtained from a photograph and the physical dimensions of the antenna or antenna system; although, the applications are flexible to the extent that they make their computation based on whatever information is available. The mathematical applications are designed to be operated by an engineer familiar with basic antenna types. All mathematical applications are based on existing engineering equations for the antenna type under consideration. A number of applications for various antenna types have been completed. At this time, two students are continuing work on the remaining antenna types to be considered for their Master's theses.

THESIS DIRECTED: Dietrich, D.S., "Predicting Radiation Characteristics From Antenna Physical Dimensions," Master's Thesis, December 1992, advisor.

MAPPING HARD REAL TIME APPLICATIONS ON LOOSELY COUPLED MULTIPROCESSORS

Shridhar B. Shukla, Assistant Professor
Department 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 multiprocessors to guarantee performance. The emphasis is on task allocation to minimize contention-based communication cost and on contention-free message routing.

SUMMARY: Current multicomputer mapping strategies are unsuitable for hard real-time applications because different mapping stages do not relate to each other very well, and therefore, make performance guarantees difficult to achieve. In this project, an integrated mapping strategy with a task allocation algorithm that minimizes the number of hot-spots in the network has been developed. It is based on a routing technique that generates and executes a distributed message transmission schedule computed using time bounds on individual messages. Simulation experiments on various 64 node multicomputer topologies have shown that routing and allocation based on contention yield mappings with guaranteed performance.

OTHER: Shukla, S.B. and D.P. Agrawal, "On Mapping Periodic Real-time Applications On Multicomputers," revised for the *IEEE Transactions on Parallel and Distributed Computing*.

COMPILE-TIME SUPPORT FOR THE PROCESSING GRAPH METHODOLOGY ON THE AN/UYS-2 PARALLEL SIGNAL PROCESSOR

Shridhar B. Shukla, Assistant Professor
Department of Electrical and Computer Engineering
Amr Zaky, Assistant Professor
Department of Computer Science
Sponsor and Funding: Naval Sea Systems Command

OBJECTIVE: The goal of this continuing project is to develop a methodology for determining the optimal chains of primitives in processing graph methodology (PGM) applications running on the AN/UYS-2.

SUMMARY: Performance of the AN/UYS-2 can be improved if the primitives of the PGM graph are chained together appropriately. In order to construct the best possible chains automatically instead of manually, a framework, based on a technique called revolving cylinder scheduling, was developed. This technique is based on mapping the graph at compile-time on a cylinder whose curved surface area is determined by the number of processors and graph characteristics such as primitive computation times and data arrival rate. The potential of this technique for chaining as well as for predictable execution was demonstrated by building a simulator for the AN/UYS-2. Work is in progress to determine the feasibility of deploying this technique in the actual AN/UYS-2 programming environment. Two theses have been completed and three more are in progress as part of this work.

CONFERENCE PRESENTATION: Shukla, S.B., B. Little, and A. Zaky,"A Compile-time Technique for Controlling Real-time Execution of Task-level Data-flow Graphs," International Conference on Parallel Processing, St. Charles, Illinois, August 1992. Won the Outstanding Paper Award.

THESIS DIRECTED: Little, B.S., LT, USN, "A Technique for Predictable Real-time Execution in the An/UYS-2 Parallel Signal Processing Architecture," Masters Thesis in Electrical Engineering, December 1991.

Bell, H., LT, USN, "A Compile-time Approach for Chaining in the AN/UYS-2 Parallel Signal Processor," Master's Thesis, March 1992.

OTHER: Shukla, S.B. and B.S. Little, "A Technique for Predictable Real-Time Execution in the An/UYS-2 Parallel Signal Processing Architecture," NPS Technical Report, NPSEC-92-002, 1992.

A FRAMEWORK FOR NODE FAILURE/REPAIR TRANSPARENCY IN DISTRIBUTED REAL-TIME SYSTEMS

Shridhar B. Shukla, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor and Funding: Naval Postgraduate School

OBJECTIVE: This project deals with the design and implementation of the primitives required to manage the communication and reconfiguration in robust distributed, real-time combat platforms.

SUMMARY: In the first year of this project, an independent mechanism for maintaining group membership in an asynchronous distributed environment has been developed. A membership protocol that ensures agreement and consistent commit actions among group members to maintain a sequence of identical group views in spite of continuous changes, either voluntary or otherwise, in processors' membership status has been developed. Such consistency among group views must be guaranteed using messages over a network which does not bound message delivery times. This protocol is based on ordering of group members in a logical ring that eliminates the need for any centralized commit responsibility typically used in such protocols. The protocol correctness has been proven formally.

THESIS DIRECTED: Raghuram, D., Scientist, DoD, India, "Design and Implementation of a Group Membership Protocol," Master's Thesis, September 1992.

SONAR SIGNAL MODELING AND CLASSIFICATION

Charles W. Therrien, Professor
Department of Electrical and Computer Engineering
Sponsor and Funding: Naval Underwater Systems Center

OBJECTIVE: To develop new technology for modeling and classifying passive sonar signals.

SUMMARY: Short duration (transient) signals received on a submarine's passive sonar are of possible use in detection and characterization of other similar vehicles. The work on this project has focused on two related problems. First we have been developing models for these signals that could lead to their efficient coding and accurate reproduction. Secondly we have investigated a scheme for classification of these short-duration signals using the signal models and certain aspects of Markov random process theory.

PUBLICATIONS: Therrien, C.W., "Summary Report on Sonar Signal Modeling," NPS Technical Report, NPSEC-93-001, October 1992.

PRESENTATION: Therrien, C.W., "Sonar Signal Modeling," ONT 3rd annual Full Spectrum Review, New London, CT, September 1992.

THESES DIRECTED: Johnson, T.P., LT, USN, "ARMA Modeling Methods for Acoustic Signals," Master's Thesis, March 1992.

Iacovetta, J.M., LT, USN, "Sensitivity of ARMA Model Parameters to the Effects of Propagation," Master's Thesis, June 1992.

Delaney, K.J., LCDR, USN, "Classification of Short-Duration Nonstationary Signals," Ph.D. Dissertation, March 1992.

ARMA MODELING OF ACOUSTIC DATA

Charles W. Therrien, Professor
Department of Electrical and Computer Engineering
Sponsor and Funding : Advanced Research Project Agency (ARPA)

OBJECTIVE: To develop ARMA signal models for some specific sonar data sets of interest to DARPA contractor ORINCON. To transfer the modeling technology to ORINCON and DARPA for their possible use in the DANTES program.

SUMMARY: This was a small effort to explore the use of sonar signal modeling techniques for possible use in the DANTES program. We worked with data selected by ORINCON to develop signal models. The models developed were able to produce synthetic data that accurately resembles the original data in various tests that were applied. The tests involved, comparison of the time series, comparison of spectrograms, and similar time/frequency representations, and audio comparison by "listening" to the signals.

RESEARCH IN MULTIDIMENSIONAL SIGNAL PROCESSING

Charles W. Therrien, Professor
Murali Tummala, Associate Professor
Department of Computer and Electrical Engineering
Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: Development of iterative algorithms for block matrix equation solution for multidimensional spectral analysis and other applications and on transient signal modeling and classification.

SUMMARY: Several fixed-data as well as data-adaptive algorithms for block matrix iterative solution have been investigated. Multigrid techniques to improve the convergence rate of the previously developed iterative algorithms have been studied. These algorithms have been applied to parameter estimation of both AR, 2-D AR, and ARMA models, where significant increase in the convergence rates has been achieved. The increased convergence rate is realized by forcing the low frequency error components to appear to be at a higher frequency by transferring to a coarser sampling prior (or grid). Currently, the investigation is focussed on the development of intergrid transfer operators suitable for signal processing problems.

Short time ARMA modeling techniques for transients and other nonstationary data also continued during the current year. A new iterative modeling algorithm which we call the Iterative Prony method was developed. This new method has some advantages in terms of convergence over the Iterative Prefiltering method which heretofore was the method of choice for ARMA modeling.

PUBLICATIONS: Richter, D.A. and M. Tummala, "Iterative System Identification Using Multigrid Techniques," *Electronics Letters*, Vol. 28, No. 4, pp. 433--435, February 1992.

Parker, R.E. and M. Tummala, "Identification of Volterra Systems with a Polynomial Network," in Proceedings IEEE International Conference on Acoustics, Speech, and Signal Processing, San Francisco, CA, March 1992.

THESES DIRECTED: Richter, D.A., LT, USN, "Multigrid Algorithms for System Modeling," Master's Thesis, December 1991.

Velasco, C.H., LT, Columbian Navy, "ARMA Modeling of Signals in the Time Domain," Master's Thesis, December 1992.

SPACE SURVEILANCE

Harold A. Titus, Professor
Department of Electrical and Computer Engineering
Sponsor and Funding: Naval Space and Surveillance Center

OBJECTIVE: An Extended Kalman Filter will be developed to track the fence data. It will be compared with the present batch processing results and against targets of known orbit. Maneuver and atmospheric sensing and glitch rejection algorithms will be developed. Real time tracks with their own covariance ellipsoids will be displayed.

SUMMARY: Update of satellite ephemeris information in the space objects catalog is currently performed once a day using a batch least squares method. This update method has disadvantages:

--- the update takes several hours daily,

--- much of the real time information is lost and/or untimely.

It would be advantageous to have an ephemeris update method that was recursive and, therefore, real time,

--- maneuvers could be detected in a timely manner and

--- atmospheric drag compensation could be performed.

We would like to design a recursive algorithm for updating satellite ephemeris for the space objects catalog. We will need data and its format and information on the current algorithm. Long term data on a few (5--10) satellites would be more useful for algorithm development and testing. These orbits should be representative of the whole spectrum of satellites in the space catalog. It would be helpful if one or two of those satellites had maneuvered during the data acquisition period.

Once this algorithm is up and running, we will develop maneuver sensing and the drag compensation problem. At that point, the short term comprehensive data would be more useful for trying to model atmospheric drag variations.
We will need documentation on the current updata algorithm and data formats and what set of orbital elements is used. The statistics of the measurement noise and orbits will be most useful.

Solutions to the problem will be variation of an Extended Halman Estimator with a neural network

applied to the maneuver sensing and to the atmospheric drag modeling problem.

TORPEDO TRACKING

Harold A. Titus, Professor
Department of Electrical and Computer Engineering
Sponsor and Funding: Naval Underwater Engineering Station

OBJECTIVE: Our task was to develop a Kalman filter torpedo tracking program which incorporated the acoustic 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 Kalman 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

Harold A. Titus, Professor
Department of Electrical and Computer Engineering
Sponsor and Funding: U.S. Army and Space Intelligence Center

OBJECTIVE: The purpose of this effort was to support the Crossbow Comnmittee and several of their intelligence teams. We studied and simulated several Soviet missiles and attempted to develop techniques to counter them.

SUMMARY: We have studi 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 by Egypt in the 1973 war. 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 testing. 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.

PULSE SHAPING AND MODELING OF AN/FPN-42 AND AN/FPN-44A LORAN-C TRANSMITTERS

Murali Tummala, Associate Professor
Department of Electrical and Computer Engineering
Sponsor and Funding: U.S. Coast Guard

OBJECTIVE: Modernization of Coast Guard's LORAN-C tube transmitters by developing techniques for automatic pulse shaping and monitoring.

SUMMARY: Automatic pulse shape control is simulated for the AN/FPN-42 and AN/FPN-44A tube type LORAN-C transmitters. Pole-zero models are developed for each transmitter over a range of operating points, which are catenated to represent observed nonlinear behavior; observed effects of time variations due to aging and climatic changes are also included. A linear controller based on a steepest descent method is implemented to shape the LORAC-C pulse. These models, the control algorithm and transmitter system details, such as power supply droop, dual rating and noise, are then incorporated into a simulation program. In a variety of realistic tests, the control algorithm successfully shaped the LORAN-C pulse; however, the algorithm has exhibited a sensitivity to additive noise, and the zero-crossing times were not always in tolerance. The algorithm controlled envelope-to-cycle difference, produced an entire pulse-code-interval of LORAN-C pulse sequence while compensating for transmitter droop and phase code imbalance and produced a near-optimal transmitter drive waveform for the transmitter-antenna system using the dummy load.

THESIS DIRECTED: Bruckner, D.C., LT, USCG, "Automatic Pulse Shaping with the AN/FPN-42 and AN/FPN-44A LORAN-C Transmitters, Master's Thesis, December 1992.

ANALYSIS AND MODELING OF AIRCRAFT EMP TEST DATA

Murali Tummala, Associate Professor
Department of Electrical and Computer Engineering
Sponsor and Funding: Naval Air Warfare Center

OBJECTIVE: Application of time series modeling techniques to aircraft EMP test data for data compression and storage, and synthesis of strength waveforms by combining several test point responses.

SUMMARY: In the first phase of this on going project, we have developed techniques for data compression and strength waveform synthesis. The techniques used consist of test-point-measurement deconvolution using a fast Fourier transform method and autoregressive (AR) and autoregressive moving average (ARMA) modeling of data. The multiple test point measurements are first deconvolved of the double exponential electromagnetic pulse (EMP) excitation to obtain the impulse response between the antenna excitation and the test point. This data is then modeled using AR and ARMA techniques. A residual signal is generated by filtering the data, which is then decimated and converted

into a 4 bit sequence for storage; data compression ratios on the order of 32:1 with little loss of data fidelity were achieved. Finally, the strength waveform is synthesized by combining the poles (and zeros) of the time series models; the combination is achieved by using both vector quantization and competitive learning techniques. The software package developed to perform these operations will be delivered to NAWC in December 1992, which will be merged with their existing test database for aircraft EMP data analysis.

THESES DIRECTED: Tse, K.B., LT, USN, "Autoregressive and Autoregressive Moving Average Modeling of Aircraft EMP Test Data," Master's Thesis, December 1992.

EVALUATION OF DETAILED WAVEFORM ANALYSIS TOOLS FOR THE SIMULATION OF SHIPBOARD POWER SYSTEMS

Stephen M. Williams, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor and Funding: Advanced Research Projects Agency

OBJECTIVE: The proposed work will develop a set of metrics for evaluating power system detailed waveform analysis tools. The scope of shipboard electrical system problems must be defined. From this class of problems, a set of applicable analytic methods for estimating system electrical performance are identified. During the period of proposed research, one such tool will be parametrically evaluated for its potential usefulness in predicting the performance of shipboard electrical systems.

SUMMARY: The Navy has a definite requirement for a simulation tool for use in developing and studying advanced naval power systems. The need is brought about primarily due to the pending shift from the traditional engineering plant configuration of separate propulsion and electrical systems to an advanced power system integrating propulsion and power generating prime movers. Metrics developed from this project include software domain, modeling environment, algorithm robustness, implementation options, and supportability.

The program actually evaluated is a product from the Massachusetts Institute of Technology, WAVESIM. Results of the study indicated re-direction of Navy simulation efforts.

PUBLICATIONS: Brochard, P.E. and S.M. Williams, "Analysis of Simulation Tools for the Study of Advanced Marine Power Systems," NPS Technical Report to Naval Surface Warfare Center, September 1992.

THESIS DIRECTED: Brochard, P.E., LT, USN, "Analysis of Simulation Tools for the Study of Advanced Marine Power Systems," Master's Thesis, September, 1992.

MODELING AND CONTROL OF ADVANCED MODULAR POWER SYSTEM

Stephen M. Williams, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Advanced Research Projects Agency
Funding: Naval Surface Warfare Center

OBJECTIVE: The proposed work will assess the importance of load input impedances on the shipboard 155 VDC combat power bus. The objectives are to develop a criterion for establishing system stability based upon a minimum knowledge of system parameters and to formulate a control approach which ensures system stability under widely varying conditions.

SUMMARY: The David Taylor Research Center and the Naval Air Warfare Center have been investigating the possibility of instabilities occurring on the DC power bus present on shipboard combat systems and aircraft power systems. New dc power distribution systems have been proposed which radically differ from conventional designs.

The purpose of the proposed research is to assess the relative importance of system parameters with respect to system performance and instability. The system parameters to be studied are the negative impedance caused by constant power switching dc supplies, the system bus impedance, and the load input filter impedance. Additionally, control strategies for the switching dc supplies will be investigated as a way to increase the margin of system stability.

System instability may arise due to low system damping and excessive source inductance. The presence of constant power loads such as the switch mode power supplies in the 155 VDC SEA WOLF power system or the converter modules proposed for the Advanced Modular Power System (AMPS) can exacerbate and cause instability as well. Such constant power switching loads present a negative resistance to the system. The approach to establish stability design rules for the Advanced Modular Power System (AMPS) will utilize PSPICE simulations and Nyquist criterion. Nonlinear models of the switching power supplies will be used in dc and transient analysis studies. The transient analysis will provide time response of the system to sudden load or generator changes.

An ac analysis will be performed to obtain Nyquist plots of the source impedance with respect to the load impedance at all locations in the system. The impedance ratios thus derived will provide information necessary to establish absolute stability design rules. It is hoped that a relaxed set of design rules can be determined to replace conventional and more stringent rules. Finally, using the newly established design rules, a new control strategy for the switching power supplies will be developed. The control strategy must meet the often opposing constraints of system performance and system stability. It is expected that an iterative design process will yield an optimum strategy.

PUBLICATIONS: Colby, M. and S.M. Williams, "Simulation of the Advanced Modular Power System Using PSPICE," NPS Technical Report to Naval Surface Warfare Center, December, 1992.

PROTOTYPING OF BUCK-BOOST DC/DC CONVERTER

Stephen M. Williams, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor and Funding: Naval Surface Warfare Center

OBJECTIVE: The goal of this project was to verify component design in a proposed new shipboard electric plant scheme.

SUMMARY: The Navy is considering a new shipboard electric plant design. To verify technical aspects of the new design, electrically scaled experimental models of selected critical components are being constructed. One such component is the buck-boost dc/dc converter.

LT Stan Fox, USN, developed simulation tools which aided in the converter design. The main objective of the work required LT Fox to visit NSWC at Annapolis, MD for one quarter to assist in the construction of the experimental model.

The primary result of this research was the successful construction and testing of the buck-boost dc/dc converter prototype. This converter is currently undergoing extensive testing to aid in the design verification of the new electric plant design.

PUBLICATIONS: Fox, S.L. and S.M. Williams, "Buck-Boost dc/dc Converter Prototyping," Technical Report to Naval Surface Warfare Center, April 1992.

RECURSIVE RAY ACOUSTICS FOR THREE-DIMENSIONAL SPEEDS OF SOUND

Lawrence J. Ziomek, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Sea System Command (NAVSEA)
Funding: NAVSEA

OBJECTIVE: Continue to generalize the Recursive Ray Acoustics (RRA) Algorithm. The RRA Algorithm is a simple, fast, and accurate algorithm that can be used to compute the position, angles of propagation, travel time, and path length along a ray path and to draw ray trace plots for speeds of sound that are functions of all three spatial variables. Investigate the possiblity of performing sound-pressure level calculations using the RRA Algorithm.

SUMMARY: During this year, enhancement of the basic RRA Algorithm began. The RRA Algorrithm can now incorporate noise corrupted, environmental data such as sound speed versus depth data and bathymetric data as a function of down range. Orthogonal function expansions using orthonormal polynomials are used to represent both the sound speed and bathymetric data. Work also began on giving the RRA Algorithm the capability to perform sound-pressure level calculations that are fast, accurate, and valid (i.e., finite) at both turning points and focal points for depth-dependent sound-speed profiles. The sound-pressure level computer code has been written and is currently being tested. In agreement with NAVSEA, versions 1 and 1A of the RRA computer program, along with a

research paper describing the basic RRA Algorithm, was transferred to the Applied Research Laboratory of The Pennsylvania State University.

PUBLICATION: Ziomek, L.J., Recursive Ray Acoustics for Three-Dimensional Sound-Speed Profiles," *Naval Research Reviews*, One/1992, Vol. XLIV, pp. 54--55.

Ziomek, L.J., "Recursive Ray Acoustics for Three-Dimensional Sound-Speed Profiles," 123rd Meeting of the Acoustical Society of America, Salt Lake City, UT, May 11--15, 1992, *Journal of the Acoustical Society of America*, Vol. 91, No. 4, Part 2, p. 2391.

OTHER: A half-day tutorial on "Advances in 3D Ray Acoustics" was presented at OCEANS 92, October 26--29, 1992, Newport, RI. The annual OCEANS conference is sponsored by the IEEE Society of Oceanic Engineering.

DEPARTMENT OF
Electrical and Computer Engineering

1992
Faculty Publications
and Presentations

TECHNICAL REPORTS

Dueck, G.W., Earle, R.C., Tirumalai, P.P., and Butler, J.T., "Multiple-Valued Programmable Logic Array Minimization by Simulated Annealing," NPS Technical Report, NPS-EC-92-004, 1992.

Hippenstiel, R., "Characterization/Feature Extraction from Non-Stationary Signals," NPS Technical Report, NPSEC-93-004, December 1992.

Janaswamy, R., "Widebanding Techniques for VHF Antennas--I," NPS Technical Report, NPSEC-92-010, September 1992.

Lee, H.-M. and Han, Y.Y., "Exponential Representation and Consistency Checking for M-Layer," NPS Technical Report, NPSEC-92-005, March 1992.

Soderstrand, M.A., Rangarao, K.V., and Loomis, H.H., Jr., "New Algorithms for the Detection and Elimination of Sine Waves and Other Narrow-Band Signals in the Presence of Broadband Signals and Noise," NPS Technical Report, August 1992.

Shukla, S.B. and Raghuram, D., "Group Membership In Asynchronous Distributed Environments Using Logically Ordered Views," NPS Technical Report, NPS-EC-92-009, September 1992.

Shukla, S. B., Little, B., and Zaky, A., "Real-Time Execution Control of Task-Level Data-Flow Graphs Using A Compile-time Approach," NPS Technical Report, NPSEC-92-007, April 1992.

Therrien, C.W. and Freer, D., "Image Processing Toolbox for use with MATLAB," NPS Technical Report, June 1992.

Therrien, C.W., Scout, J.B., and Tummala, M., "Detection of BPSK Signals Using the ESPRIT Method," NPS Technical Report, NPSEC-92-008, August 1992.

Therrien, C.W., "Summary Report on Sonar Signal Modeling," NPS Technical Report, NPSEC-93-001, October 1992. [SECRET-NOFORN]

Therrien, C.W., Tummala, M., and Wellington, C.H., "Application of a Back Propagation Neural Network for Noise Cancellation," NPS Technical Report, NPSEC-93-002, November 1992.

Therrien, C.W., "Adaptive Noise Cancellation Applied to the NUWES Test Range," NPS Technical Report, NPSEC-93-003, November 1992.

Tummala, M., Therrien, C.W., and Herdegen, D.W., "Adaptive Noise Cancellation Applied to NUWC Test Ranges," NPS Technical Report, NPSEC-93-002, November 1992.

Brochard, P.E. and Williams, S.M., "Analysis of Simulation Tools for the Study of Advanced Marine Power Systems," NPS Technical Report, Naval Surface Warfare Center, September 1992.

Fox, S.L. and Williams, S.M., "Buck-Boost dc/dc Converter Prototyping," NPS Technical Report, Naval Surface Warfare Center, April 1992.

Williams, S.M., "Proposed Requirements for an Electric Power Engineering Option at the Naval Postgraduate School," report to Commander, Naval Sea Systems Command, May 1992.

Colby, M. and Williams, S.M., "Simulation of the Advanced Modular Power System Using PSPICE," NPS Technical Report, Naval Surface Warfare Center, December 1992.

JOURNAL ARTICLES

Schueller, K.A. and Butler, J.T., "On the Design of Cost-Tables for Realizing Multiple-Valued Circuits," *IEEE Transactions on Computers*, February 1992, pp. 178--189; this is an extended version of K.A. Schueller, P.P. Tirumalai, and J.T. Butler, "Analysis of the Cost Table Approach to the Design of Multiple-Valued Circuits," Proceedings of the 1986 International Symposium on Multiple-Valued Logic, May 1986, pp. 42-50.

Fargues, M.P. and Beex, A.A., "Analysis of Clock Jitter in Switched-Capacitor Systems," *Transactions on Circuits and Systems, Part 1: Fundamental Theory and Applications*, Vol. 39, No. 7, pp. 506-519, July 1991.

Fouts, D.J., "A Gallium Arsenide Digital Phase Shifter for Clock and Control Signal Distribution in High-Speed Digital Systems," *IEEE Journal of Solid State Circuits*, Vol. 27, No. 5, pp. 802-809, May 1992.

Hippenstiel, R., Chaulk, E., and Miller, J., "An Adaptive Tracker for Partially Resolved Acoustic Arrivals with Application to Ocean Acoustic Tomography," *Journal of the Acoustical Society of America*, Vol. 92, No. 3, pp. 1759-1762, September 1992.

Janaswamy, R., "Oblique Scattering from Lossy Periodic Structures with Application to Anechoic Chamber Absorbers," *IEEE Transactions on Antennas and Propagation*, Vol 40, No. 2, pp. 162-169, February 1992.

Janaswamy, R., "2-D Radiation Boundary Conditions on an Arbitrary Outer Boundary," *Microwave and Optical Technology Letters*, Vol. 5, No. 8, pp. 393-395, July 1992.

Janaswamy, R., "A Fredholm Integral Equation Approach to Propagation Predictions over Small Terrain Irregularities," *IEEE Transactions on Antennas and Propagation*, Vol 40, No. 11, November 19[illegible].

Lamm, A.W. and Hussain, A.M., "Performance Analysis of Direct-Detection Optical CDMA Communication Systems with Avalanche Photodiodes," *IEEE Transactions on Communications*, Vol. COM-40, No. 4, pp. 810-820, April 1992.

Lamm, A.W., "Arbitrary Tight PBE Bounds for Optical CDMA Communications," *IEE Electronics Letters*, Vol. 28, No. 12, pp. 1139-1140, June 1992.

Lamm, A.W. and Ozluturk, F.M., "Performance Bounds for DS/SSMA Communications with Complex Signature Sequences," *IEEE Transactions on Communications*, Vol. COM-40, No. 10, pp. 1607-1614, October 1992.

Miller, J.H. and Chiu, C.-S., "Localization of the Sources of Short Duration Acoustic Signals," *Journal of the Acoustical Society of America*, Vol. 92, No. 5, pp. 2997-2999, 1992.

Lynch, J.F., Newhall, A.E., Miller, J.H., and Chiu, C.-S., "Three Dimensional Ray Acoustics in a Realistic Ocean," in *Ocean Prediction and Acoustic Propagation Models*, D. Lee and A. Robinson, editors, accepted September 1992.

Miller, J.H., Lynch, J.F., Chiu, C.-S., Westreich, E.L., Gerber, J., Hippenstiel, R., and Chaulk, E., "Acoustic Measurements of Surface Gravity Wave Spectra in Monterey Bay using Travel Time Fluctuations," *Journal of the Acoustical Society of America*, accepted November 1992.

Morgan, M.A. and Welch, T.B., "Field Feedback Computation of Scattering by 2-D Penetrable Objects," *IEEE Trans. Antennas and Propagation*, vol. AP-40, pp. 202-206, April 1992.

Morgan, M.A., "Research in Ultra-Wideband Impulse Radar Target Identification," *Naval Research Reviews*, One/1992, Vol. XLIV, pp. 28-34, 1992.

Pace, P.E., Ramoorthy, P.A., and Styer, D., "High-Resolution Rechnique for Guided-Wave Analog-to-Digital Converters," *Electronics Letters*, Vol. 28, pp. 2174-2175, November 1992.

Pieper, R.J., Raj, K., and Poon, T.-C., "A Visibility Dependent Depth of Focus for Incoherent Sinusoidal Sources," *Applied Optics*, Vol. 31, No. 7, pp. 977-986, March 1992.

Varnum, K.C.M. and Robertson, R.C., "Error Probabilities of Coherent Optical Heterodyne FSK--CDMA Signals in a Noncoherent Detection System Degraded by Laser Phase Noise," *Journal of Optical Communications*, Vol. 13, No. 3, pp. 85-92, September 1992.

Robertson, R.C. and Lee, K.Y. Lee, "Performance of Fast Frequency-Hopped MFSK Receivers with Linear and Self-Normalization Combining in a Rician Fading Channel with Partial-Band Interference," *IEEE Journal on Selected Areas in Communications*, Vol. 10, No. 4, pp. 731-741, May 1992.

Robertson, R.C. and Ha, T.T., "Error Probabilities of Fast Frequency-Hopped FSK with Self-Normalization Combining in a Fading Channel with Partial-Band Interference," *IEEE Journal on Selected Areas in Communications*, Vol. 10, No. 4, pp. 714-723, May 1992.

Robertson, R.C. and Ha, T.T., "A Model for Local/Mobile Radio Communications with Correct Packet Capture," *IEEE Transactions on Communications*, Vol. 40, No. 4, pp. 847-854, April 1992.

Robertson, R.C. and Ha, T.T., "Error Probabilities of Fast Frequency-Hopped MFSK with Noise-Normalization Combining in a Fading Channel with Partial-Band Interference," *IEEE Transactions on Communications*, Vol. 40, No. 2, pp. 404-412, February 1992.

Healey, A., McGhee, R., Cristi, R., Papoulias, F., Kwak, S., Kanayama, Y., Lee, Y., Shukla, S., and Zaky, A., "Research on Autonomous Underwater Vehicles at the Naval Postgraduate School," *Naval Research Reviews*, Vol. XLIV, 1992 (1).

Bourke, R.H., Chiu, C.-S., Lynch, J.F., Miller, J.H., Muench, R.D., and Plueddemann, A.J., "Initial Results from the Barents Sea Polar Front Experiment," Eos, *Transactions, American Geophysical Union*, Vol. 73, No. 43, p. 289, 1992.

Siomacco, E.M. and Tummala, M., "Parametric Modeling of Integrated Circuit Interconnections," *IEEE Transactions on Circuits and Systems, II: Analog and Digital Signal Processing*, Vol. 39, No. 6, pp. 377-382, June 1992.

Richter, D.A. and Tummala, M., "Iterative System Identification Using Multigrid Techniques," *Electronics Letters* (IEE Publication), Vol. 28, No. 4, pp. 433-435, February 1992.

Ziomek, L.J. and Brackenridge, R.P., "Estimation of the Spherical Coordinates of Multiple Broadband Targets via Adaptive Beamforming and Nonlinear Least Squares," *Journal of the Acoustical Society of America*, Vol. 91, pp. 2799-2804, 1992.

Ziomek, L.J., "Recursive Ray Acoustics for Three-Dimensional Sound-Speed Profiles," 123rd Meeting of the Acoustical Society of America, Salt Lake City, UT, May 1992, *Journal of the Acoustical Society of America*, Vol. 91, No. 4, Part 2, p. 2391.

Ziomek, L.J., "Recursive Ray Acoustics for Three-Dimensional Sound-Speed Profiles," *Naval Research Reviews*, One/1992, Vol. XLIV, pp. 54-55, 1992.

CONFERENCE PUBLICATIONS

Butler, S.W. and Butler, J.T., "Profiles of Topics and Authors of the International Symposium on Multiple-Valued Logic," Proceedings of the International Symposium on Multiple-Valued Logic, May 1992, pp. 372-379.

Dueck, G.W., Earle, R.C., Tirumalai, P.P. and Butler, J.T., "Multiple-valued Programmable Logic Array Minimization by Simulated Annealing," Proceedings of the International Symposium on Multiple-Valued Logic, May 1992, pp. 66-74.

Fargues, M.P. and Ferreira, M.P., "Adaptive RRQR-Based Factorization: Improving the Algorithm Tracking Capabilities," 26th Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, October 1992.

Janaswamy, R., "A Fredholm Integral Equation Approach to Propagation over Irregular Terrain," IEEE International Antennas and Propagation Symposium, Chicago, July 1992.

Lamm, A.W., "Error Probability Bounds for APD Based Optical CDMA Communications," Proceedings of the 1992 Conference on Information Sciences and Systems, Princeton University, p. 107, March 1992.

Lamm, A.W., Tantaratana, S., and Vincent, P., "Effects of Fading and Modulation on Noncoherent PN Sequence Sequential Acquisition Schemes," Proceedings of IEEE Military Military Communications Conference, San Diego, pp. 17.1.1-17.1.5, October 1992.

Lee, C.-H., "Massively Interconnected Models for a Beamformer," Proceedings of the 1992 Complex System Engineering Synthesis Architecture Workshop, NSWC, July 1992.

Lee, C.-H., "Parallel Computing for Array Processing," Proceedings of the 26th Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, October 1992.

Lee, H.-M., "Earth Flattening Approximation and Fock's Theory for Low Altitude em Propagation Over the Ocean," Proceedings of the 1992 International Symposium on Antennas and Propagation, Sapporo, Japan, pp. 513-516, September 1992.

Lee, H.-M., "From Mie Solution to Fock's Theory for Short Range Propagation," Proceedings of the 1992 URSI International Symposium on Electromagnetic Theory, Sydney, Australia, pp. 351-353, August 1992.

Lee, H.-M. and Han, Y.Y., "Improvement of M-Layer: A Tropospheric Propagation Program," Digests of the Fifth Biennial IEEE Conference on Electromagnetic Field Computation, MP26, Claremont, California, August 1992.

Lee, H.-M., "Creeping Waves Over a Flattened Earth," Abstracts of the National Radio Science Meeting, Vol. 74, Boulder, Colorado, January 1992.
Michael, S., Proceedings of the 34th Midwest Symposium on Circuits and Systems, Vol. 1 and 2, June 1992.

Michael, S., "Analysis of Radiation Damage and Annealing Process in Advanced Solar Cells using DLTS Techniques," Proceedings of the 11th International Photovoltaic Solar Energy Conference, October 1992.

Pace, P.E., Ramamoorthy, P.A., and Styer, D., "Resolution Enhancement Technique for Guided-Wave Analog-to-Digital Converters," IEEE Lasers and Electro-Optics '92 Annual Proceedings, EOS2.2, pp. 372--373, November 1992.

De Paula, A. and Pieper, R.J., "A More Complete Analysis for Subnyquist Band-pass Sampling," 24th Southeastern Symposium on System Theory, pp. 20-24, March 1992.

Pendergraft, K. and Pieper, R.J., "Frequency Dependent Power Transmission of Transverse Waves Propagating in Nonuniform Materials," 24th Southeastern Symposium on System Theory, pp. 92-96, March 1992.

Moore, J.T. and Pieper, R.J., "Effects of the Paraxial Approximation on Propagation Impulse Responses," 24th Southeastern Symposium on System Theory, pp. 372-374, March 1992.

Ugarte, A.R. and Pieper, R.J., "A New Model for Predicting the MRTD Curve for Thermal Imagers," 24th Southeastern Symposium on System Theory, pp. 231-234, March 1992.

Ozluturk, F.M., Tantaratana, S., and Lam, A.W., "Probability of Bit Error for DS/SSMA Systems with MPSK Signaling and Complex Signature Sequences," Proceedings of IEEE Military Communications Conference, San Diego, pp. 35.5.1-35.5.5, October 1992.

Powers, J.P. and Netzer, D.W., "Automatic Particle Sizing from Rocket Motor Holograms, Practical Holography VI (1992), SPIE Vol. 1667, SPIE, Bellingham WA, pp. 136-145, 1992

Robertson, R.C., Vece, T.W., and Ha, T.T., "Performance of a Fast Frequency-Hopped DFT-Based MFSK Receiver with Noise-Normalization Combining in a Fading Channel with Partial-Band Interference," Proceedings of IEEE Military Communications Conference, Vol. 1, pp. 48-52, 1992.

Robertson, R.C., Riley, J.F., and Ha, T.T., "Error Probabilities of Fast Frequency-Hopped FSK with Ratio-Statistic Combining in a Fading Channel with Partial-Band Interference," Proceedings of IEEE Military Communications Conference, Vol. 3, pp. 865-869, 1992.

Parker, R.E. Jr., and Tummala, M., "Identification of Volterra Systems with a Polynomial Network," in Proceedings of the IEEE International Conference on Acoustics, Speech, Signal Processing, San Francisco, CA, March 1992.

Sasao, T. and Butler, J.T., "On the Analysis of an FPGA Architecture," Proceedings of the International Symposium on Logic Synthesis and Microprocessor Architecture, July 1992, pp. 162-168.

Walters, R.J., Summers, G.P., and Bruening, J., "A Detailed Study of the Photo-Injection Annealing of InP Solar Cells," Proceedings of the 12th Space Photovoltaic Research and Technology Conference, NASA Lewis Research Center, Cleveland, OH, October 20-22, 1992.

Watkins, B.E. and Tummala, M., "Multiple Stage Vector Quantization Using Competitive Learning," in Proceedings of the IEEE International Symposium on Circuits and Systems, San Diego, CA, May 1992.

Williams, S.M., Brownfield, G.T., and Duffus, J.W., "Harmonic Propagation on an Electric Distribution System: Field Measurements Compared with Computer Simulation," Proceedings of the Fifth International Conference on Harmonics in Power Systems, Atlanta, GA, September 1992.

Williams, S.M., Sityar, I., Rager, P., and Reitweisner, J., "Design of an Electric Power Interface Compatibility 200kVA Mobile Test Facility," Conference Record of the 1992 Industry Applications Society Annual Meeting, Houston, TX, October 1992.

CONFERENCE PRESENTATIONS

Jamali, J., Wood, S.L., and Cristi, R., "Experimental Validation of the Kroneker Product Godard Blind Adaptive Algorithm," 26th Asilomar Conference on Signals, Systems and Computers, Pacific Grove, CA, November 1992.

Fouts, D.J. and Gonter, T.C., "A Microprocessor Interface for Ferroelectric Capacitor Memory," 26th Annual Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, October 1992.

Billingsly, A., Fouts, D.J., and Hamming, R., "Memory Latency Reduction Using an Address Prediction Buffer," 26th Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, October 1992.

Fouts, D.J. and Gonter, T.C., "A Microprocessor Interface for Ferroelectric Capacitor Memory," 26th Annual Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, October 1992.

Billingsly, A., Fouts, D.J., and Hamming, R., "Memory Latency Reduction Using an Address Prediction Buffer," 26th Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, October 1992.

Robertson, R.C., Riley, J.F., and Ha, T.T., "Error Probabilities of Fast Frequency-Hopped FSK with Ratio-Statistic Combining in a Fading Channel with Partial-Band Interference," MILCOM 92, San Diego, CA.

Robertson, R.C., Vece, T. W., and Ha, T. T., "Performance of a Fast Frequency-Hopped DFT-Based MFSK Receiver with Noise-normalization Combining in a Fading Channel with Partial-Band Interference," MILCOM 92, San Diego, CA.

Jenn, D.C., "Solution of Inverse Scattering Problems Using a Method of Moments Approach," Applied Computational Electromagnetics Society, The Eigth Annual Review of Progress in Applied Computational Electromagnetics, March 1992.

Jenn, D.C., "Radar Cross Section Synthesis Using the Method of Moments," North American Radio Science Meeting, June 1992.

Lee, C.-H., "Simulated Annealing Applied to Acoustic Signal Tracking," SPIE/IS&T Symposium on Electronic Imaging Science and Technology, San Jose, CA, February 1992.

Szu, H., Yeh, C., Rogers, G., Jenkins, M., Farsaie, A., and Lee, C.-H., "Speed Up Performances on MIMD Machines," International Conference on Neural Networks, Baltimore, MD, June 1992.

Loomis, H.H., Jr. and Bernstein, R., Jr., "Realization of TDOA Estimation Architectures," Poster paper presented at the NSF Workshop of Cyclostationarity, W. A. Gardner, organizer, Yountville, CA, August 1992.

Loomis, H.H., Jr., "Digital Implementations of Cyclic Spectrum Analyzers," presented to the Governmnent Only Spread Spectrum Conference (GOSC), National Security Agency, May 1992.

Loomis, H.H., Jr., and Bernstein, R. F., Jr., "SSCA High Speed Parallel Architecture," Spread Spectrum Workshop, Naval Postgraduate School, Monterey, CA, April 1992.

Michael, S., "Analysis of Radiation Damage and Annealing Process in Advanced Solar Cells Using DLTS Techniques," 11th International Photovoltaic Solar Energy Conference, October 1992.

Lashkari, K., Denner, W.W., Miller, J.H., and Chiu, C.-S., "Monterey Bay Acoustic Environmental Monitoring System, 123rd Meeting of the Acoustical Society of America, Salt Lake City, May 1992.

Denner, W.W., Lashkari, K., Miller, J.H., and Chiu, C.-S., "Possible Uses of Submarine Canyons in Acoustic Thermometry," 124th Meeting of the Acoustical Society of America, New Orleans, October 1992.

Miller, J.H. and Chiu, C.-S., "Localization of the Sources of Short Duration Acoustic Signals in a Coastal Ocean Environment," 124th Meeting of the Acoustical Society of America, New Orleans, October 1992.

Moose, P.H., "Modulation and Coding for Bandwidth Efficient Mobile Radio Digital Communications," Monterey Bay Subsection of IEEE, May 1992 (invited presentation).

Powers, J.P. and Netzer, D.W., "Automatic Particle Sizing from Rocket Motor Holograms," Practical Holography VI (1992), February 1992.

Shukla, S.B., Little, B., and Zaky, A., "A Compile-time Technique for Controlling Real-time Execution of Task-level Data-flow Graphs," International Conference on Parallel Processing, St. Charles, Illinois, August 1992. (Won the Outstanding Paper Award).

BOOK CONTRIBUTIONS

Therrien, C.W., Discrete Random Signals and Statistical Signal Processing, (Englewood Cliffs, NJ: Prentice Hall Inc., 1992).

Morgan, M.A. and Larison, P.D., "Natural Resonance Extraction From Ultra-Wideband Scattering Signatures," Chapter in Ultra- Wideband Radar: Proceedings of the First Los Alamos Symposium, B.W. Noel, Ed., (Boca Raton, FL: CRC Press, Inc., 1992, pp. 203--215).

Morgan, M.A. and Walsh, N.J., "Ultra-Wideband Impulse Electromagnetic Scattering Laboratory," Chapter in Ultra-Wideband Radar: Proceedings of the First Los Alamos Symposium, B.W. Noel, Ed., (Boca Raton, FL: CRC Press, Inc., 1992, pp. 553--564).

WORKSHOP PRESENTATION

Fouts, D.J., "Testing High-speed Digital Integrated Circuits", Workshop on testing high-speed integrated circuits at the University of California at Santa Barbara, October 1992.

WORKSHOP PRESENTATION with published abstract (invited)

Therrien, C.W., "Signal Modeling for Passive Sonar Data," *3rd Annual ONT Full Spectrum Review*, September 1992, held at Naval Undersea Warfare Center, New London, CT. [SECRET-NOFORN]

SEMINAR PRESENTATION

Loomis, H.H., Jr., "Applications of Cyclostationarity to Signal Detection and Geolocation," presented to ECE Department Signal Processing Seminar, November 1992.

DEPARTMENT OF MATHEMATICS

Professor R.H. Franke
Chairman



DEPARTMENT OF MATHEMATICS

The research program of the Department of Mathematics seeks to advance the state of knowledge in areas important to the goals and mission of the Department of Defense, such as scientific and parallel computing, weather forecasting, fluid flow, orbital mechanics, image processing, and simulation and modeling.

Specific research areas of Mathematics Department faculty and students, including sponsor knowledge, is detailed later in this chapter. Below is a brief summarization of the Department of Mathematics research program.

SCIENTIFIC COMPUTATION AND APPLIED MATHEMATICS

The area of scientific computation includes both numerical (on serial and parallel computers), and analytical (symbolic) solutions to a variety of problems of interest to the Department of the Navy and the Department of Defense. Research has been continued by **Professors Neta** and **Gragg** to develop algorithms for the INTEL hypercube to solve problems of ordinary differential equations in parallel. Such systems appear in many areas of application, such as weather forecasting and prediction of satellite orbits.

Professors Danielson, Neta and several students are working on the parallelization of several existing codes for prediction of satellite orbits. The parallelization of the analytic algorithms in use at NAVSPASUR and AFSPACECOM is almost complete. A more accurate semianalytic model is now under investigation.

Professors Gragg, Thornton and **Borges** are working on parallel solutions (by divide and conquer) of eigenproblems.

Professor Neta is developing a finite element code for the solution of the shallow water equations on a massively parallel machine (MasPar).

On scientific, non-parallel computing, **Professor Franke** continues his work on scattered data approximation especially with application to meteorolical data. **Professor Franke** and **Professor Jayachandran** are continuing work on quality assessment problems for meteorological data.

Professor Henson is continuing his work with multigrid and multilevel methods as applied to image reconstruction. He is also working with Professor Rasmussen on multilevel approaches to improve the computational speed on some optimization problems in signal processing and path planning.

Professors Canright and Scandrett are continuing their work on transducer modeling.

Professor Canright is also continuing his work on welding problems as applied to the construction of ships and submarines. **Professor Scandrett** is also

working on scattering from double-hulled structures. **Professor Danielson** is also working on this project but his work is related to predicting the strength of stiffened plate structures.

Professor Frenzen is working with **Professor Scandrett** on non-acoustic ASW to detect upstream influences from internal waves created by submarines.

Professor Borges is continuing his work on quasi-Gaussian quadratures as applied to global illumination models and human color perception (electronic image processing). He is also working on model identification of reciprocal stochastic processes as applied to image processing.

Professor Peters is working on digital signal processing. **Professor Fakhroo** is working on active noise control problems.

DISCRETE MATHEMATICS

Professor Fredericksen continues his research in coding, information theory and digital communications. He is also working in cryptography.

Professor Leader is working on chaotic attractors as cryptographic keystream ciphers.

Professor Rasmussen is working on chromatic properties of certain graphs.

Professor Owen continues his research into game theory.

SIMULATION COMPUTATION

Professors Neta and Mansager are working on audio detection algorithms for incorporation into Janus combat model. **Professor Mansager** is also working in combat modeling to simulate the Javelin.

FURTHER APPLICATIONS OF QUASI-GAUSSIAN QUADRATURE AND NUMERICAL RECONSTRUCTION OF DIFFERENTIAL OPERATORS

Carlos F. Borges, Assistant Professor
Department of Mathematics
Sponsor: Research Initiation Program
Funding: Naval Postgraduate School

OBJECTIVE: Continued research into applications of the quasi-Gaussian quadrature method and continued research into the numerical reconstruction of differential operators. To date, research into quasi-Gaussian quadrature has focused on applications in electronic imaging. The second part, numerical reconstruction of differential operators, is a continuation of work with R. Frezza of the University of Padua, Italy. We are investigating methods for the reconstruction of differential operators from observations, especially operators associated with reciprocal stochastic processes, a generalization of the familiar Markov processes. We plan to apply these techniques to stochastic control theory and image compression.

SUMMARY: APPLICATIONS OF QUASI-GAUSSIAN QUADRATURE: This year I have published two papers on the quasi-Gaussian method and have a third manuscript on applications of these methods to color reproduction in the review process. There is a possibility that I may be able to get funding from the Fuji Photo Film Co. to pursue these investigations further. I have begun collaborations with V.R. Algazi of the Center for Image Processing and Integrated Computing at UC Davis on this and related areas in color reproduction an image processing.

NUMERICAL RECONSTRUCTION OF DIFFERENTIAL OPERATORS: This work was begun last year as a collaboration with Prof. R. Frezza of the University of Padua, Italy. Our goal is to develop effective numerical algorithms for reconstructing differential operators from observations. So far the work has focussed on reciprocal stochastic processes which are a generalization of Markov processes. These have very important applications in control theory and image processing and we are pursuing the inverse problem in the hopes of developing better methods in stochastic control and in image compression. We currently have one manuscript accepted, a second in review, and a third in preparation as a result of this work. The first is on model identification of Gaussian reciprocal processes and was presented at the Computation and Control conference in Bozeman, Montana this year. It will appear in *Progress in Systems and Control* early next year. The second is on numerical reconstruction of tridiagonal matrices, the discretized case, which has been submitted to the *Journal of Numerical Linear Algebra* and its Applications. The third is an extension of some of the ideas from the first and was solicited for the Journal of Mathematical systems, Estimation and Control. It should be completed by April 1993.

ANALYSIS OF THERMOCAPILLARY CONVECTION IN WELDING

D. R. Canright, Assistant Professor
Department of Mathematics
Sponsor and Funding: Office of Naval Research

OBJECTIVE: The goal of this project is to determine the scaling and structure of the "cold-corner singularity" in thermocapillary flow in weld pools. This is a continuing project.

SUMMARY: Recent work in modeling thermocapillary convection in materials processing, for example in the pool of liquid metal formed during welding, shows a region of rapid flow and intense heat transfer, concentrated in the "cold corner" region. A theoretical understanding of this region, currently lacking, is essential for accurate numerical models. The objective of this study is to analyze the coupled thermal and flow fields in this important region, including the dependence on the governing parameters. The results should be useful in developing more complete numerical models of the welding process, to understand how to make welds more reliable. In 1992, a thorough scaling analysis determined local scales for four different regimes of behavior, and their dependence on two dimensionless parameters. A robust computer code was developed for direct simulation of the coupled nonlinear flow/thermal system, including arbitrary grid spacing. Numerical simulations were computed for a wide variety of parameter pairs. These results showed the details of the structure in the corner as well as the transitions between regimes. The numerical results agreed with the scaling analysis.

CONFERENCE PRESENTATION: Canright, D., "Thermocapillary Convection Near a Cold Wall," 45th Annual Meeting of the Division of Fluid Dynamics of the American Physical Society, Tallahassee, FL, 22-24 November 1992.

DEVELOPMENT OF MATHEMATICAL MODELS FOR THE STRUCTURAL STABILITY OF BOUBLE HULL SHIPS

D. A. Danielson, Professor
Department of Mathematics
Sponsor and Funding: ATLSS Engineering Center, Lehigh University

OBJECTIVE: Improve the structural design of double hull ships.

SUMMARY: A proposed new surface ship hull concept consisting of a double skin that wraps around the bottom, sides, and main deck was modeled as a circular cylindrical shell surrounding an elastic core. Analytical formulas were obtained for the maximum stresses in the hull caused by end bending ments and lateral pressure loading. The formulas were applied to a new hull designed by David Taylor. The calculations indicate that the stiffness of the proposed bulkheads could be reduced without incurring significant secondary stresses in the double hull.

PUBLICATIONS: Danielson, D.A., "Analytical Strength Formulas for Ship Hulls," NPS Technical Report,

NPS-MA-92-005, 1992.

Danielson, D.A., "Analytical Strength Formulas for Ship Hulls," ATLSS Engineering Research Center Report TDL 91-01, Lehigh University, 28 January 1992.

ORBIT PREDICTION ON PARALLEL COMPUTERS

D. A. Danielson, Professor
B. Neta, Professor
Department of Mathematics
Sponsor: Naval Space Surveillance Center
Funding: Naval Space Surveillance Center and NPS Space Systems Academic Group

OBJECTIVES: To investigate the feasibility of using parallel computers to efficiently predict orbits of objects. To document and improve the orbit predictor Semianalytic Satellite Theory.

SUMMARY: Parallel versions of PPT2, the analytic orbit propagator currently in use by NAVSPASUR were developed and tested. A parallel version of SGP4, in use by USSPACECOM is currently under development. Semianalytic Satellite Theory is now being documented to facilitate parallelization in the future.

PUBLICATIONS: Danielson, D.A. and B. Neta, "Solution of Ordinary Differential Initial Value Problems on an INTEL Hypercube," *Computers and Mathmatics with Applications*, Vol. 23, 1992, pp. 65-72.

Danielson, D. A. and B. Neta, "Analysis of Finite Elements and finite Differences for Shallow Water Equations, A Review," *Mathmatics and Computers in Simulations*, Vol. 34, 1992, pp. 141-161.

Danielson, D.A. and B. Neta, "Parallel Computing May Improve Space Surveillance," *ONR Naval Research Review*, Vol. 44, 1992, p. 54.

Danielson, D. A. and B. Neta, "Solution of Ordinary Differential Initial Value Problems on an INTEL Hypercube with Applications to Orbit Determination," Proceedings of the 1992 Space Surveillance Workshop, M.I.T. Lincoln Laboratory, Lexington, MA, 7-9 April 1992, A.J. Coster and K.P. Schwan (eds.), Vol. 1, 1992, pp.205-208.

PRESENTATIONS: Danielson, D.A. and B. Neta, "Orbit Determination on Parallel Computers," Space Systems Seminar, NPS, 14 April 1992.

Danielson, D.A. and B. Neta, " Solutions of Ordinary Differential Initial Value Problems on an INTEL Hypercube with Applicationss to Orbit Determination," Space Surveillance Workshop, M.I.T. Lincoln Laboratory, Lexington, MA, 7-9 April 1992.

Danielson, D.A. and B. Neta, "Parallel Orbit Prediction," Twelfth Parallel Circus, North Carolina Supercomputer Center, Research Triangle Park, 31 October 1992.

THESIS DIRECTED: Phipps, Warren E., Jr., CPT, USA, "Parallelization of the NAVSPASUR Orbit Propagation Model," Master's Thesis, June 1992.

QUALITY ASSESSMENT OF METEOROLOGICAL DATA

R. Franke, Professor
T. Jayachandran, Professor
Department of Mathematics
Sponsor and Funding: Naval Research Laboratory (Monterey)

OBJECTIVE: The objective of the project is to investigate ways of assessing the quality of radiosonde observations. For observations that have a consistent bias, often due to radiation (either incoming from sunlight, or outgoing during the night- time), a scheme for the adaptive estimation of the bias and subsequent correction is investigated.

SUMMARY: Using data from the Adaptive Quality Control and Analysis Statistical Database maintained by the Naval Research Laboratory (Monterey), the long-term behavior of the radiosonde observation values minus forecast values in the geopotential height was investigated. A persistent bias consistent with solar radiation angles was observed for one type of radiosonde used in the U.S. In cooperation with personnel at NRL a parallel prediction run has been made using the operational system at Fleet Numerical Oceanography Center and an adaptive correction system to correct for consistent bias in the observed minus forecast values. Analysis of the data is presently underway.

OTHER: Baker, N., R. Franke, T. Jayachandran, The determination of radiosonde geopotential height biases by the Navy's global data assimilation system, preprint to appear in Preprints of the Eleventh Conference on Numerical Weather Prediction, January 1993.

SCATTERED DATA APPROXIMATION

R. Franke, Professor
Department of Mathematics
Sponsor: Naval Research Laboratory
Funding: Naval Postgraduate School

OBJECTIVE: The objective was the construction and evaluation of methods for approximation of functions of several variables from scattered data measurements.

SUMMARY: Two separate approaches were taken during the course of this project. One was construction of least squares approximations using multiquadric functions. The principal problem is the determination of locations at which to center the quadric basis functions, such locations being referred to as knots. Two algorithms were investigated: a greedy algorithm sequential algorithm for adding knots, and an optimization of knot locations with a fixed number of knots. It was discovered that near multiple knots tended to occur routinely, and this was determined to be a by-product of the limited local behavior possible from a single quadric function. Excellent fitting capability using only a few knots was found to be possible by optimizing on knot location. A approach was an investigation of interpolation by

multiquadric functions to given data while imposing constraints on the interpolation function. An algorithm has been implemented to compute constrained multiquadric functions, but further work is necessary to determine whether such approximations are reasonable to compute and use in applications.

Nonlinear Mode Coupling in Free Electron Lasers

C. L. Frenzen, Associate Professor
Deaprtment of Mathematics
Sponsor: Research Initiation Program
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project was to investigate nonlinear mode coupling in free electron lasers. The nonlinear evolution of two optical modes coupled to the electrons' electromagnetic field was studied in an attempt to understand sideband instabilities in free electron lasers.

SUMMARY: Nonlinear equations governing the evolution of the electron and optical fields in a free electron laser with two optical modes were derived and studied. These equations form an oscillatory system with slowly varying coefficients. The system was examined in the sustained resonance limit, when the electron energy is very close to the resonant energy of the principal optical mode. In this limit a second order nonlinear pendulum equation with slowly varying coefficients is obtained.

STABLE PARALLEL DIVIDE AND CONQUER ALGORITHMS FOR EIGENPROBLEMS AND SINGULAR VALUE PROBLEMS (1992)

William B. Gragg, Professor
John R. Thornton, Assistant Professor
Department of Mathematics
Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: To produce and analyze high quality parallel numerical software for real symmetric tridiagonal eigenproblems and bidiagonal singular value problems based on ideas of Gragg and Warner. To understand the difficulties of obtaining numerically orthogonal eigenvectors and to construct provably rigorous code for solving these problems.

SUMMARY: We (Gragg) had previously developed matlab codes for the real symmetric tridiagonal problem. The codes were not sufficiently well understood. There remained the problem of selecting which of the many variants the final code should consist of. John Thornton started from first principles and developed a fortran code with an eye toward hypercube implementation. Gragg worked on this project at the Interdisciplinary Project Center for Supercomputing (IPS) at the Swiss Federal Institute of Technology (ETH). This center has a small group

working on such problems, including Peter Arbenz and Kevin Gates. Two other visitors to ETH, Jack Dongarra and Christopher Beattie, were also interested in such algorithms and presented talks. Beattie used "modification" to solve the real symmetric definite generalized eigenproblem. His treatment required a "technical" condition that was not satisfied in general. Our approach using "extension" was quickly generalized to give a numerically stable solution of this basic problem and our matlab code was likewise generalized.

During this quiet time in Zuerich, away from NPS, Gragg was able to read, and quickly digest the essence of, a paper by Barlow which had been on his desk for over a year. Barlow used overly complicated techniques to do a backward error analysis of the Dongarra-Sorensen-Tang algorithm. In particular there was a simple inverse eigenvalue problem involved which had an explicit solution. Although Gragg had gotten some nontrivial inequalities in anticipation of further hard analysis, time was running out. Complete proofs were not (quite) in sight. Then came word, by e-mail, from Sorensen at Rice. Gu and Eisenstat at Yale had managed to get orthogonal eigenvectors, in working precision, without sep arithmetic. This was for the Cuppen-Dongarra-Sorensen approach, using "modification". Eisenstat kindly sent a draft of their manuscript, electronically, to Gragg on a Thursday. Over the weekend Gragg modified (with some emotional pain and loss of sleep) the Gu-Eisenstat approach to work also with our "extension" idea. A stable matlab code for the generalized problem, using one form of our zero finder, was running successfully. This work has been published with Carlos Borges. We have made some further improvements and the code seems to work extremely well, with about three iterations per eigenvalue, on average. An earlier (rare) problem of "overshoot" of the zeros seems to have been cured. The iteration is monotone, mathematically, and now seems so numerically. It seems within reach to prove the latter.

Bottom line. TDC is now numerically stable, and provably so. The error analysis of the Gu-Eisenstat approach is (not quite but almost) complete. But, their algorithm is LESS PARALLEL than that of Sorensen-Tang, using sep arithmetic!! Some inequalities in our "Zuerich notes" indicate that it may be possible to get a rigorous treatment of the latter. We hope to do this soon, with Borges.

PUBLICATIONS: Gragg, W.B., J.R. Thornton and D.D. Warner, "Parallel Divide and Conquer Algorithms for the Symmetric Tridiagonal eigenproblem and Bidiagonal Singular Value Problem," Modeling and Simulation, Vol. 23, Part 1, Willaim G. Vogt and Marvin H. Mickle (eds.), 1992, pp. 49-56.

PRESENTATIONS: Gragg, W.B., J.R. Thorton and D.D. Warner, "Parallel Divide and Conquer Algorithms for the Symmetric Tridiagonal Eigenproblem and the Bidiagonal Singular Value Problem," 23rd Pittsburgh Confewrence on Modeling and Simulation, Pittsburgh, PA, 30 April 1992.

Gragg, W.B., "Divide and Conquer Algorithms for Structured Eigenvalue Problems," Division of Optimization and Systems Thoery, Department of Mathmatics, Royal Institute of Technology, Stockholm, Sweden, 21 May 1992.

Gragg, W.B., "Jacobi Matrices and their Unitary Analogs," Department of

Mathmatics, University of Fribourg, Fribourg, Switzerland, 2 June 1992.

Gragg, W.B., " Flows on Jacobi and Unitary Hessenberg Matrices," Seminar for Applied Matmatics, Swiss Federal Institute of Technology, Zuerich, Switzerland, 24 June 1992.

Gragg, W.B., " Divide and Conquer Algorithms for Structure Eigenvalue Problems," Department of Mathmatics, University of Karlsruhe, Karlsruhe, Germany, 16 July 1992.

Graggg, W.B., "Stable Divide and Conquer Algorithms for Structured Eigenproblems," Department of Mathmatics, University of Bielefeld, Bielefeld, germany, 11 September 1992.

Gragg, W.B., " Stable Divide and Conquere Algorithms for Structured Eigenproblems," 1992 Shanghai International Conference on Numerical Linear Algebra and Its Applications, Shanghai, People's Republic of China, 28 October 1992.

MULTIGRID, MULTILEVEL, AND MULTILEVEL PROJECTION METHODS

Van Emden Henson, Assistant Professor
Department of Mathematics
Sponsor: NPS Research Council (Research Initiation Program)
Funding: Naval Postgraduate School

OBJECTIVE: To formulate theoretical foundations of the multigrid, multilevel, and multilevel projection method (PML), and apply them to several problems, specifically to the image reconstruction problem and to the solution of certain nonlinear PDEs.

SUMMARY: Multigrid and multilevel methods are numerical computation methods that take advantage of all of the scales of a problem in order to accelerate the convergence to the solution. Design and implementation of the methods, however, is not simple, and many workers have resisted using them because of their complexity. Recently a new approach called multilevel projection was formulated by Stephen F. McCormick which greatly simplifies the design and implementation of multilevel methods. This project investigates the theoretical foundation and the application of these methods to several types of problems, including solution and grid refinement methods for PDEs, specifically certain semilinear elliptic equations that arise in non-Newtonian fluid flow, and multilevel methods for image reconstruction (the Radon Transform problem).

OTHER: This project is ongoing research. While publications and conference presentations have not yet been produced, a paper entitled "Multilevel Projection Methods Applied to a Semilinear Elliptic Problem" has been accepted for presentation at the 6th Copper Mountain Conference on Multigrid Methods, scheduled for April, 1993, in Copper Mountain, Colorado. This is a joint paper with Professor Aihua Shaker, and will also be submitted to a refereed journal. In addition, this research, applied to image reconstruction, is the topic of the dissertation research of Major Bruce Robinson, USA, now in its initial stages.

MULTILEVEL APPROACHES TO OPTIMIZATION AND DISCRETE OPTIMIZATION PROBLEMS

Van Emden Henson, Assistant Professor
Craig W. Rasmussen, Professor
Department of Mathematics
Sponsor: NPS Research Council (New Initiative Program)
Funding: Naval Postgraduate School

OBJECTIVE: To devise techniques by which multilevel methodology can be applied to computationally slow optimization and discrete optimization problems, and to develop an underlying theory for these applications.

SUMMARY: Many problems in optimization and discrete optimization can be solved only by computationally slow, "grinding" processes. A similar computational "stalling" characterizes many of the classical iterative methods for solving partial differential equations (PDEs). Over the past fifteen to twenty years multigrid methods have been developed to solve these PDE problems, and have been tremendously successful. This research is intended to investigate the possibility that multigrid-like algorithms, called multilevel methods, can be developed for the computationally slow optimization and discrete optimization problems. Target problems include multicommodity flow, path planning, and signal processing problems.

OTHER: This project was unfunded in fiscal 1992, but has been funded for fiscal 1993. During 1992, however, several important accomplishments were completed. Under my direction, a Master's thesis was written by LT Kevin J. Cavanaugh, USCG, entitled "A Multilevel Approach to Minimum Cost Network Flows". This thesis includes new research performed by LT Cavanaugh, and features several positive results. A joint paper by Cavanaugh and Henson, including these results, has been accepted for presentation at the 6th Copper Mountain Conference on Multigrid Methods, scheduled for April, 1993, in Copper Mountain, Colorado. In addition, this research is to be the topic of a Master's thesis to be written by LT Annette Cornett, USN, to be jointly directed by Professors Craig Rasmussen and myself.

CHAOTIC ATTRACTORS AS CRYPTOGRAPHIC KEYSTREAM GENERATORS

Jeffery J. Leader, Assistant Professor
Department of Mathematics
Sponsor and Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project was to investigate the feasibility of using chaotic iterations possessing strange attractors as a method of generating running keystreams.

SUMMARY: In collaboration with thesis student LT Jim Heyman, the Henon map was thoroughly investigated as a possible pseudorandom keystream generator for additive stream ciphers. It was found that the resulting keystreams were balanced and had excellent autocorrelation and linear complexity profiles, but that the runs were poorly balanced;

n-tuples containing long runs of a single bit were more sparse than expected. A comparison to the standard method (linear feedback shift registers) was made. The extremely long periods of the Henon keystreams partially counterbalance the perfect runs properties of the shift register m-sequences. In addition, neural network-based pure keystream attacks were signifigantly more successful on the shift registers than on the Henon sequences. Other attacks and other attractors, including those of the Theodorus map, were also considered.

JAVELIN/TUG-V MODEL-TEST-MODEL

B.K. Mansager, Adjunct Professor
Department of Mathematics
Sponsor and Funding: Training and Analysis Command, Monterey

OBJECTIVE: The goal of this project is to further develop the M-T-M concept by investigating the influence of using combat simulations in the design of a field test and in posttest analysis.

SUMMARY: Began an effort to control variables within the Janus(A) combat model. Specifically, creating a "best fit" model representation of the Javelin and Tug-V systems, careful evaluation of the P_h and P_k data and analysis of the Ft. Hunter-Liggett terrain. Supervises a contractor effort to compare the M1A1 test to Janus(A) results.

PUBLICATIONS: Mansager, B.K. and B. Neta, "Audio Detection Algorithms," NPS Technical Report, NPS-MA-92-008, 1992.

CONFERENCE PRESENTATION: Mansager, B.K., "*MTM Process for Javelin*," Javelin TIWG, NPS, 27 August 1992.

AUDIO DETECTION ALGORITHMS

Beny Neta, Professor
Department of Mathematics
Sponsor and Funding: Training and Analysis Command, Monterey

OBJECTIVE: To develop sound algorithm and to incorporate it into the Janus simulation.

SUMMARY: It is known that audio cueing plays an important role in detection and acquisition of targets on the battlefield. Current combat simulations such as Janus play visual detection processes, and use them to generate target lists from which engagements are drawn. At present, there is not a comparable algorithm for playing audio cueing. The work proposed is designed to investigate how such cueing could be incorporated into the Janus simulation.

PUBLICATION: Neta, B. and B.K. Mansager, "Audio Cueing Algorithms," NPS Technical Report, NPS-MA-92-010, 1992.

MULTILINEAR EXTENSIONS OF GAMES AND THEIR APPLICATIONS

Guillermo Owen, Professor
Department of Mathematics
Sponsor and Funding: National Science Foundation

OBJECTIVE: This project is to generalize the theory of multilinear extensions of games and considers possible applications.

OTHER: "The Not-quite Non-atomic Game: Normal Approximation," accepted for publication by International Journal of Game Theory.

ASTRODYNAMIC STANDARDIZATION

I. B. Russak, Associate Professor
Department of Mathematics
Sponsor: Naval Weapons Center - Dahlgren, Virginia
Funding: Unfunded

OBJECTIVES: To develop a new high precision satellite tracking code for the Navy in order to use: 1) theory more current than that used in developing the existing tracking code some twenty years ago and 2) resolve discrepancies in tracking results among various military tracking codes.

SUMMARY: Based on groundwork laid out in a meeting between myself, Professor Neta and Dr. Knowles, the technical director of NAVSPASUR (coordinator of the Astrodynamic Standardization Project) in 1991 (see 1991 FAR) an understanding of the existing high precision satellite tracking codes both military and civilian is essential to the development of a new code for the Navy. The incorporation of the best of these will form the basis for a new code. Investigation into existing high precision satellite tracking codes has continued from 1991 into 1992 with the analysis (not yet complete) of codes from organizations such as Jet Propulsion Laboratory, TRW, etc.

DEPARTMENT OF MATHEMATICS

1992 Faculty Publications and Presentations

TECHNICAL REPORTS

Borges, Carlos F., "Some Inverse Problems For Jacobi And Arrow Matrices," NPS Technical Report, NPS-MA-93-002, July 1992-September 1992.

Borges, Carlos F., "Parallel Divide And Conquer Algorithm For The Generalized Real Symmetric Difinite Tridiagonal," NPS Technical Report, NPS-MA-93-009, September 1992 - December 1992.

Brunnett, Guido, "Elastic Curves On The Sphere," NPS Technical Report, NPS-MA-93-010, September 1992 - November 1992.

Canright, D., "Thermocapillary Flow Near A Cold Wall," NPS Technical Report, NPS-MA-93-011, January 1992 - December 1992.

Crouch, Peter E., "Elastic Curves On The Sphere," NPS Technical Report, NPS-MA-93-010, September 1992 - November 1992.

Danielson, D. A., "Analytical Strength Formulas For Ship Hulls," NPS Technical Report, NPS-MA-92-005, also released as an ATLESS Engineering Research Center Report, Lehigh University, 1992.

Franke, Richard, "Least Squares Surface Approximation To Scattered Data Using Multiquadric Functions," NPS Technical Report, NPS-MA-93-008, January 1992 - December 1992.

Frezza, Ruggero, "*Some* Inverse Problems For Jacobi And Arrow Matrices," NPS Technical Report, NPS-MA-93-002, July 1992 - September 1992.

Gragg, William B., "A Parallel Divided And Conquer Algorithm For The Generalized Real Symmetric Definite Tridiagonal Eigenproblem," NPS Technical Report, NPS-MA-93-009, September 1992 - December 1992.

Gragg, William B., "Some Inverse Problem For Jacobi And Arrow Matrices," NPS Technical Report, NPS-MA-93-002, July 1992 - September 1992.

Hagen, Hans, "Least Squares Surface Approximation To Scattered Data Using Multiquadric Functions," NPS Technical Report, NPS-MA-93-008, January 1992 - December 1992.

Leader, Jeffery J., "Power Iterations And The Dominant Eigenvalue Problem," NPS Technical Report, NPS-MA-93-007, March 1992 - June 1992.

Leader, Jeffery J., "Boundedness And Asymptotics Of The Generalized Theodorus Itertion," NPS Technical Report, NPS-MA-93-006, March 1992 - June 1992.

Mansager, B., "Audio Detection Algorithms, NPS Technical Report, NPS-MA-92-008, 1992.

Neta, Beny, "Finite Element Approximation Of The Shallow Water Equations On The Maspar," NPS Technical Reports NPS-MA-93-014, November 1992 - March 1993.

Neta, Beny, "Audio Detection Algorithms," NPS Technical Report, NPS-MA-92-008, 1992.

Neta, Beny, "Software for the Parallel Conservative Scheme for the Shallow Water Equations," (with L. Lustman) NPS Technical Report, NPS-MA-92-004, 1992.

Neta, Beny, "Audio Detection Algorithm," (with B. Mansager), NPS Technical Report, NPS-MA-92-010, 1992.

Nielson, Gregory M., "Least Squares Surface Approximation To Scattered Data Using Multiquadric Functions," NPS-MA-93-008, January 1992 - December 1992.

Schoenstadt, Arthur L., "The Utility Of HF Propagation Models For Predicting The Operating Frequency Of A Non-Cooperative Transmitter," NPS Technical Report, NPS-MA-93-005, August 1991 - October 1991.

Thanakij, Rex, "Finite Element Approximation Of The Shallow Water Equations On The Maspar," NPS Technical Report, NPS-MA-93-014, November 1992 - March 1993.

JOURNAL ARTICLES

Borges, Carlos, "Optemal Spectral Sampling for Color Imaging," Color Hard Copy and Graphic Arts, *SPIE*, Vol. 1670, February 1992, pp. 3353-358.

Canright, David, "*Review of MDEP*," CODE E Fall 1992: pp. 13-14.

Danielson, D.A., "Parallel Computing May Improve Space Surveillance," *Naval Research Reviews*, 1992.

Franke, Richard and McMahon, John R., "Knot Selection for Least Square Thing Plate Splines," *SIAM JSSC 13*, 1992, pp. 484-498.

Fredrickson, Hal, "Gray Codes and the Thue-Morse-Hedlund Sequence," *Journal of Combinatorial Mathematics and Combinatorical Computing 11*, April 1992, pp. 3-11.

Fredrickson, Hal, "A New Look at the deBruijn Graph," *Discrete Applied Mathematics*, (special issue on Interconnection Networks), October 1992, pp. 193-203.

Frenzen, Chris, "Error Bounds for Asymptotic Expansions of Gamma Function Ratios with Complex Arguments," *SIAM Journal on Mathematical Analysis*, Vol. 23, No. 2, March 1992, pp. 505-511.

Gragg, William B., "Solution of Ordinary Differential Initial Value Problems on an Intel Hypercube," (with L. Lustman and B Neta). *Computer Math. Applic.* 23 (1992) pp. 65-72.

Gragg, William B., "Downdating of Szego polynomials and Data fitting applications," (with G.S. Ammar and L. Reichel). *Linear Algebra Appl.* 72 (1992) pp. 315-337.

Gragg, William B., "Parallel Divide and Conquer Algorithms for the symmetric tridiagonal eigenproblem and bidiagonal singular value problem (with John R. Thornton and Daniel D. Warner), In *Modeling and Simulation,* Vol. 23, Part 1 (William G. Vogt and Marvin H. Mickle, Editors) pp. 49-56. University of Pittsburgh School of Engineering, 1992.

Neta, Beny, "Solution of Ordinary Differential Initial Value Problems on an INTEL Hypercube," (with L. Lustman and W. Gragg) *Computers and Mathematics with Applications,* Vol.23, 1992, pp. 65-72.

Neta, Beny, "Analysis of Finite Elements and Finite Differences for Shallow Water Equations, A Review," *Mathematics and Computers in Simulations,* Vol.34 1992, pp. 141-161.

Neta, Beny, "Parallel Computing May Inprove Space Surveillance," *ONR Naval Research Review,* Vol. 44, 1992, p.54.

Owen, G., Gilles, R. and Brink, R.V.D., "Games with Permission Stuctures, I: The Conjunctive Case," *International Journal of Game Theory,* 1992, pp. 277-293.

Owen, G., Borm, P., Tijs, S. and Nouweland, A.V.D., "On the Position Value for Communication Situations," *SIAM Journal of Discrete Mathematics,* 1992, pp. 305-320.

Owen, G., LeBreton, M. and Weber, S., "Strongly Balanced Games," *International Journal of Game Theory,* 1992, pp. 419-427.

Owen, G., "The Assignment Game: The Reduced Game," *Annales de L'Economie at la Satistique,* 1992, 71-79.

Owen, G., "The Finagle Poin for Characteristic Function Games," in *Rational Interaction,* ed. R. Selton, Springer (Berlin), 1992, 35-43.

Owen, G., and Maschler, M., "A Consistent Shapely Value for NTU Games," in *Rational Interaction,* ed. Selten, 1992, 5-12.

Owen, G., and Winetr, E., "The Multilinear Extension and the Coalitional Value," *Games and Economic Behavior,* 1992, 582-587.

Shaker, Aihua, "Acoustic Emission From a Nucleating Point Fracture in a Composite Plate," (co-authored); *Journal of American Acoustical Society,* 1992, pp. 2964-2976.

CONFERENCE PUBLICATIONS

Borges, Carlos, "Optimal Point Sampled Spectral Representations for computer Graphics Illumination Models," in Proceedings of the Second International Conference on Computational Graphics and Visualization Techniques, 14 December 1992, pp. 36-43, Lisbon, Portugal.

Borges, Carlos, "Optimal Spectral Sampling for Color Imaging," at Imaging Science and Technology: Electronic Imaging 1992 San Jose, CA., 13 February 1992.

Borges, Carlos, "On the Karhunen-Loeve Expansion and Model Identification of Reciprocal Stochasstic Processes," at Computation and Control III. Bozeman, Montana, 7 August 1992.

Borges, Carlos, "Optimal Point Sampled Spectral Representations for Computer Graphics Illumination Models," at Computer Graphics International 1992. Lisbon, Portugal, 14 December 1992.

Gragg, William B., "Inverse Problems for Orthogonal Matrices, Toda Flows, and Signal Processing," (with G.S Ammar and L. Faybusovich), in Proceedings of 31st. Conference on Decision and Control, (Tucson), pp. 1488-1493. IEEE, New York, 1992.

Neta, Beny. "Solution of Ordinary Differential Initial Value Problems on an INTEL Hypercube with Applications to Orbit Determination, " Proceedings of the 1992 Space Surveillance Workshop." M.I.T. Lincoln Laboratory, Lexington, MA, 7-9 April 1992, A.J. Coster and K.P. Schwan (eds.) Vol. i (1992) pp. 205-208.

CONFERENCE PRESENTATIONS

Canright, David and Davis, S.H., "Buoyant Convection niar a Solidifying Dendrite," Interactive Dynamics in Convection and Solidification (sponsored by NATO), Chamonix, France, 7-14 March 1992. (Short paper published in the conference proceedings.)

Canright, David, Baker, S.R. and Scandrett, C.L., " Applicaton of the T-matrix Method Workshop on Transducers for Sonics and Ultrasonics, Orlando FL, 6-8 May 1992.

Canright, David, "Thermocapillary Convection Near a Cold Wall," 45th Annual Meeting of the Division of Fluid Dynamics of the American Physical Society, Tallahassee, FL, 22-24 November 1992.

Fakhroo, Fariba, "Legendre-tour Approximation for an Active Noise Control Problem," Presented at SIAM Conference on Control and its Applications, September 1992.

Gragg, William B., "Algorithms for Updating QRP Factorizations," SIAM Regional Meeting, Kent State University, Kent Ohio, 13 March 1992.

Gragg, William B., "Updating and Downdating Szego Polynomials," SIAM Regional Meeting, Kent State University, Kent, Ohio, 14 March 1992.

Gragg, William B., "Parallel Divide and Conquer Algorithms for the Symmetric Tridiagonal Eigenproblem and the Bidiagonal Singular Value Problem." 23rd Pittsbugh Conference on Modeling and Simulation, Pittsburgh, Pennsylvania, 30 April 1992.

Gragg, William B., "Jacobi Matrices and Their Unitary Analogs," Division of Optimization and Systems Theory, Department of Mathematics, Royal Institute of Technology, Stockholm, Sweden, 17 May 1992.

Gragg, William B., "Divide and Conquer Algorithms for Structured Eigenvalue Problems," Division of Optimization and Systems Theory, Department of Mathematics, Royal Institute of Technology, Stockholm, Sweden, 21 May 1992.

Gragg, William B., "Jacobi Matrices and their Unitary Analogs," Department of Mathematics, University of Fribourg, Fribourg, Switzerland, 2 June 1992.

Gragg, William B., "Flows on Jacobi and Unitary Hessenberg Matrices. Seminar for Applied Mathematics, Swiss Federal Instutute of Technology, Zuerich, Switzerland, 24 June 1992.

Gragg, William B., "Divide and Conquer Algorithms for Structured Eigenvalue Problems. Departmentof Mathematics, University of Karlsruhe, Karlsruhe, Germany, 11 September 1992.

Gragg, William B., "Stable Divide and Conquer Algorithms for Structured Eigenproblems." 1992 Shanghai International Conference on Numerical Linear Algebra and Its Applications, Shanghai, People's Republic of China, 28 October 1992.

Gragg, William B., "Inverse Problems for Orthogonal Matrices, Toda flows, and Signal Processing, 31st IEEE Conference on Decision Control, Tucson, Arizona, 17 December 1992.

Neta, Beny, "Orbit Determination on Parallel Computers," Space Systems Seminar, NPS, 14 April 1992.

Neta, Beny, "Parallel Orbit Prediction," Twelfth Parallel Circus, North Carolina Supercomputer Center, Research Triangle Park, 31 October 1992.

Owen, G., "The Not-quite Non-atomic Game," at University of Florece Italy, 4 May 1992.

Owen, G., "Multi-person Bargaining," University of Florence 5 May 1992.

Owen, G., "The Not-quite Non-Atomic Game," University of Siena, Italy, 6 May 1992.

Owen, G., "Multi-person Bargaining," University of Bergamo, Italy, 8 May 1992.

Owen, G., "Recent Advances in Game Theory," University of Urbino, Italy, 12 May 1992.

Owen, G., "The Not-quite Non-atomic Game," University of Hamburg, Germany 18 May 1992.

Owen, G., "The Not-quite Non-atomic Game," University of Copenhagen, Denmark, 20 May 1992.

Owen, G., "Applications of Games to Discrete Mathematics and Operations Research," A sequence of three lectures for Landelijk Network of the Netherlands, given at Tilburg University, 25-27 May 1992.

Owen, G., "The Not-quite Non-atomic Game," University of California, Irvine, 4 June 1992.

Owen, G., "Indirect Control of corporations, University of Texas, Arlington, 13 November 1992.

Owen, G., "Indirect Control of Corporations," Mathematics Department Colloquium, October 1992.

Rasmussen, Craig, "Characterization of Graphs with Interval competition Graphs, Sixth SIAM Conference on Discrete Mathematics, University of British Columbia, Vancouver, B.C., June 1992.

BOOKS

Danielson, D.A., Vectors and Tensors in Engineering and Physics, Addison-Wesley, 1992.

Weir, M., Student's Study Guide, Parts I & II, 4th Ed. Supplement for CALCULUS by Thomas/Finney, Addison-Wesley Publishing Company, Reading MA, 379 Pages, May 1992.

ENCYCLOPEDIA ARTICLE

Owen, G., "Game Theory," in Encyclopedia of Physical Science, Vol. VII, pp. 37-44, (Academic Press, Orlando, FL., 1992).

WORKSHOP PRESENTATIONS

Leader, Jeffery, "Teaching ODEs with PHASER" at the conference/workshop "Teaching ODEs with Computer Experiments," Claremont, CA, 17 June 1992.

Gragg, William B., "Schur Flows," Workshop on Hamiltonian and Gradient flows, Algorithms and Control, Fields Institute for Research in Mathematical Sciences, Waterloo, Canada, 14 April 1992.

Gragg, William B., "Dating Szeto Polynomials - Updating, Workshop on Numerical Linear Algebra in Signal Processing, Institute for Mathematics and Applications, University of Minnesota, Minneapolis, 21 April 1992.

Gragg, William B., "Dating Szeto Polynomials - Downdating, Workshop on Numerical Linear Algebra in Signal Processing, Institute for Mathematics and Applications, University of Minnesota, Minneapolis, MN, 22 April 1992.

Neta, Beny, " Solution of Ordinary Differential Initial Value Problems on an INTEL Hypercube with Applications to Orbit Determination," Space Surveillance Workshop, M.I.T. Lincoln Laboratory, Lexington, MA, 7-9 April 1992.

COMPUTER PROGRAMS PUBLISHED

Canright, David, "Fractal Editor(FrEd)," computer program published as shareware (available on CompuServe: go IBMAPP, in Graphics library, FREDEX.EXE\ /fakk 1992.

DEPARTMENT OF MECHANICAL ENGINEERING

Professor M.D. Kelleher
Chairman


D LTA SHEAR

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 structures; underwater shock and vibration/noise; 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. Results of research are published in student theses, NPS technical reports, and in papers presented both at, and appearing in, national conference proceedings, and published in scientific journals. The following is an overview of each area of research followed by individual faculty summaries.

SOLID MECHANICS, SHOCK AND VIBRATION

Professor Shin continued his work in the area of underwater shock and transient machinery condition monitoring and diagnostics sponsored by DNA and NAVSEA as well as NPS Direct Research Fund. Project funded by DNA are concerned with the nonlinear dynamic response and failure mechanism of submerged structures to underwater explosion (UNDEX). The comparatively recent introduction of "double hull" submarines, with a significant volume of water between a thick inner hull and a thinner outer hull, has raised questions regarding the survivability of these submarines. Of particular interest here is the ability of weapons currently in the U.S. arsenal to effectively disable or sink this type of submarine. The ability to predict the response of double hull cylindrical models with fluid located between the inner and outer hulls, subjected to side-on underwater shock loading, was fully investigated. The progress in transient machinery condition monitoring and diagnostics was made in: (a) characterizing the time-frequency dependent signatures of transient machinery such as turbine-driven Torpedo Ejection Pump (TEP) system of Trident class submarine, and (b) developing successful diagnostics methods for detection of faults in machine operation, and predicting machinery failure using back-propagation neural network approach.

Professor Kwon developed an accurate and efficient micro-mechanical model for nonlinear and damage analyses of fibrous composites. The objective of the model was to predict the global deformation at the composite level from nonlinear deformations of constituent materials as well as micromechanical damage, such as matrix cracks and fiber breakage. Comparison between predicted and experimental results for glass/epoxy and graphite/epoxy composites was very good. This project was sponsored by the Naval Postgraduate School and Naval Surface Warfare Center. A project sponsored by the Nuclear Defense Agency is in the area of fluid-structural interaction subjected to an underwater explosion. A failure analysis of aluminum cylinders exposed to both side and end attacks was performed using numerical and experimental techniques. The objective of this study was to enhance understanding of failure modes and mechanisms of structures

subjected to an underwater explosion. The effects of surface coating on submerged structures exposed to an underwater shock were also investigated numerically.

SHIP SYSTEMS

Professor Calvano has been conducting a study for the Naval Sea Systems Command (NAVSEA) to investigate methods for improving the design of survivability features for surface ships, within cost constraints, as well as methods for the assessment of ship survivability. This work is intended to build a basis for long-term support of NAVSEA in Total Ship Survivability as related to the engineering of total ship systems. The task is being approached using the ship design process as a frame of reference to explore ways to further the development of survivability as an integral element of that process. Professor Calvano has also been investigating methods for assessing the mission survivability of surface ships and the technology used to enhance their survivability. An analysis of the value of a modern warship's staying power (anti-vulnerability) relative to the value of defensive firepower and other measures for so-called active survivability (anti-susceptibility), offensive firepower, and detection and tracking power are being studied.

DYNAMIC SYSTEMS, CONTROLS AND ROBOTICS

Professors Healey and Papoulias along with faculty in the Computer Science Department and the Electrical and Computer Engineering Department have been continuing their 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. The objective is to demonstrate ever increasing autonomy of vehicle behavior in a controlled environment. Progress has included a major effort in matching the experimental maneuvering behavior obtained and the use of Kalman filtering for the parameter identification. The use of Neural Networks in adaptive autopilot operations has been studied. A design outline for the use of a small GPS/INS package (funded in part by NOSC Hawaii) has been performed with a view to providing a strap-on navigational unit for underwater use. The transient performance of small thrusters has shown that significant additional thrust may be achieved from a small unit by using pulsed operation although more needs to be done. The use of a high frequency high resolution sonar has led to new technique for correcting navigation errors while maneuvering in the vicinity of a target.

Professor Healey has begun a study for the Strategic Systems Program Office (SP24) of the use of neural networks as a technology that may enhance the operational ease with which navigation errors are computed and corrected. Applications to the damping of Schuler oscillations has been studied in which, to begin with, a time varying Kalman filter system has been designed to compensate navigational errors due to accelerometer calibration, ocean current, side slip, and EM log errors. Neural network diagnostic systems are being studied for their potential as additive improvements to the existing Kalman filter based correction algorithms. The commonly used gyro stabilized platform containing accelero-meters for motion sensing has been considered as the hardware implementation of the Inertial Navigation System studied. **Professor Healey** is

also studying a neural network based approach to failure diagnostics for underwater vehicles for the Naval Coastal Systems Center (NCSC). In support of the Autonomous Control Logic program at NCSC, this work is aimed at investigating methods of using neural networks for autonomous system failure diagnostic devices that would be easily trained and execute rapidly in real time. Two types of failure have been identified; internal failures, caused by changes to machinery such as propulsion motors, their controllers, sensors used to monitor shaft speed, changes in voltage levels in the main supply, and excessive noise or bias shifts in the outputs of sensors; and external failures such as the loss of a propeller or control plane. A backpropagation network has been trained to monitor the voltage and current levels in a propulsion motor. Results have been indicated that loading changes arising from excessive shaft friction can be detected easily as a shift in the nonlinear mapping of the normal levels of voltage and current with each other. A "Hopfield" dynamic network has been investigated for its suitability to identify vehicle response parameters, as a preliminary to eventual input into a failure detection network.

Professor Driels has been carrying out a study on heat transfer parametric identification for the Naval Air Warfare Center (NAWC), China Lake. This work is designed to augment that performed at NAWC into the determination of convective heat transfer coefficients for thrust vector control vanes. Our work focusses on the development of robust and flexible optimization schemes to identify the coefficients from experimental data supplied by NAWC. This work is now being extended to investigate the effect of erosion on the vane, and to address the issue of how to ensure reliable experimental data before tests are conducted.

In the area of robotics, **Professor Driels** has been investigating the correlation of haptic and visual search techniques. In this project, a basic research program has been undertaken into the mechanics of haptic probing. The study concluded that there is strong correlation between the foveal visual sense and the haptic sense, at least in terms of their use in exploring objects. Recent work has focussed on the development of hybrid exploratory system comprising a visual and haptic (proprioceptive) component. This system has allowed the investigation of exploratory procedures close to those experienced by Navy divers.

Professor Driels has also been carrying out research for the NASA, Johnson Space Center on a force override rate controller for remote actuation. This work is designed to develop new control algorithms which allow the shuttle manipulator control system to automatically switch from rate control to force control. This will allow the system to better perform assembly tasks, such as those associated with the planned space station project. The work involves theoretical analysis of the control structure, followed by implementation on the PUMA manipulator in the controls laboratory. In addition, a new type of force-torque sensor for use in the control system will be developed. This unit is based on force sensing technology, and will be developed for use as both the master and slave units in the force sensing control system.

Professor Papoulias has been engaged in a study of the nonlinear dynamics and motions of marine vehicles, in particular, the nonlinear interactions of guidance and control laws for both manned and autonomous vehicles.

Professor Mukherjee has been investigating the control of under actuated robot manipulators. The objectives of this research are to investigate the kinematic and dynamic behavior of under-actuated dynamical systems, of robot manipulators in particular, in the presence of second-order nonholonomic constraints of motion, and to establish motion planning and control schemes for the under-actuated system. This is a continuing project. The results of the research indicate that second-order nonholonomic constraints are difficult to deal with. The better way of dealing with under-actuated systems is, therefore, to either under-actuate a cyclic coordinate of the system or impose artificial constraints that generate cyclic-like coordinates. The net effect is the partial integrability of the second order constraints into first order differential constraints. Then the control of the system becomes much simpler to design.

FLUID DYNAMICS, HEAT TRANSFER AND TURBOMACHINERY

Professor Sarpkaya has been working on 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 (ONR). Numerous physical experiments have been carried out in a large towing tank with various lifting surfaces and submerged bodies in homogeneous and density-stratified medium. Second, experiments with single and multiple vortices have been conducted in a large water basin using both stratified and homogenous medium. Third, experiments have been performed in a recirculating water tunnel with a single turbulent vortex. The velocity and turbulence measurements were made with an LDV system. 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, the energy spectra, the distribution of the turbulent kinetic energy, and the fractal dimension.

Professor Sarpkaya, under the sponsorship of the National Science Foundation (NSF), has also been conducting computational and experimental fluid dynamics research towards the understanding of the effect of unsteadiness on the characteristics of the resulting time-dependent flow. In this work, 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 a U-shaped oscillating-flow tunnel for various Reynolds and Keulegan-Carpenter numbers. The results were found to be in reasonable agreement with those obtained experimentally. The methodology is being extended to Gaussian oscillations of the flow about a cylinder to simulate the ocean environment.

Professor Marto, together with **Adjunct Professor Memory**, continued his research on enhanced two-phase heat transfer. The influence of a helical wire wrap on film condensation of steam on a horizontal smooth tube was determined. A wide variety of nucleate boiling data of CFC-114 and HCFC-124 were obtained during boiling from various enhanced surfaces. The influence of oil on boiling performance was also studied. Results can be used to design more compact shipboard vaporators and condensers.

Professor Kelleher has been continuing the work on field modeling of fire and smoke spread in confined spaces. In this work, a finite difference model to simulate the spread of fire and smoke in the fire simulation experimental facility at the Naval Air Warfare Center 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 code has been used to model fires in the experimental facility currently in operation at the Naval Air Warfare Center, China Lake, CA. Results have been obtained for simulations of fires in this facility both with and without a ventilation opening in the side wall.

Professor Joshi has been conducting an investigation of heat transfer fluid flow during fusion welding processes. The Gas Tungsten Arc Welding process has been investigated. Using a laser vision system, weldpool free surface flow patterns were investigated for a variety of operating conditions for HY 80 steel and aluminum. Several new features such as circumferential stirring and surface undulations were observed, which are not accounted for in the existing models. A new modeling effort has been initiated to examine the convective transport in the weldpool, in light of the visualizations. An exiting heat conduction model was also used to correlate fusion zone macrostructures with thermal histories.

Professors Joshi and Kelleher have continued their investigation of advanced techniques for liquid immersion cooling of electronic equipment under the sponsorship of the Naval Surface Warfare Center, Crane. In the experimental part of this work, two liquid immersion cooling studies were undertaken. Single phase natural, mixed and forced convection in a vertical channel from an array of flush heat sources were experimentally studied. Both aiding, as well as opposed conditions were investigated. The second study dealt with the enhancement of natural convection due to bubble pumping. The configuration considered was a three by three arrangement of leadless chip carriers on a ceramic substrate. In the numerical part of this work, two-dimensional computations were carried out to model prior natural convection experimental studies on isolated components. The three-dimensional code developed for the analysis of heat transfer and fluid flow problems in rectangular systems was used to study two configurations. The first involved the modeling of a chip carrier package during steady and transient liquid immersion cooling. The second study simulated the natural convection transport from a three-by-three array of heated protrusions.

Professor Millsaps has begun a research program to study advanced aerodynamic seals. The objective of this work is to improve the aerodynamic and rotordynamic characteristics of sealing devices (labyrinth, annular, brush, etc.) for use in gas turbine and steam turbine power plants. Preliminary analytical work suggests that non-uniform seal clearances may be responsible for synchronous

vibration problems in gas turbine rotors.

MATERIALS SCIENCE

Professor Perkins is continuing his investigation of the mechanisms of lattice transformations and internal friction in high-damping alloys. The main objective of this research is to develop models to delineate the damping mechanisms in certain so-called "quiet metals". The ultimate aim is to develop, on the microscopic and sub-microscopic level, a unified mechanistic model for the damping behavior of high damping alloys. Since results to date indicate that damping in these alloys is always linked to phase transformations (which may be magnetic transitions, lattice-displacive transformations, or diffusional trans-formations), and more particularly to boundaries which result from such transformations, a major objective is to define the microstructural features which play a role in the damping mechanisms.

Professor McNelley has been undertaking several research projects dealing with aluminum alloys and aluminum based metal matrix composites. In one of these projects, a study is being made of the role of grain boundaries in fine-grained, superplastic aluminum alloys and the development of such grain boundaries during thermomechanical processing of these materials. He has also been investigating mechanisms to obtain improved combinations of strength, ductility and toughness in Al-based metal-matrix composite materials by thermo-mechanical processing. Discontinuously reinforced metal-matrix composite materials have many attractive properties but lack adequate ductility and toughness for many engineering and military applications. Improved combinations of strength and ductility have been obtained with use of controlled heat treatments on processed material. A third project which Professor McNelley has been working on addresses the continuous measurement of aging using eddy current sensors during heat treatment of precipitation hardening alloys. The goal of this program is the development of sensors for the continuous measurement of the aging response during heat treatment of a precipitation hardening alloy. Intelligent processing requires such a sensor to monitor material response in real time and provide input to a controller.

Professor Fox has continued his work in a wide variety of topics. He has been investigating techniques to accurately measure the low-angle structure factors of elements and intermetallic alloys by various diffraction methods so that their electronic bonding mechanisms can be investigated. A second project being carried out for the Naval Surface Warfare Center, Annapolis involves the investigation of 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. In a third project, also sponsored by NSWC, Professor Fox has been using electron microscopy and X-Ray diffraction to investigate the degradation of yttria stabilized zirconia ceramic thermal barrier coatings for gas turbine applications.

Professor Dutta has been investigating the structure, properties and Naval applications of metal matrix composites. For the Naval Surface Weapons Center,

White Oak, he has been investigating the microstructural development in metal matrix composites and to determine the effect of processing on their properties. For NSWC, Crane, he has undertaken two projects: the first is a study of the effect of thermal residual stresses on the mechanical properties of metal matrix composites, while the second project, carried out with Adjunct Professor Mitra is studying the characterization of aluminum nitride substrates and copper-aluminum nitride metallizations for electronic packaging applications.

Adjunct Professor Crooks has been investigating the microstructure/cryogenic property correlations in welded aluminum-copper-lithium alloys. This work is being carried out under a Cooperative Research and Development Agreement (CRDA) with Martin Marietta Manned Space Systems.

TOTAL SHIP SURVIVABILITY

C. N. Calvano, Associate Professor
Department of Mechanical Engineering
Sponsor and Funding: Naval Sea Systems Command (NAVSEA 50B)

OBJECTIVE: The purpose of this project was to conduct research on methods for improving the design of survivability features for surface ships, within cost constraints, as well as methods for the assessment of ship survivability. Intended to build a basis for long-term support of NAVSEA in Total Ship Survivability as related to the engineering of total ship systems.

SUMMARY: The task was approached using the ship design process as a frame of reference to explore ways to further the development of survivability as an integral element of that process. It was concluded that a significant stumbling block to the effective and coherent incorporation of survivability concerns in the design of a ship is the lack of a common understanding and language among the various technical communities which contribute to the design of Navy combatant ships as well as among different segments of the Navy. It remains a goal of research in this area to develop survivability design tools and appropriate measures of effectiveness, but this goal will remain elusive until common understanding of survivability principles is more widespread. An article to address this common understanding was written for publication in the ASNE Journal.

SURFACE SHIP SURVIVABILITY

C. N. Calvano, Associate Professor
W. Hughes, Adjunct Professor
Department of Mechanical Engineering
Sponsor and Funding: Naval Sea Systems Command(NAVSEA 512)

OBJECTIVE: The purpose of this project was to conduct research on methods for assessing the mission survivability of surface ships and on the technology used to enhance their survivability and to apply this knowledge to Total Ship Systems Engineering course development. An analysis of the value of a modern warship's staying power (anti-vulnerability) relative to the value of defensive firepower and other measures for so-called active survivability (anti-susceptibility), offensive firepower, and detection and tracking power was to be conducted.

SUMMARY: The methods of aircraft survivability were reviewed to explore ways to apply these or similar methods to surface ships. Methods for complying with directives and public law mandating increased emphasis on survivability determination, demonstration and testing were also explored. The development of a survivability assessment methodology that can be used in trade-off studies to establish the military worth of survivability enhancement features was begun. The impact of survivability features on ship attributes was explored by means of a total ship design done as a

student-performed design project. TSSE course notes were amended to include discussion of survivability principles and design processes. An analysis of the value of a modern warship's staying power relative to the value of defensive firepower and other measures, offensive firepower, and detection and tracking power was conducted, revealing that staying power, or the ability to absorb damage without loss, plays a larger part in overall survivability than is usually understood.

METHODS OF SHIP SURVIVABILITY

C. N. Calvano, Associate Professor
Department of Mechanical Engineering
Sponsor and Funding: Naval Postgraduate School

OBJECTIVE: Recognizing that considerable aircraft survivability work has been done by investigators who know little about ships, the PI, knowing a good bit about ships but little about generic survivability methods, was to use this RIP project to support him in gaining expertise in survivability methods to enhance the credibility and effectiveness of his work under other funded research projects and to establish his presence as a continuing researcher in ship survivability design.

SUMMARY: After surveying aircraft survivability methods, fruitful areasfor further application of those methods in ship survivability evaluation and enhancement are being identified. Specific effort is being devoted to analytical methods which could effectively substitute for destructive techniques in complying with recent directives and Public Law concerning "live fire testing" of weapons systems to demonstrate their survivability. Sponsorship for the writing of a survivability manual has been obtained and the formal processing of the reimbursable research proposal is underway.

JP-5 THERMAL BREAKDOWN IN T56-A-427 ENGINE FUEL NOZZLES

R. Crooks, Adjunct Professor
Department of Mechanical Engineering
Sponsor and Funding: Naval Air Test Center, Patuxent River, MD

OBJECTIVE: The goal of this study was to evaluate means of preventing the blockage in fuel nozzles due to coking of JP-5 fuel which occurs at temperatures above 300°F. This project was initiated in 1991 and is to be continued in 1993.

SUMMARY: Operational effectiveness of the T56-A-427 engine used in the E-2C+ has been adversely affected by coking of JP-5 in fuel nozzles during thermal soakback after shutdown. The coking occurs as oxidized fuel adheres to the stainless steel, eventually blocking fuel nozzles passages. Efforts in 1992 focussed on assessment of coking parameters and design of a system to evaluate modified nozzle surfaces. The fuel contributing to blockage is approximately 1 ml per cycle. Measurable blockage is observed after 30 cycles. During 1992 we designed a

test cell to simulate thermal cycle conditions at the fuel nozzle swirl plate, where blockage occurs. In the test apparatus 1 ml of fuel is injected into a chamber at room temperature. One end of the chamber has a provision for attachment of samples which serve as experimental swirl plates, and heating elementsare clamped to the outside of the chamber. The fuel in the chamber is heated to temperatures and rates to match the conditions observed at the PAX River Telemetry Center, during evaluation of soakback in the T-56-A-427 engine of the E-2C+. The thermal exposure is followed by a purge. These three stages represent one cycle. The experimental apparatus is controlled by a digital data acquisition and control system. Two simple modifications to circumvent the coking problem have been suggested, namely fuel or nozzle modifications. The approach we are pursuing involves modification of nozzle swirl plate and/or fuel line surfaces with non-stick coatings to minimize adhesion of the oxidized fuel. We have contacted commercial manufacturers of non-stick coatings and hope to evaluate modified samples in our test apparatus early in 1993.

OTHER: Results and program plans were reviewed during an on-site meeting with representatives of NavAir, NAPC and several NPS students and staff members.

MICROSTRUCTURE/CRYOGENIC PROPERTY CORRELATIONS IN WELDED Al-Cu-Li ALLOYS

R. Crooks, Adjunct Professor
Department of Mechanical Engineering
Sponsor: Martin Marietta Manned Space Systems, New Orleans, LA

OBJECTIVE: Light-weight, high-strength Al-Cu-Li alloys are being considered for assembly of the Space Shuttle Tank -- a large, welded structure. The fracture behavior of the welded material at cryogenic temperatures has been an area of concern. Our purpose in this program was to correlate the microstructures of welded specimens with their fracture behavior when subjected to bending at cryogenic temperatures.

SUMMARY: Welded panels representing three composition variations of the Al-Cu-Li alloy Weldalite ™ and one of the Al-Cu alloy 2219 were provided by Martin Marietta Manned Space Systems after welding by Variable Polarity Plasma Arc (VPPA) technique with 2319 filler alloy. Slow three-point bend tests were performed on these welds at 77K and 298K and interrupted at the onset of fracture. Metallographic sections were used to establish crack paths of the cryogenically tested Weldalite material. The most common failure modes involved intergranular fracture in an equiaxed grain region near the fusion zone boundary. The equiaxed grains are thought to form as a result of rapid freezing of partially melted material at the edge of the weld pool. The alloys were closely examined to determine the distribution of grain boundary particles in the fusion zone boundary region. Many of the equiaxed grain boundaries contained continuous second phase particles, and electron diffraction data indicated that these were not the equilibrium ternary phases present in slowly cooled

alloys. Morphologically similar particles were present on a small number of grain boundaries in the heat-affected zone, possibly due to liquation. Large, discrete particles were found at equiaxed grain triple junctions, and some of these were identified as equilibrium T_B (Al_7Cu_4Li). Both the extent of the equiaxed grain region and the amount of second phase appear to decrease as the copper and lithium contents decrease. The Weldalite™ samples with the lowest copper and lithium contents, nominally Al-4.0Cu-1.0Li, exhibited better cryogenic strength and ductility than 2219 when properly welded.

THESIS DIRECTED: Sedlak, John S., LCDR, USCG, "Microstructure-Cryogenic Behavior Correlations in Welded Al-Cu-Li Alloys," M.S. Thesis, September 1992.

CORRELATION OF HAPTIC AND VISUAL SEARCH

Morris R. Driels, Professor
Department of Mechanical Engineering
Sponsor: Naval Ocean Systems Center
Funding: Naval Postgraduate School

OBJECTIVE: The objectives of this project were to complete the acquisition and installation of the force reflecting telemanipulator in the laboratory, and then use it to investigate the basic structure of haptic *sensing*. In addition, preliminary research on sensory data fusion were to be attempted.

SUMMARY: A basic research program has been undertaken into the mechanics of haptic probing. The study concluded that there is strong correlation between the foveal visual sense and the haptic sense, at least in terms of their use in exploiting objects. Recent work has focussed on the development of a hybrid exploratory system comprising a visual and haptic (propreoceptive) component. This system has allowed the investigation of explorative procedures close to those experienced by Navy divers.

PUBLICATIONS: Driels, M.R., "The Effect of Sensory Feedback on the Identification of Objects Using a Teleoperator," (with Spain & Aviles), International *Journal of Automation in Construction*, Vol. 1, pp. 167-173, 1992.

Driels, M.R., "Combined Visual and Haptic Search for Remote Object Identification," (with D. Klein), proceedings of the SPIE OE Technology Conference, Boston, MA, 15-20 November 1992.

Driels, M.R., "The Quality of Visual and Haptic Search for Object Recognition," proceedings of the IEEE International Conference on Intelligent Control, pp. 255-260, Glasgow, August 1992.

THESIS DIRECTED: Klein, D., LCDR, USN, "Modelling of Full Vision System Using Combined Visual/Haptic Search for Remote Teleoperation," Master's Thesis, December 1992.

HEAT TRANSFER PARAMETRIC IDENTIFICATION

Morris R. Driels, Professor
Department of Mechanical Engineering
Sponsor and Funding: Naval Air Warfare Center

OBJECTIVE: This work is designed to augment that performed at NAWC into the determination of convective heat transfer coefficients for thrust vector control vanes. Our work focuses on the development of robust and flexible optimization schemes to identify the coefficients from experimental data supplies by NAWC. This work is now being extended to investigate the effect of erosion on the vane, and to address the issue of how to ensure reliable experimental data before tests are conducted.

PUBLICATION: Driels, M.R., "Testing and Analysis of Heat Transfer in Materials Exposed to Non-Metallized HTPB Propellant," (with A. Danielson), 1992 JANNEF Rocket Nozzle Technology Subcommittee Meeting, Sunnyvale, CA, December 1992.

FORCE OVERRIDE RATE CONTROLLER FOR REMOTE ACTUATION

Morris R. Driels, Professor
Department of Mechanical Engineering
Sponsor and Funding: NASA, Johnson Space Center

OBJECTIVE: The work is designed to develop new control algorithms which allow the shuttle manipulator control system to automatically switch from rate control to force control. This will allow the system to better perform assembly tasks, such as those associated with the planned space station project. The work involves theoretically analysis of the control structure, followed by implementation on the PUMA manipulator in the controls laboratory. In addition, a new type of force-torque sensor for use in the control system will be developed. This unit is based on force sensing technology, and will be developed for use a both the master and slave units in the force sensing control system.

THESES DIRECTED: Edwards, R., "Optimum Poses Measurements for Kinematic Parameter Identification," Master's Thesis, June 1992.

Syvertsen, J., "Force Override Rate Controller for Remote Actuation," Master's Thesis, September 1992.

EFFECT OF PROCESSING AND MICROSTRUCTURE ON THE PROPERTIES OF PARTICULATE METAL MATRIX COMPOSITES

I. Dutta, Assistant Professor
Department of Mechanical Engineering
Sponsor and Funding: NSWC - White Oak

OBJECTIVE: To investigate microstructural development in metal matrix composites and to determine the effect of processing on the properties of MMCs from a mechanistic standpoint.

SUMMARY: The effect of reinforcement distributions and processing conditions on the early stages of precipitation in composite matrices (2014 A1 and 6061 A1) has been studied. Mechanical property development as a function of processing history was also investigated. 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 and microstructural development of MMCs, appropriate thermo-mechanical treatments to obtain the optimum combination of mechanical properties in these materials cannot be designed.

PUBLICATION: Dutta, I., and C.P. Harper, "Effect of Alumina Particulate Addition on the Aging Response of 2014 Aluminum-Matrix Composites," Proceedings of the International Conference on A1 Alloys, Vol. 1, p. 519, 1992.

CONFERENCE PRESENTATION: Karmarkar, S.D., A.P. Divecha and I. Dutta, "Processing, Microstructure and Properties of Centrifugally Cast A356A1/SiC Composites," Aeromat 92, Anaheim, May 1992.

THESIS DIRECTED: May, C., "Effect of Post-Fabrication Thermo-Mechanical Treatments on Aging Response of Centrifugally Cast SiC-2014 A1 Composites," Master's Thesis, June 1992.

EFFECT OF THERMAL RESIDUAL STRESSES ON THE MECHANICAL PROPERTIES OF METAL MATRIX COMPOSITES

I. Dutta, Assistant Professor
Department of Mechanical Engineering
Sponsor and Funding: Naval Surface Warfare Center and Naval Postgradutae School

OBJECTIVE: (1) To Find the effects of residual stresses on uniaxial properties of discontinuous composites; and (2) to evaluate the impact of residual stresses on thermal fatigue behavior of Gr/A1 composites.

SUMMARY: In this project, the effect of thermal residual stresses on composite flow stress has been studies via Finite Element Modeling, based on SiC whisker / A1 composites. In addition, thermal cycling studies were conducted on continuous fiber composites to evaluate the impact of residual stresses on continuous Gr/A1 MMCs experimentally. 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.

CONFERENCE PRESENTATION: Dutta, I., "Impact of Residual Stresses on Uniaxial Deformation of SiC Whisker Reinforced Aluminum-Matrix Composites," 3rd Annual Navy R&D Information Exchange Conference, Silver Spring, Maryland, April 1992.

THESIS DIRECTED: Wiest, A.D., "Thermal Cycling Response of Unidirectional and Cross-Plied Graphite Aluminum Laminates," Master's Thesis, September 1992, (co-advisor: Prof. S. Mitra).

CHARACTERIZATION OF ALUMINUM NITRIDE SUBSTARATES AND COPPER-ALUMINUM NITRIDE METALLIZATIONS FOR ELECTRONIC PACKAGING APPLICATIONS

I. Dutta, Assistant Professor
Department of Mechanical Engineering
Sponsor and Funding: Naval Surface Warfare Center, Crane

OBJECTIVE: To correlate the process - microstructure - property relationships of aluminum nitride substrates, and characterize the 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. Interfacial adhesion in metallized substrates, and residual stresses in metal films on AlN area also being studied.

PUBLICATIONS: Dutta, I., S. Mitra and L. Rabenberg, "Oxidation of Aluminum Nitride at Near-Ambient Temperatures," *Journal of American Ceramics Society*, p. 3149, 1992.

Dutta, I., S. Mitra and J.H. Cooper, "Process-Dependence of Microstructure and Properties of Sintered Aluminum Nitride Substrate Materials for Electronic Packaging Materials Science," Electronic Packaging Materials Science-Vi, Proceedings of the MRS Spring Meeting, November 1992.

A COMBINATIVE METHOD FOR THE ACCURATE MEASUREMENT OF STRUCTURE FACTORS AND CHARGE DENSITIES OF INTERMETALLIC ALLOYS

A.G. Fox, Associate Professor
Department of Mechanical Engineering
Sponsors: Department of Energy and the
Naval Air Development Center
Funding: Naval Postgraduate School

OBJECTIVE: To accurately measure the low-angle structure factors of elements and intermetallic alloys by various diffraction methods so that their electronic bonding mechanisms can be investigated.

SUMMARY: A knowledge of the distribution of bonding electrons in solids can give important information about their physical properties. One way to gain such knowledge is to accurately measure the low angle structure factors by some means, and then use these to generate maps of the electron charge distributions. In the present work electron diffraction has been used to measure the low-angle structure factors of ßNiAl. and an electron charge distribution has been generated for this alloy and important bonding information has emerged. During 1991, x-ray diffraction work commenced on the TiAl system and in 1992 continued so that accurate values of the lattice parameters and Debye-Waller factor of TiAl were obtained. During the last quarter of 1992 electron diffraction measurements of the low-angle structure factors of TiAl were made on the 1.5 MeV high voltage electron microscope at the University of California, Berkeley. Further measurements are currently being made and these results are presently being analyzed.

PUBLICATIONS: Fox, A.G., Stoner, T.A., and Cade, S.C., "Towards Extinction-Free Metallurgical Powders for X-ray Diffraction. An Application to TiAl," *Scripta Metallurgica et Materiala*, Vol. 27, p. 1765, 1992.

Maslen, E.N., A.G. Fox and M.A. O'Keefe, "X-ray Scattering" - a contribution to the International Tables for Crystallography, Vol. C, Mathematical, Physical and Chemical Tables. Published for the International Union for Crystallography by Kluwer Academic Publishers, Dordrecht/Boston/London. Section 6, Brown, P.J., Fox, A.G., Maslen, E.N., O'Keefe, M.A., Sabine, T.M., and Willis, B.T.M., "Interpretation of Diffracted Intensities," Subsection 6.1.1., p. 476, 1992.

CONFERENCE PRESENTATIONS: Fox, A.G. and Tabbernor, M.A., "The Structure Factors, Charge Density and Debye-Waller Factors of Martensitic Ni-Rich ßNiAl" presented at the International Conference on Martensite Transformations, Monterey, CA, 20-24 July 1992.

Fox, A.G. and Tabbernor, M.A., "The Measurement of Small Structure Factors by the Critical Voltage Effect in HEED. The Superlattice Reflections in ßNiAl, ßCoAl and TiAl' presented at the 50th Annual Meeting of EMSA, Boston, MA, pp. 1174-1175, 16-22 August 1992.

Fox, A.G., "High Voltage Electron Diffraction and its Contribution to Understanding the Bonding Mechanisms

in Elements and Alloys," an invited talk presented at the Microstructure of Materials Symposium in honor of Professor Gareth Thomas' sixtieth birthday, Lawrence Berkeley Laboratory, University of California, Berkeley, CA, 22-23 October 1992.

THESIS DIRECTED: Stoner, T.A., "Preparation of Extinction-Free Ti-51 at.% Al Powder and Characterization by X-Ray Diffraction." Master's Thesis, March 1992.

OTHER: Fox, A.G., "The Bonding Charge Densities of Intermetallic Alloys," a seminar presented at the Naval Air Development Center, Warminister, PA, 7 January 1992.

MICROSTRUCTURES AND MECHANICAL PROPERTIES OF HIGH-STRENGTH, LOW-ALLOY (HSLA) STEELS AND THEIR WELDMENTS

A.G. Fox, Associate Professor
Department of Mechanical Engineering
Sponsors and Funding: Annapolis Detachment, Carderock Division, Naval Surface Warfare Center, MD

OBJECTIVE: To investigate the microstructure and mechanical properties of HY and HSLA 80-130 series steels and their weldments to evaluate new weld consumables and parent steels for Naval shipbuilding applications.

SUMMARY: In recent years, the U.S. Navy has been replacing the HY80-100 series of high strength alloy steels with their high-strength, low-alloy (HSLA) equivalents. This is being done because the stringent weld 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 HSLA or ultra low carbon bainitic (ULCB) steels for ship and submarine construction. In addition, the Navy's stringent requirement that weld metal have the same strength as the base plate presents an interesting challenge in weld wire development for both HSLA and HY steels. This project aims to support these objectives with fundamental physical metallurgy studies at NPS. This project was very successful with one Mechanical Engineer and two Masters Theses completed in 1992, one publication submitted, one conference proceeding and two other talks presented.

PUBLICATION: Fox, A.G., Douglas, B.A, and Comerford, L.W., "On the Size, Type and Distribution of Non-Metallic Inclusions in a Multirun GMA Weldment Made on a 50 mm Plate of HSLA-100 Steel."

CONFERENCE PRESENTATION: Fox, A.G., Mikalac, S., and Vassilaros, M.G., "The Microstructure and Mechanical Properties of a HSLA-100 Steel and HSLA-100 with Increased Copper in Plate Form," presented at the Gilbert R. Speich Symposium on the Fundamentals of Aging and Tempering of Bainitic and Martensitic Steel Products, Montreal, Quebec, Canada, pp. 155-161, 18-21 October 1992.

THESES DIRECTED: Novak, F.C., LT, USN, "A Correlation of Welding Solidification Parameters to Weld Macrostructure," Mechanical Engineers Thesis, June 1992.

Suka, A., LT, Japanese Navy, "Microstructure and Mechanical Properties of High Copper HSLA-100 Steel in 2" Plate Form." Master's Thesis, June 1992.

McDonald, E.P., LT, USN, "Factors Influencing the Microstructure and Mechanical Properties of UCLB-100 TIG Multipass Weldments." Master's Thesis, September 1992.

OTHER: A.G. Fox, "The Mechanical Properties and Microstructure of two HSLA-100 Steels in 19mm Plate Form," presentation made at the Annapolis Detachment of the Carderock Division, Naval Surface Warfare Center (NWSC), Annapolis, MD, 6 January 1992.

Fox, A.G., "Current Collaborative Materials Projects between NPS and NWSC," presentation made at the Annapolis Detachment of the Carderock Division, Naval Surface Warfare Center (NWSC), Annapolis, MD, 21 September 1992.

X-RAY DIFFRACTION AND ELECTRON MICROSCOPE STUDIES OF YSZ CERAMIC COATINGS FOR GAS TURBINE APPLICATIONS

A.G. Fox, Associate Professor
Materials Science Group,
Department of Mechanical Engineering
Sponsors and Funding: Annapolis Detachment, Carderock Division of the Naval Surface Warfare Center, MD

OBJECTIVE: To investigate the degredation of yttria stabilized zirconia ceramic thermal barrrier coatings when exposed to vanadium pentoxide.

SUMMARY: The U.S. Navy has an ongoing program of research into yttria stabilized zirconia (YSZ) ceramic coatings for gas turbine blades. Although very successful when used with high quality fuels, YSZs can deteriorate when cheaper fuels are used, particularly when vanadium is present in the fuel as an impurity when degredation of the YSZ occurs so that significant reduction in turbine blade lifetimes results. The object of the present work is to investigate the diffusion of V_2O_5 into a YSZ of composition ZrO_2-9.4 mol.% Y_2O_3 by X-ray diffraction and electron microscopy in order to try and understand why vanadium in fuels degrades YSZs. During 1992 experiments at NPS were performed which indicated that V_2O_5 reacts preferentially with Y_2O_4 but in regions well away from the diffusion interface between the V_2O_5 and the YSZ where all the yttria is apparently 'tied up' as YVO_4 the vanadia can react with the free zirconia now available to form the compound ZrV_2O_7. Both YVO_4 and ZrV_2O_7 are extremely brittle and thus the YSZ rapidly degrades on exposure to vanadia.

THESIS DIRECTED: Kondos, K.G., LT, Hellenic Navy, "X-ray Diffraction and Electron Microscope Studies of Yttria Stabilized Zirconia Ceramic Coatings Exposed to Vanadia." Master's Thesis, June 1992.

LARGE SCALE VEHICLE STUDIES

A.J. Healey, Professor and Chairman
Department of Mechanical Engineering
Sponsor and Funding: Naval Sea Systems Command

OBJECTIVE: This initial study was to review the effectiveness of control algorithms used for vehicle stabilization and navigation filter design and to recommend upgrades as new systems are planned.

SUMMARY: Project was initiated in August 1992 and a final report has been written with a proposal for follow on work in 1993.

STUDIES IN NEURAL NETWORK APPLICATIONS TO ENHANCED EFFECTIVENESSOF NAVIGATION SYSTEMS

A.J. Healey, Professor and Chairman
Department of Mechanical Engineering
Sponsor and Funding: Strategic Systems Program Office Code SP24

OBJECTIVE: To involve Naval Officers in the issues of potential improvements to submarine Inertial Navigation Systems involving both software and operational considerations.

SUMMARY: The use of neural networks has been proposed as a technology that may enhance the operational ease with which navigation errors are computed and corrected. Applications to the damping of Schuler oscillations has been studied in which, to begin with, a time varying Kalman filter systems are being studied for their potential as additive improvements to the existing Kalman filter based correction algorithms. The commonly used gyro stabilized platform containing accelerometers for motion sensing has been considered as the hardware implementation of the Inertial Navigation System studied.

TRANSPORTATION STUDY FOR THE M119A HOWITZER

A.J. Healey, Professor and Chairman
Department of Mechanical Engineering
Sponsor and Funding: United States Army Material Command

OBJECTIVE: To involve Army students in performing a study of the dynamic motions and stresses in the "A" frame of an M119A Howitzer while under tow in field conditions.

SUMMARY: It has been shown that under extraordinary extreme conditions the loading is such that field movement would cause damagealthough in most normally rough terrain conditions, Army procedure should be changed to allow field movement in the firing configuration.

The project was initiated in March 1992 and a final report is in preparation.

NEURAL NETWORK BASED APPROACH TO FAILURE DIAGNOSTICS FOR UNDERWATER VEHICLES

A.J. Healey, Professor and Chairman
Mechanical Engineering Department
Sponsor: Naval Coastal Systems Center

OBJECTIVE: In the last few years, the potential of neural networks as signal processing schemes for real time parameter identification and automated system diagnostics has attracted attention. In support of the Autonomous Control Logic program at NCSC, this work is aimed at investigating methods of using neural networks for autonomous system failure diagnostic devices that would be easily trained and execute rapidly in real time.

SUMMARY: Two types of failure have been identified; internal failures, caused by changes to machinery such as propulsion motors, their controllers, sensors used to monitor shaft speed, changes in voltage levels in the main supply, and excessive noise or bias shifts in the outputs of sensors; and external failures such as the loss of a propellor or control plane. A backpropagation network has been trained to monitor the voltage and current levels in a propulsion motor. Results have indicated that loading changes arising from excessive shaft friction can be detected easily as a shift in the nonlinear mapping of the normal levels of voltage and current with each other. A 'Hopfield' dynamic network has been investigated for its suitability to identify vehicle response parameters, as a preliminary to eventual input into a failure detection network.

THESIS DIRECTED: Navarette, J., "Neural Network Based Propulsion System Fault Diagnostics for the NPS AUV II" Master's Thesis, June 1992

PUBLICATIONS:

Healey, A.J., "A Neural Network Approach to Failure Diagnostics for Underwater Vehicles," Proceedings of IEEE Oceanic Engineering Society Symposium on Autonomous Underwater Vehicles, AUV-92 Washington D.C., 2-3 June 1992, pp. 131-135.

Chu, S. R., Shoureshi, R., Healey, A. J., "A Hopfield-Based Neuro-Diagnostic System," Proceedings of the American Control Conference, Chicago, Illinois, June 24-26, 1992.

Healey, A.J., Bahrke, F., Navarrete, J., "Failure Diagnostics for Underwater Vehicles: A Neural Network Approach" Maneuvering and Control of Marine Craft, Computational Mechanics Publications, ISBN No. 1-56252-109-8, 1992. Section 5, pp. 293-306.

PLANNING, NAVIGATION, DYNAMICS AND CONTROL OF AUTONOMOUS UNDERWATER VEHICLES

A.J. Healey, Professor and Chairman
F.A. Papoulias, Assistant Professor
Department of Mechanical Engineering
Robert B. McGhee, Professor and Chairman
Yuh-Jeng Lee, Assistant Professor
Y. Kanayama, Professor
Se-Hung Kwak, Adjunct Research Professor
Department of Computer Science
R. Cristi, Associate Professor
S.B. Shukla, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Office of Naval Technology, Code 23
Funding: NPS Direct Research Fund

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 ever increasing autonomy of vehicle behavior in a controlled environment. Progress for this reporting period has included a major effort in matching the experimental maneuvering behavior obtained last year and the use of Kalman filtering for the parameter identification. The use of Neural Networks in adaptive autopilot operations has been proposed and studied. A design outline for the use of a small GPS/INS package (funded in part by NOSC Hawaii) has been performed with a view to providing a strap-on navigational unit for underwater use. During this year the transient performance of small thrusters has shown that significant additional thrust may be achieved from a small unit by using pulsed operation although more needs to be done. The use of a high frequency high resolution sonar has led to new technique for correcting navigation errors while maneuvering in the viscinity of a target. An integrated simulator for the development and testing of control code has been designed during this year and will allow for intercommunication and data transmission between the Departments involved in this project and includes a separate GESPAC computer to replicate the vehicle control computer connected to and IRIS graphics workstation as an environmental simulator. This system will be used to debug mission control code prior to downloading into the vehicle at poolside. Further information is available from the Principal Investigator.

PUBLICATIONS: Healey, A.J., et. al. "Research in Autonomous Underwater Vehicles at NPS," *Naval Research Reviews*, Vol XLIV No. 1 1992 pp-43-51.

Healey, A.J., Good, M., "The NPS AUV II Autonomous Underwater Vehicle Testbed: Design and Experimental Verification," *Naval Engineers Journal*, ASNE, May 1992. pp.191-202

Healey, A. J., "Model Based Maneuvering Controls for Autonomous Underwater Vehicles,." Transs ASME

Journal of Dynamic Systems, Measurement and Control Vol. 114, No. 4, 1992 pp. 614-622

Healey, A.J., Bahrke, F., Navarrete, J., "Failure Diagnostics for Underwater Vehicles: A Neural Network Approach," Maneuvering and Control of Marine Craft, *Computational Mechanics Publications*, ISBN No. 1-56252-109-8, 1992. Section 5 pp. 293-306

Healey, A.J., "Experimental Verification of Autonomous Underwater Vehicle Behavior Using the NPS AUV II," Maneuvering and Control of Marine Craft, *Computational Mechanics Publications*, ISBN No. 1-56252-109-8, 1992. Section 4 pp. 217-236

Papoulias, F. A., Healey, A. J., "Path Control of Surface Ships Using Sliding Modes," *Journal of Ship Research*, Vol. 36, No. 2, 1992 pp. 141-153

Healey, A.J., Marco, D. B., " Experimental Verification of Mission Planning by Autonomous Mission Execution and Data Visualization using the NPS AUV II," Proceedings of IEEE Oceanic Engineering Society Symposium on Autonomous Underwater Vehicles, AUV-92 Washington D.C., June 2-3, 1992, pp. 65-73.

Healey, A.J., "A Neural Network Approach to Failure Diagnostics for Underwater Vehicles," Proceedings of IEEE Oceanic Engineering Society Symposium on Autonomous Underwater Vehicles, AUV-92 Washington D.C., June 2-3, 1992, pp. 131-135.

Chu, S. R., Shoureshi, R., Healey, A. J., "A Hopfield-Based Neuro-Diagnostic System, " Proceedings of the American Control Conference, Chicago, Illinois, June 24-26, 1992.

Marco, D. B., Healey, A.J., "Sliding Mode Acoustic Servoing for an Autonomous Underwater Vehicle from Simulations and Experiments," Proceedings of the 1992 Offshore Technology Conference, Houston Texas, 1992 Paper No. OTC 6974.

Healey, A.J., Marco, D.B., "Slow Speed Flight Control of Autonomous Underwater Vehicles: Experimental Results with NPS AUV II," Proceedings of the 2nd International Offshore and Polar Engineering Conference, San Francisco, 14-19 July 1992.

Papoulias, F.A., "Guidance and Control Laws for Vehicle Path Keeping Along Curved Trajectories," Applied Ocean Research, Vol. 14, No. 5.

Papoulias, F.A. and Chism, S.R., "Path Keeping of Autonomous Underwater Vehicles Using Sliding Mode Control," International Shipbuilding Progress, Vol. 39, No. 419, 1992.

Papoulias, F.A., "Loss of Stability of Guidance and Control Laws for Autonomous Vehicles," Dynamics and Stability of Systems, Vol. 8, No. 1.

Byrnes, R.B., MacPherson, D.L., Kwak, S.H., McGhee, R. B., Nelson, M.L., "An Experimental Comparison of Hierarchical and Subsumption Software Architectures for Control of an Autonomous Underwater Vehicle," Proceedings of IEEE Oceanic Engineering Society Symposium on Autonomous Underwater Vehicles, AUV-92 Washington D.C., June 2-3, 1992. pp.135-141

Kwak, S. H., McKeon, J. B., Clynch, J. R., McGhee, R. B., "Incorporation of Global Positioning System into Autonomous Underwater Vehicle Navigation," Proceedings of IEEE Oceanic Engineering Society Symposium on Autonomous Underwater Vehicles, AUV-92 Washington D.C., June 2-3,

1992. pp.291-297

Y. Lee and Luqi, "Controlling an Autonomous Underwater Vehicle using an Expert System. Proceedings of the Second International Conference on Automation, Robotics and Computer Vision, pages AI-3.6.1--6, Singapore, 15-18 September 1992.

Y. Lee and J. Bonsignore. Underwater Multi-dimensional Path Planning. Proceedings of the Tenth Annual National Conference on Ada Technology, pages 357--360, Arlington, Virginia, 24-27 February 1992.

THESES DIRECTED: Bahrke, Fred "Parameter Identification and Sliding Mode Control for the NPS AUV II" Master's Thesis, March 1992

Navarette, J., "Neural Network Based Propulsion System Fault Diagnostics for the NPS AUV II" Master's Thesis, June 1992.

Cody, S. E., "An Experimental Study of the Response of Small Thrusters To Step and Triangular Inputs" Master's Thesis, December 1992.

Ingold, B.J., "AUV Navigation from Image Profile Segments using a High Frequency Sonar" Master's Thesis, December 1992.

Simakis, D.A., "Vehicle Guidance and Control Along Circular Trajectories," Master's Thesis September, 1992.

Panoff, T.J., ``Reference Path Generation and Tracking of Marine Vehicles'', Master's Thesis, September 1992.

Venne, D.V., ``Effects of Positional Information Time Lags on Motion Stability of Autonomous Vehicles'', Master's Thesis, September 1992.

Falcao, Marco A.G., "Allocation of Periodic Tasks with Precedences on Transputer Based Systems", Master's Thesis, September 1992

Cengiz, E., "Efficient Grid Based Techniques for Solving the Weighted Region Least Cost Path Problem on Multiprocessors" MS Thesis December 1992

Nagengast, S., "Correction of Inertial Measurements Using GPS Updates for Underwater Navigation", Master's Thesis, Spertember 1992

Menke, K. W., "Nonlinear Adaptive Control Using Backpropagating Neural Networks", Master's Thesis, June 1992.

ADVANCED TECHNIQUES FOR LIQUID IMMERSION COOLING OF ELECTRONIC EQUIPMENT

Y. Joshi, Associate Professor
M.D. Kelleher, Professor
Department of Mechanical Engineering
Sponsors and Funding: Naval Surface Warfare Center and the Naval Postgraduate School

OBJECTIVE: Experimental and computational investigations of liquid immersion cooling of electronic components.

SUMMARY: Two liquid immersion cooling studies were undertaken. Single phase natural, mixed and forced convection in a vertical

channel from an array of flush heat sources were experimentally studied. Both aiding, as well as opposed conditions were investigated. The second study dealt with the enhancement of natural convection due to bubble pumping. The configuration considered was a three by three arrangement of leadless chip carriers on a ceramic substrate.

PUBLICATION: Joshi, Y. and Kelleher, M.D., "Liquid Immersion Cooling of Electronic Equipment, *Naval Research Reviews*, Vol. XLIV, No. 1, pp. 35-42, 1992.

CONFERENCE PRESENTATION: Mukutmoni, D., Kelleher, M.D., and Joshi, Y., "Computations of Liquid Immersion Cooling for a Three by Three Array of Chips in a Rectangular Enclosure," National Electronics Packaging Conference, Anaheim, CA, February 1992.

THESES DIRECTED: Syring, J.D., LT, USN, "Mixed and Forced Convection from an Array of Discrete Heat Sources in a Vertical Channel," Master's Thesis, March 1992.

Rahall, R.G., LCDR, USN, "Convective Heat Transfer from Discrete Heat Sources in a Liquid Filled Vertical Channel," Master's Thesis, December 1992.

Thompson, R.G., LCDR, USN, "Natural Convection Heat Transfer Studies of Simulated and Actual Electronic Components Using Dielectric Liquids for Immersion Cooling," Master's Thesis, June 1992.

Arata, F.A., LT, USN, "Nucleate Boiling Heat Transfer Study of Direct Immersion Cooling of a 3x3 Array of Vertically Oriented Electronic Components in a Dielectric Liquid," Master's Thesis, September 1992.

COMPUTER AIDED ANALYSIS OF ELECTRONIC EQUIPMENT COOLING

Y. Joshi, Associate Professor
M.D. Kelleher, Professor
Department of Mechanical Engineering
Sponsor: Naval Surface Warfare Center, Crane, IN

OBJECTIVE: Computational modeling of electronic equipment cooling.

SUMMARY: Two-dimensional computations were carried out to model prior natural convection experimental studies on isolated components. The three-dimensional code developed for the analysis of heat transfer and fluid flow problems in rectangular systems was used to study two configurations. The first involved the modeling of a chip carrier package during steady and transient liquid immersion cooling. The second study simulated the natural convection transport from a three-by-three array of heated protrusions.

PUBLICATIONS: Sathe, S.B. and Joshi, Y., "Natural Convection Cooling of a Substrate-Mounted Protrusion in a Square Enclosure: A Parametric Study," *Journal of Heat Transfer*, Transactions of ASME, Vol. 114, pp. 401-409, 1992.

Wrobleski, D. and Joshi, Y., "Transient Natural Convection From a Leadless Chip Carrier in a Liquid Filled Enclosure: A Numerical Study," *Journal of Electronic Packaging*," Transactions of ASME, Vol. 114, pp.

271-279, 1992.

CONFERENCE PRESENTATIONS: Wroblewski, D. and Joshi, Y., "Liquid Immersion Cooling of a Substrate Mounted Protrusion in a Three-Dimensional Enclosure: The Effects of Protrusion Aspect Ratios and Enclosure Boundary Conditions," National Heat Transfer Conference, San Diego, August 1992.

THESIS DIRECTED: Hickey, C.N., LT, USN, "Natural Convection from a Horizontal Heater in Response to Steady and Pulsatile Input Powers," Master's Thesis, June 1992.

COMPUTATIONS AND EXPERIMENTS ON HEAT TRANSFER AND FLUID DYNAMICS OF FUSION WELDING

Y. Joshi, Associate Professor
Department of Mechanical Engineering
Sponsor: None
Funding: Unfunded

OBJECTIVE: Investigation of heat transfer and fluid flow during fusion welding processes.

SUMMARY: The Gas Tungsten Arc Welding process was investigated. Using a laser vision system, weldpool free surface flow patterns were investigated for a variety of operating conditions for HY 80 steel and aluminum. Several new features such as circumferential stirring and surface undulations were observed, which are not accounted for in the existing models. A new modeling effort has been initiated to examine the convective transport in the weldpool, in light of the visualizations. An existing heat conduction model was also used to correlate fusion zone macro-structures with thermal histories.

THESIS DIRECTED: Schupp, P.E., LT, USN, "Weldpool Flow Visualization Studies During Gas Tungsten Arc Welding of Steel and Aluminum," Master's Thesis, March 1992.

Novak, F.G., LT, USN, "A Correlation of Welding Solidification Parameters to Weld Microstructure," Master's Thesis, June 1992.

FIELD MODELING OF FIRE AND SMOKE SPREAD IN CONFINED SPACES

M.D. Kelleher, Professor and Chairman
Department of Mechanical Engineering
Sponsor and Funding: Naval Postgraduate School

OBJECTIVE: Develop a finite difference numerical model for the realistic determination of the time dependent fire and smoke spread in confined spaces. Develop graphics postprocessing routines, both color and monochrome, to provide effective presentation of results. The computer code 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 simulation experimental facility at the Naval Air Warfare Center 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 has 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. Graphics post-processing capabilities have been developed which provide color representations of the isotherms at any instant in the fire. Routines have also been developed which provide two dimensional plots of the instantaneous isobars and vectors plots of the instantaneous velocity vectors. These routines greatly enhance the presentation of the results. The code has been used to model fires in the experimental facility currently in operation at the Naval Air Warfare Center, China Lake, CA. Results have been obtained for simulations of fires in this facility both with and without a ventilation opening in the side wall.

THESES DIRECTED: Torkelson, K., LT, USCG, "NumericalField Model Simulation of Full-Scale Fire Tests in a Closed Spherical/Cylindrical Vessel Using Advanced Graphics Techniques," M.S. in M.E., September 1992.

Delaney, Michael, LCDR, USN, "Numerical Field Model Simulation of Full Scale Fire Tests in a Closed and Open Compartment," M.S. in M.E., December 1992.

FRACTURE ANALYSIS IN METAL-MATRIX COMPOSITES

Y.W. Kwon, Assistant Professor
Department of Mechanical Engineering
Sponsor and Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project was to develop a nonlinear analysis model for fiber-reinforced metal matrix composites and to investigate the crack tip behavior of metal-matrix composites at the micro- and macro-mechanics level.

SUMMARY: A new and efficient three-dimensional model was developed to analyze material-nonlinear behavior of metal matrix composites: plasticity and thermo-viscoplasticity. This model directly used constituents material properties such as fiber and matrix. A finite element formulation was developed for this model so that general three-dimensional composite structures including laminated plates and shells could be analyzed.

The present model and finite element formulation was verified using examples to which solutions were available. Present numerical solutions compared very well with available solutions. Elastoplastic deformation of matrix resulted in bilinear behavior of the bending stress in fiber for a composite plate subjected to a bending load. Thermo-elastoviscoplastic analysis of a cross-ply composite showed that at some location s, stresses peaked up quickly and dropped gradually as time

elapsed while at some other locations stresses decreased quickly and stayed the same.

The developed model was also applied to study the crack tip behavior of composites. Interaction between a macroscale crack and a near damage zone was studied for composite plates subjected to a tensile load. Composite damage such as fiber breakage and matrix cracks near a crack tip increased the stress intensity factor at the tip for linear elastic deformation. It also spread the yield zone of matrix for the elastoplastic analysis.

Crack closure study indicated that crack closure might result in non-conservative solutions around the crack tip compared to no-closure solutions depending on the material properties of fiber and matrix. If the two materials had so different elastic modulii, the crack closure solution was not conservative. It was caused by the transverse shear effect. Furthermore, warping of the crack face near the crack tip was more severe in a composite plate than in an isotropic plate.

PUBLICATIONS: Kwon, Y.W., "Material Nonlinear Analysis of Composite Plate Bending Using a New Finite Element Formulation," *Computer and Structures*, Vol. 41, No. 5, pp. 1111-1117.

Kwon, Y.W., "Finite Element Analysis of Thermoelastoplastic Stresses in Composites, "*European Journal of Mechanical Engineering*, Vol. 37, No. 2, June 1992, pp. 83-88.

Kwon, Y.W., "Analysis of Composite Plates Containing Cracks," *Journal of Pressure Vessel Technology*, ASME Transactions, Vol. 114, August 1992, pp. 358-363.

Kwon, Y.W., "Analysis of Crack Closure in Unidirectional Composite Plates Subject to Bending Loads," *Engineering Fracture Mechanics*, Vol. 42, No. 5, pp. 825-831.

CONFERENCE PRESENTATIONS: Kwon, Y.W., Elastoplastic Crack Closure Analysis of a Composite Plate in Bending," Composite Material Technology-1992, ASME PD-Vol. 45, 1992, pp. 245-252.

Kwon, Y.W. and Serttunc, M., "Static and Dynamic Buckling of a Fiber Embedded in a Matrix with Interface Debonding," Recent Advances in Structural Mechanics-1992, ASME PVP-Vol. 248/NE-Vol. 10, pp. 41-48.

Kwon, Y.W., "Analysis of Metal Matrix Composites," Third Annual R&D Information Exchange Conference, Naval Surface Warfare Center, Silver Spring, MD, 8-10 April 1992.

THESES DIRECTED: Serttunc, M., "Effects of Interfacial Debonding and Fiber Breakage on Static and Dynamic Buckling of Fibers Embedded in Matrices," Master's Thesis, September 1992.

Babiloglu, E., "A Numerical Study of Dynamic Crack Propagation in Composites," Master's Thesis, September 1992.

HEAT TRANSFER OF HCFC-124 AND HCFC-124/LUBRICANT MIXTURES USING ENHANCED SURFACES

P.J. Marto, Distinguished Professor
Department of Mechanical Engineering
Sponsor and Funding: NSWC Carderock Div, Annapolis Detachment

OBJECTIVE: The purpose of this research is to compare the heat transfer performance characteristics of HCFC-124/oil mixture to those of CFC-114/oil mixtures in order to assess if the new HCFC-124 refrigerant can be used as a "drop-in" replacement for CFC-114.

SUMMARY: During FY92, the existing heat transfer facility was modified in order to use the alternative refrigerant HCFC-124. This required that the laboratory be fully isolated from other facilities with 100% full petition walls and be specially ventilated in order to comply with the refrigerant manufacturer's standards of use. In addition, an air-monitoring system and alarm were ordered and installed to ensure safe operation. Finally, the single tube boiling apparatus was modified using fiberglass reinforced pyrex glass components in order to withstand the higher pressures expected with HCFC-124. While these modifications were being made, significant time was spent in investigating the boiling and condensing characteristics of enhanced tubes that might be used in future naval refrigeration systems. These tests were completed using CFC-113 and CFC-114 in order to provide a reference data base for comparison with the new data to be obtained with HCFC-124.

PUBLICATIONS: Marto, P.J. and Anderson, C.L., "Nucleate Boiling Characteristics of R-113 in a Small Tube Bundle," *Journal of Heat Transfer*, Vol. 114, pp. 425-433, May 1992.

Memory, S.B. and Marto, P.J., "The Influence of Oil on Boiling Hysteresis of R-114 from Enhanced Surfaces," Pool and External Flow Boiling, V.K. Dhir and A.E. Bergles (Eds), ASME, New York, pp. 63-71, 1992.

Memory, S.B., Chilman, S.V. and Marto, P.J., "Nucleate Boiling Characteristics of a Small Enhanced Tube Bundle in a Pool of R-113, Two-Phase Flow and Heat Transfer, J.H. Kim, R.A. Nelson and A. Hashemi (Eds), ASME HTD-Vol. 197, New York, pp. 129-138, 1992.

Memory, S.B., Mazzone, R.W. and Marto, P.J., "Enhanced Film Condensation of R-113 using Wire-Wrap on a Horizontal Roped Tube Bundle," Heat Transfer, Vol. 1, Institution of Chemical Engineers, Symposium Series No. 129, Warwickshire, U.K., pp. 249-262, 1992.

THESIS DIRECTED: Haas, R.E., "Nucleate Pool Boiling of R-114/Oil Mixtures in a Small Enhanced Tube Bundle, Master's Thesis, June 1992.

Lake, L.R., "The Influence of a Lower Heated Tube on Nucleate Pool Boiling from a Horizontal Tube, Master's Thesis, June 1992.

Guido, J.D., "Experimental Development of Tubeside Heat Transfer Correlations for Laminar Flow with and without Inserts, Master's Thesis, September 1992.

GRAIN BOUNDARIES IN SUPERPLASTIC ALUMINUM

T.R. McNelley, Professor
Department of Mechanical Engineering
Sponsor: Proposed to the Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this program is to study the role of grain boundaries in fine-grained, superplastic aluminum alloys and the development of such grain boundaries during thermomechanical processing of these materials.

SUMMARY: This work has focused on the identification of the mechanisms of recrystallization during thermomechanical processing of fine-grained aluminum alloys and the types of grain boundaries that form during processing. This work has also addressed the associated mechanisms of superplastic deformation of fully processed materials. It has been shown that particle-stimulated nucleation (PSN) of recrystallization occurs during the latter stages of processing for appropriate processing conditions applied to an A1-10Mg-0.1Zr alloy. The alloy composition and process parameters dictate the critical particle size for PSN and larger particles are necessary in a commercial 2519 alloy.

PUBLICATIONS: Crooks, R., Kalu, P.N. and McNelley, T.R., "Comments on 'A Model for Subgrain Superplasticity'", *Scripta Metallurgica et Materialia*, Vol. 26, pp. 145-149 (1992).

McNelley, T.R., Crooks, R., Kalu, P.N., and Rogers, S.A., "Precipitation and Recrystallization During Processing of a Superplastic A1-10Mg-0.1Zr Alloy," *Materials Science and Engineering*, accepted for publication (1992).

CONFERENCE PRESENTATIONS: McNelley, T. R. and Kalu, P.N., "The Influence of Processing Strain on hte Low-Temperature Superplastic Response of an A1-10Mg-0.1Zr Alloy," in the General Abstract Session on Effects of Deformation on Microstructure, 121st. Annual Meeting of TMS, San Diego, CA, 1-5 March 1992.

Crooks, R., McNelley, T.R., and Kalu, P.N., "Process Control for Superplasticity in an A1-Mg-Zr Alloy," the International Conference on Advanced Synthesis of Engineered Structual Materials, San Francisco, CA, 20 August - 2 September 1992.

McNelley, T.R., Crooks, R., Kalu, P.N., and Rogers, S.A., "Precipitation and Recrystallization During Processing of a Superplastic A1-Mg-Zr Alloy," Grain Boundary and Interface Phenomena in the High Temperature Plasticity of Solids, Berkeley, CA, 16 October 1992.

McNelley, T.R., Crooks, R., and Kalu, P.N., "Low temperature Superplasticity and Microstructural Dynamics of an A1-Mg Alloy," in Advances in Superplasticity and Superplastic Forming, Annual Fall Meeting of TMS and ASM International, Chicago, IL, 2 November 1992.

THESIS DIRECTED: Lyle, P.C., "Correlation of processing, Microstructure and Superplasticity in an A1-Mg-Zr Alloy," Master's Thesis, March 1992 (advised with P. N. Kalu).

Mathe, W.J., "Precipitate Coarsening During Overaging of 2519 A1-Cu Alloy: Application to Superplastic Processing," Master's Thesis, March

1992 (Co-advised with P. N. Kalu).

Bohman, S.D., "Thermomechanical Processing of Aluminum Alloy 2519 for Grain Refinement and Superplasticity," Master's Thesis, June 1992 (Co-advised)with P. N. Kalu).

Buckley, J.F., "The Deformation Characteristics and Microstructural Dynamics of an Al-10Mg-0.1Zr Alloy," Master's Thesis, June 1992.

Rogers, S.A., "The Role of Particles in Recrystallization of a Thermomechanically Processed Al-Mg Alloy," Master's Thesis, September 1992 (Co-advised with R. Crooks).

Dunlap, J.R., "Study of Grain Refinement in Al Alloy 2519 Using Backscatter Orientation-Contrast Mode in the Scanning Electron Microscope," Master's Thesis, December 1992 (Co-advised with R. Crooks).

THERMOMECHANICAL PROCESSING AND DUCTILITY ENHANCEMENT OF DURALCAN COMPOSITE MATERIALS

T.R. McNelley, Professor
Department of Mechanical Engineering
Sponsor: Proposed to Duralcan-USA, San Diego, CA
(As a CRDA Program)
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this program is to obtain improved combinations of strength, ductility and toughness in Al-based metal -matrix composite materials by thermomechanical processing.

SUMMARY: Discontinuously reinforced metal-matrix composite materials have many attractive properties but lack adequate ductility and toughness for many engineering and military applications. Significant ductility enhancement has been attained in extruded 6061 Al-Al_2O_3 processed using methods developed to improve the distribution of the Al_2O_3 particles. These processing procedures also achieve a fully recrystallized grain structure if the particles become sites for particle-stimulated nucleation. Improved combinations of strength and ductility were obtained with use of controlled heat treatments on processed material.

PUBLICATIONS: McNelley, T.R. and Kalu, P.N., "Elevated Temperature Defor-mation and Fracture Characteristics of a Thermomechanically Processed 6061 Al-Al_2O_3 Composite," *Scripta Metallurgica et Materialia*, Vol. 26, pp. 1309-1324 (1992).

McNelley, T.R. and Kalu, P.N., "Thermomechanical Processing and Ductility Enhancement of a 60661 a1-Al_2O_3 Metal Matrix Composite," in Advanced Synthesis of Engineered Structural Materials, Proceedings of the International Conference, J. J. Moore (ed.), ASM International, Materials Park, OH, in press (1992).

CONFERENCE PRESENTATIONS: Kalu, P.N. and McNelley, T.R., "The Effect of Thermomechanical Processing on the Elevated Temperature Properties of 6061 Al-Al_2O_3 Composites," in the General Abstract Session on composites, 121st. Annual Meeting of TMS, San Diego, CA, 1 - 5 March 1992.

McNelley, T.R. and Kalu, P.N.,

"Thermomechanical processing and Ductility Enhancement of a 6061 Al-A_2O_3 Metal Matrix Composite," the International Conference on Advanced Synthesis of Engineered Structural Materials, San Francisco, CA, 30 August - 2 September 1992.

McNelley, T.R., "Thermomechanical Processing and Ductility Enhancement of Duralcan composites," Seminar, Duralcan-USA, Inc., 30 July 1992.

THESIS DIRECTED: Eastwood, D.F., "The Effect of Thermomechanical Processing Parameters on the Ambient Behavior of 10 Volume Percent 6061 Al - Alumina Matrix Composite Material," Master's Thesis, March 1992 (Co-advised with P. N. Kalu).

Schauder, T.J., "The Effects of Thermomechanical Processing Parameters on Elevated-Temperature Behavior of a 6061 Al - Al_2O_3 Metal Matrix Composite," Master's Thesis, March 1992 (Co-advised with P. N. Kalu).

Manfredi, M.S., "Computer Simulation of Random and Non-Random Second - Phase Particle Distributions For Both Constant and Varying Particle Size," Master's Thesis, September 1992.

ADVANCED AERODYNAMIC SEAL RESEARCH

K. Millsaps, Assistant Professor
Department of Mechanical Engineering
Sponsor and Funding: Naval Postgraduate School

OBJECTIVE: To improve the aerodynamic and rotodynamic characteristics of sealing devices (labyrinth, annular, brush, etc.) for use in gas turbine and steam turbine power plants.

SUMMARY: Preliminary analytical work suggests that non-uniform seal clearances may be responsible for synchronous vibration problems in gas turbine rotors.

CONTROL OF UNDER-ACTUATED ROBOT MANIPULATORS

R. Mukherjee, Professor
Department of Mechanical Engineering
Sponsor and Funding: Naval Postgraduate School

OBJECTIVE: The objectives of this research is to (a) investigate the kinematic and dynamic behavior of under-actuated dynamical systems, of robot manipulators in particular, in the presence of second order nonholonomic constraints of motion, and (b) establish motion planning and control schemes for the under-actuated system. This is a continuing project.

SUMMARY: The results of the research indicate that second-order nonholonomic constraints are difficult to deal with. The better way of dealing with under-actuated systems is therefore to either under-actuate a cyclic coordinate of the system or impose artificial constraints that generate cyclic-like coordinates. The net effect is the

partial integrability of the second order constraints into first order differential constraints. Then the control of the system becomes much simpler to design.

CONFERENCE PRESENTATION: Mukherjee, R. and Chen, D., "Stabilization of Free-Flying Under-Actuated Mechanisms in Space," American Control Conference, 1992.

THESIS DIRECTED: Costain, R., LT, USA, "Motion Planning of a Three Link Under-Actuated Planar Manipulator," Master's Thesis, September 1992.

MECHANISMS OF LATTICE TRANSFORMATIONS AND INTERNAL FRICTION IN MARTENSITIC AND ANTIFERROMAGNETIC HIGH-DAMPING ALLOYS

J. Perkins, Professor
Department of Mechanical Engineering
Sponsor and Funding: Naval Postgraduate School

OBJECTIVE: The main objective of this research was to develop models to delineate the damping mechanisms in certain so-called "quiet metals." The ultimate aim was to develop, on the microscopic and sub-microscopic level, a unified mechanistic model for the damping behavior of high damping alloys. Since result to date indicate that damping in these alloys is always linked to phase transformations (which may be magnetic transitions, lattice-displacive transformations, or diffusional transformations), and more particularly to boundaries which result from such transformations, a major objective was to define the microstructural features which play a role in the damping mechanisms.

SUMMARY: In general, high damping mechanisms in quiet metal alloys are associated with the internal friction created near various types of boundaries. However, different alloys have different types of boundaries, and there are different atomistic mechanisms of damping, and therefore different controlling and operational parameters. For example, the domain boundaries in ferromagnetic alloys are quite different from the intervariant boundaries in martensitic alloys. On the other hand, the intervariant boundaries are quite similar in form and character to the inter-domain twin boundaries which separate the antiferromagnetic domains in quenched homogenous FCT Cu-Mn-based alloys. Aged Cu-Mn alloys, however, present a completely different microstructural form, in which it has only recently been recognized that the "boundaries" are effectively very broad, with a gradual transition of structure. This latter case, in contrast to the distinct nature of martensitic intervariant boundaries, suggests a "boundaryless" mechanism, or at least a broad gradient of structure with which the internal friction mechanism operates. This is a primary area in which further investigation is required.

NUMERICAL ANALYSIS OF UNSTEADY FLOW ABOUT BLUFF BODIES

T. Sarpkaya, Distinguished Professor
Department of Mechanical Engineering
Sponsor and Funding: National Science foundation

OBJECTIVE: Computational and experimental fluid dynamics 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 a U-shaped oscillating-flow tunnel for various Reynolds and Keulegan-Carpenter numbers. The results were found to be in reasonable agreement with those obtained experimentally. The methodology is being extended to Gaussian oscillations of the flow about a cylinder to simulate the ocean environment.

PUBLICATIONS: Sarpkaya, T. and Butterworth, W., "Separation Points on a Cylinder in Oscillating Flow," *Journal of Offshore Mechanics and Arctic Engineering*, Trans. ASME, Vol. 114, pp. 28-36, February 1992.

Sarpkaya, T., "Brief Reviews of Some Time-Dependent Flows," *Journal of Fluids Engineering*, Trans. ASME Vol. 114, No. 3, pp. 283-298.

Sarpkaya, T., "Recent Progress in Basic Numerical and Physical Experiments on Oscillating Flow About cylinders," *Viscous Fluid dynamics in Ship and Ocean Technology*, Vol. 1, pp. 375-404, March 1992, Osaka University press, Osaka, Japan.

Sarpkaya, T., Putzig, C., Gordon, D., Wang, X., and Dalton, C., "Vortex Trajectories Around a Circular Cylinder in Oscillatory Plus Mean Flow," *Journal of Offshore Mechanics and Arctic Engineering*, Trans, ASME, Vol. 114, No. 4, pp. 291-298.

CONFERENCE PRESENTATIONS: Sarpkaya, T., Putzig, C., and Gordon, D., "Numerical Analysis of Wave and Current Induced Flow About a Circular Cylinder," Proceedings of the Off shore Technology Conference, Vol. 1, pp. 456-463, Houston, TX, 4-7 May 1992.

Sarpkaya, T., "Offshore Hydrodynamics - Research Trends and Opportunities," Proceedings of the International Conference on Offshore Mechanics and Arctic Engineering, Vol. 1, pp. 78-89, Calgary, Canada, 7-11 June 1992.

Sarpkaya, T. and Putzig, C., "Vortex Trajectories Around a Circular Cylinder in Oscillatory Plus Mean Flow," proceedings of the International Conference on Offshore Mechanics and Arctic Engineering, Vol. 1, pp. 69-77, Calgary, Canada, 7-11 June 1992.

Sarpkaya, T., "Forty Years of Fluid Loading - The Past and Beyond," invited leading lecture presented at the International Conference on the Behavior of Offshore Structures, Imperial college, London, 7-10 June 1992.

THESIS DIRECTED: Lotshaw, John E.,

LT, USN, "Numerical Analysis of Oscillating Flow about a Circular Cylinder," Master's Thesis, June 1992.

Navover, Kenneth C., LT, USN, "Numerical Analysis of Transitory Oscillating Flow About a Cylinder," Master's Thesis, September 1992.

INTERACTION OF A VORTEX PAIR WITH A FREE SURFACE

T. Sarpkaya, Distinguished Professor
Department of Mechanical Engineering
Sponsors and Funding: Chief of Naval Research (ONR) and the 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 physical experiments have been carried out in a large towing tank with various lifting surfaces and submerged bodies in homogeneous and density-stratified medium. Second, experiments with single and multiple vortices have been conducted in a large water basin using both stratified and homogeneous medium. Third, experiments have been performed in a recirculating water tunnel with a single turbulent vortex. The velocity and turbulence measurements were made with an LDV system. 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, the energy spectra, the distribution of the turbulent kinetic energy, and the fractual dimension. The evidence presented herein shows that numerous tentacle-like vortex sheets of finite length, resulting from helical instabilities, stretch out or are thrown away from the outer edges of the vortex core. The vortex peels off randomly and sheds vorticity along its length. The core of a turbulent vortex is not a benign, smooth, exchange of momentum between the outer regions and the core leads to the various velocity components. Experiments have also shown that near the free surface turbulence becomes quasi-two-dimensional. The metamorphic of the isotropic turbulence to a two-dimensional anisotropic state is currently under investigation and holds the key to the understanding of the SA images.

PUBLICATIONS: Sarpkaya, T., "Interaction of a Turbulent Vortex with a Free Surface," *proceedings of the Nineteenth Symposium on Naval Hydrodynamics*, Vol. 1, pp. 163-174, National Academy Press.

Sarpkaya T. and Lundblat, W., "Three-Dimensional Interactions of Vortices with a Free Surface," *AIAA Paper No.92-0739*, presented at the 30th Aerospace Sciences Meeting of AIAA in Reno, NV, 6-10 January 1992.

THESIS DIRECTED: Neubert, D.E., Jr., LT, USN, "Trailing Vortex/Free-Surface Interaction, "Master's Thesis, December 1992.

DYNAMIC RESPONSE AND FAILURE OF COMPOSITE AND METAL STRUCTURES TO UNDERWATER SHOCK LOADS

Y.S. Shin, Professor
Y.W. Kwon, Assistant Professor
Department of Mechanical Engineering
Sponsors and Funding: Defense Nuclear Agency and the Naval Postgraduate School

OBJECTIVE: To advance our understanding on shock induced dynamic behavior and failure mechanism of composite and metal structures through the analytical studies and the underwater explosion testings.

SUMMARY: The significant progress in this research was made in understanding the failure process and physics of submarine hull collapse when subjected to underwater explosions (UNDEX). The comparatively recent introduction of "double hull" submarines, with a significant volume of water between a thick inner hull and a thinner outer hull, has raised questions regarding the survivability of these submarines. Of particular interest here is the ability of weapons currently in the U.S. arsenal to effectively disable or sink this type of submarine. The ability to predict the response of double hull cylindrical models with fluid located between the inner and outer hulls, subjected to side-on underwater shock loading, was fully investigated. A finite element hydrocode was used to numerically predict model responses, and these predicted responses were compared with experimentally measured responses. Both elastic and inelastic cases were examined. The numerically predicted and experimentally measured elastic response were in relatively close agreement. For the inelastic cases, the accuracy of the numerical strain predictions was found to be very sensitive to the material property values used, and initial imperfections in the physical model had to be incorporated into the numerical model in order to trigger the type of dynamic buckling seen in some of the experimental tests. The types of materials include strain-rate insensitive aluminum, strain-rate sensitive steel alloy such as HY-80 and HY100, and S-2 glass fiber composites.

PUBLICATIONS: Nelson, K., Shin, Y., and Kwon, Y., "Failure of Aluminum Cylinder from Underwater Shock Effects," Proceedings of 63rd Shock and Vibration Symposium, Vol. I, pp. 83-95, Las Cruces, NM, 27-29 October 1992.

Chisum, J., and Y. Shin, "Damage Response Predictions of Double Hull Cylinders To Underwater Explosions: Initial Imperfection Effects," Classified Proceedings of 63rd Shock and Vibration Symposium, Las Cruces, NM, 27-29 October 1992.

Bergersen, J., Kwon, Y., and Shin, Y., "Effect of Surface Coating on Cylinders Exposed To Underwater Shock," Proceedings of 63rd Shock and Vibration Symposium, Vol. I, pp.

96-105, Las Cruces, NM, 27-29 October 1992.

THESIS DIRECTED: Chisum, J.E., LT, USN, "Response Predictions for Double Hull Cylinders Subjected to Underwater Shock Loading," Engineer's Degree, June 1992. (Advisor: Y.S. Shin)

Nelson, Kurt W., CDR, USN, "Dynamic Response and Failure Analysis of Aluminum Cylinders Subjected to Underwater Explosion," Master's Thesis, June 1992. (Advisor: Y.S. Shin)

Fox, P.K., LCDR, USN, "Nonlinear Dynamic Response of Cylindrical Shells Subjected To Underwater Side-on Explosion," Engineer's Degree, March 1992. (Advisor: Y.S. Shin)

Bergersen, J.K., LCDR, USN, "Effect of Surface Coating on Cylinders Subjected To Underwater Shock," Master's Thesis, September 1992. (Advisor: Y.S. Shin)

OTHER: Y.S. Shin gave an invited lecture on Underwater Explosions and Their Responses to Structures at the 63rd shock and Vibration Symposium, Las Cruces, NM, 26 October 1992.

MACHINERY NOISE, VIBRATION AND DIAGNOSTICS: ANALYSIS, DESIGN AND TESTING

Y.S. Shin, Professor
Department of Mechanical Engineering
Sponsor and Funding: Naval Sea Systems Command

OBJECTIVE: To develop condition monitoring and diagnostics methods for transient machinery such as turbine-driven torpedo ejection pump system.

SUMMARY: The significant progress in this research was made in: (a) Characterizing the time-frequency dependent signatures of transient machinery such as turbine-driven torpedo ejection pump (TEP) system of Trident class submarine, and (b) Developing successful diagnostics methods for detection of faults in machine operation, and predicting machinery failure using backpropagation neural net approach. The sensitivity analysis of Pseudo Wigner-Ville Distribution (PWVD) was fully investigated, and computer program has been released as version 4.0 and extensive studies were performed to process the time-dependent transient signatures to generate PWVD function for turbine-driven torpedo ejection pump signatures. As we are developing the monitoring scheme to characterize the TEP signatures, we are also developing the diagnostics method using Artificial Neural Network (ANN) which is based on massively parallel distributed processing system consisting of a series of interconnected individual processing elements which process information in a manner similar to neurons in biological system. Among the many different paradigms in ANN, the back-propagation methods was configured to provide machinery diagnostics for simple mechanical system to evaluate the detectability of mechanical component failure. The results were quite promising to apply to TEP condition monitoring and diagnostics which will eventually eliminate expensive periodic maintenance.

THESIS DIRECTED: Spooner, Scott G., LT, USN, "An Energy Analysis of the Pseudo Wigner-Ville Distribution in Support of Machinery Monitoring and Diagnostics," Master's Thesis, June 1992.

SHOCK QUALIFICATION OF COMBAT SYSTEMS EQUIPMENT

Y.S. Shin, Professor
Department of Mechanical Engineering
Sponsor and Funding: Naval Sea Systems Command

OBJECTIVE: To develop and design "tuned" mounting fixture to simulate the ship shock environment for combat system's equipment using U.S. Navy's Mediumweight Shock Machine.

SUMMARY: Shipboard combat system's equipments must be designed to withstand severe shock excitations induced by underwater explosion, either conventional or nuclear. The equipment tends to vibrate at its fundamental natural frequency or a low range of natural frequencies, when excited by the shock wave. The maximum amplitude of the vibration usually occurs after the shock wave passes the ship. The shock response wave form is remarkably different at various levels within the ship. In essence, the ship acts as a low pass mechanical filter which alters the characteristics of the propagating shock wave from one possessing high frequency component to one that contains relatively low frequency components. Thus, the shock qualification for combat systems equipments, which are usually located in upper levels of the ship, is a vibration problem in which relatively low frequency equipment support foundation excitations are observed. The U.S. Navy's shock qualification requirements are mandated in MIL-S-901D. Of particular interest is the U.S. Navy's Mediumweight Shock Machine (MWSM) used for shock qualification of equipment ranging from 230 to 6000 lbs. This hammer-anvil device delivers high energy, high frequency shock excitation to items affixed to it. This type of high frequency excitation waveform is significantly different from the actual waveforms that have been observed at various equipment locations during ship shock trials. The differences can be reduced by substituting a specially designed "tuned" test mounting fixture for the default mounting fixtures currently used to affix test items to the MWSM. A tuned mounting fixture, designed to respond at specific natural frequencies when excited by the MWSM, will provide a better simulation of the actual shock phenomena experienced by shipboard equipment. We examined the differences in shock spectra between the pre-shock trial analysis of combat system's equipment for DDG-51 Class Ship and those produced by Mediumweight Shock Machine as required by MIL-S-901D. The use of a designed "tuned" mounting fixture will afford a better representation of the actual shock phenomena experienced by surface shipboard combat systems equipments when they are qualified on the U.S. Navy Mediumweight Shock Machine.

THESIS DIRECTED: Corbell, R., Shin, Y., and McLean. M., "Shock Qualification of Combat Systems Equipment Using Tuned Mounting Fixtures on the U.S. Navy Mediumweight Shock Machine," Master's Thesis, June 1992.

PUBLICATION: Corbell, R., Shin, Y., and McLean, M., "Shock Qualification of Combat Systems Equipment Using Turned Mounting Fixtures on the U.S. Navy Mediumweight Shcok Machine," Proceedings of the 63rd Shock and Vibration Symposium, Vol. I, pp. 278-290, Las Cruces, NM, 27-29 October 1992.

DEPARTMENT OF MECHANICAL ENGINEERING

1992 Faculty Publications and Presentations

JOURNAL ARTICLES

Crooks, R., Kalu, P.N., and McNelley T.R., "Comments on 'A Model for Subgrain SuperElasticity'," *Scripta Metallurgica et Materiala*, Vol. 26, pp. 145-149, 1992.

Driels, M.R., "The Effect of Sensory Feedback on the Identification of Objects Using a Teleoperator," (with Spain and Aviles), *International Journal of Automation in Construction*, Vol. 1, pp. 167-173, 1992.

Driels, M.R., "An Analysis of Contemporary Printed Wiring Board Manufacturing Environments in the USA," (with Klegka), *International Journal of Advanced Manufacturing Technology*, Vol. 7, pp. 29-37, 1992.

Dutta, I., Mitra, S., and Rabenberg, L., "Oxidation of Aluminum Nitride at Near-Ambient Temperatures," *Journal American Ceramics Society*, 75, p. 3149, 1992.

Fox, A.G., Stoner, T.A., and Cade, S.C., "Towards Extinction-Free Metallurgical Powders for X-ray Diffraction. An Application to TiA1," *Scripta Metallurgica et Materiala*, Vol. 27, pp. 1765-1770, December 1992.

Healey, A.J., "Research in Automation Underwater Vehicles at NPS," *Naval Research Reviews*, Vol. XLIV, No. 1, pp. 43-51, 1992.

Healey, A.J. and Good, M., "The NPS AUV II Autonomous Underwater Vehicle Testbed: Design and Experimental Verification," *Naval Engineers Journal*, ASME, pp. 191-202, May 1992.

Healey, A.J., "Model Based Maneuvering Controls for Autonomous Underwater Vehicles," *Trans ASME Journal of Dynamic Systems, Measurement and Control*, Vol. 114, No. 4, pp. 614-622, 1992.

Joshi, Y. and Kelleher, M.D., "Liquid Immersion Cooling of Electronic Equipment," *Naval Research Reviews*, Vol. XLIV, No. 1, pp. 35-42, 1992.

Mukutmoni, D. and Yang, K.T., "Wave Number Selection for Rayleight-Benard Convection in a Small Aspect Ratio Box," *International Journal of Heat and Mass Transfer*, Vol. 35, 2145-2159, 1992.

Kwon, Y.W., "Finite Element Analysis of Thermoelastoplastic Stresses in Composites," *European Journal of Mechanical Engineering*, Vol. 37, No. 2, pp. 83-88, June 1992.

Kwon, Y.W., "Analysis of Composite Plates Containing Cracks," *Journal of Pressure Vessel Technology*, ASME Transactions, Vol. 114, pp. 358-363, August 1992.

Kwon, Y.W., "Material Nonlinear Analysis of Composite Plate Bending Using a New Finite Element Formulation," *Computers and Structures*, Vol 41, No. 5, pp. 1111-1117.

Kwon, Y.W., "Analysis of Crack Closure in Unidirectional Composite Plates Subject to Bending Loads," *Engineering Fracture Mechanics*, Vol. 42, No. 5, pp. 825-831.

Marto, P.J., "Nucleate Boiling characteristics of R-113 in a Small Tube Bundle, (with C.L. Anderson), *Journal of Heat Transfer*, Vol. 114, pp. 425-433, May 1992.

Marto, P.J., "Film Condensation Heat Transfer Measurements on Horizontal Tubes: Problems and Progress," *Experimental Thermal and Fluid Science*, Vol. 5, pp. 556-569, 1992.

McNelley, T.R. and Kalu, P.N., "Elevated Temperature Deformation and Fracture Characteristics of a Thermomechanically Processed 6061 Al - Al_2O_3 Composite," *Scripta Metallurgica et Materialia*, Vol. 26, pp. 1309-1324, 1992.

Mitra, S., "Elevated temperature Mechanical Properties of a Rapidly Solidified Al-Fe-V-Si Alloy," *Scripta Metallurgica et Materialia*, 27, p. 1992.

Nakamura, Y. and Mukherjee, R., "Formulation and Efficient Computation of Inverse Dynamics of Space Robots," *IEEE Transactions on Robotics and Automation*, Vol. 8, No. 3, pp. 400-406, June 1992.

Papoulias, F.A., "Guidance and Control Laws for Vehicle Path Keeping Along Curved Trajectories," *Applied Ocean Research*, Vol. 14, No. 4.

Papoulias, F.A. and Healey, A.J., "Path Control of Surface Ships Using Sliding Modes," *Journal of Ship Research*, Vol. 36, No. 2, pp. 141-153.

Papoulias, F.A. and Healey, A.J., "Path Control of Surface Ships Using Sliding Modes," *Journal of Ship Research*, Vol. 36, No. 2.

Papoulias, F.A., "Stability and Bifurcations of Towed Underwater Vehicles in the Dive Plane," *Journal of Ship Research*, Vol. 36, No. 3.

Papoulias, F.A., "Loss of Stability of Guidance and Control Laws for Autonomous Vehicles," *Dynamics and Stability of Systems*, Vol. 8, No. 1.

Papoulias, F.A. and Chism, S.R., "Path Keeping of Autonomous Underwater Vehicles Using Sliding Mode Control," *International Shipbuilding Progress*, Vol. 39, No. 419.

Sarpkaya, T., "Review of the Mechanics Fluids," *Applied Mechanics Reviews*, Vol. 45, No. 10, pp. 143-144, October 1992.

Sarpkaya, T., "Brief Reviews of Some Time-Dependent Flows," *Journal of Fluids Engineering*, ASME, Vol. 114, No. 3, pp. 283-298.

Sarpkaya, T., "Recent Progress in Basic Numerical and Physical Experiments on Oscillating Flow About Cylinders," *Viscous Fluid Dynamics in Ship and Ocean Technology*, Vol. 1, pp. 375-404, Osaka University Press, Osaka, Japan.

Sarpkaya, T. and Butterworth, W., "Separation Points on a Cylinder in Oscillating Flow," *Journal of Offshore Mechanics and Arctic Engineering*, Trans. ASME, Vol. 114, pp. 28-36, February 1992.

Sarpkaya, T., Putzig, C., Gordon, D., Wang, X., and Dalton, C., "Vortex Trajectories Around a Circular Cylinder in Oscillatory Plus Mean Flow," *Journal of Offshore Mechanics and Arctic Engineering*, Trans ASME, Vol. 114, No. 4, pp. 291-298.

Sathe, S.B. and Joshi, Y., "Natural Convection Cooling of a Substrate-Mounted Protrusion in a Square Enclosure: A Parametric Study," *Journal of Heat Transfer*, Transactions of ASME, Vol. 114, pp. 401-409, 1992.

Wroblewski, D. and Joshi, Y., "Transient Natural Convection from a Leadless Chip Carrier in a Liquid Filled Enclosure: A Numerical Study," *Journal of Electronic Packaging*, Transactions of ASME, Vol. 114, pp. 271-279, 1992.

CONFERENCE PROCEEDINGS

Bergersen, J.K., Kwon, Y.W., and Shin, Y.S., "Effect of Surface Coating on Cylinders Exposed to Underwater Shock," 63rd Shock & Vibration Symposium, pp. 96-105, Las Cruces, New Mexico, October 1992.

Calvano, C.N., "Systems Engineering Education for Navy Ship Designer's," proceedings of the Annual Conference of the American Society for Engineering Education, June 1992.

Chisum, J., and Shin, Y., "Damage Response Predictions of Double Hull Cylinders to Underwater Explosions: Initial Imperfection Effects," Appeared in Classified proceedings of the 63rd Shock and Vibration Symposium, Las Cruces, NM, 27-29 October 1992.

Chu, S.R., Shoureshi, R., and Healey, A.J., "A Hopfield-Based Neuro-Diagnostic System," proceedings of the American Control Conference, Chicago, IL, 24-26 June 1992.

Corbell, R., Shin, Y., and McLean, M., "Shock Qualification of Combat Systems Equipment Using Tuned Mounting Fixtures on the U.S. Navy Mediumweight Shock Machine," proceedings of the 63rd Shock and Vibration Symposium, Vol. 1, pp. 278-290, Las Cruces, NM, 27-29 October 1992.

Driels, M.R., "Combined Visual and Haptic Search for Remote Object Identification," (with D. Klein), proceedings SPIE OE Technology Conference, Boston, MA, 15-20 November 1992.

Driels, M.R., "Testing and Analysis of Heat Transfer in Materials Exposed to Non-Metallized HTPB Propellant ," (with A. Danielson), Proceedings 1992 JANNEF Rocket Nozzle Technology Sub-Committee Meeting, Sunnyvale, CA, December 1992.

Driels, M.R., "The Duality of Visual and Haptic Search for Object Recognition," proceedings IEEE International Conference on Intelligence Control, Glasgow, UK, August 1992.

Dutta, I., and Harper, C.P., "Effect of Alumina Particulate Addition on the Aging Response of 2014 Aluminum-Matrix Composites," proceedings of the 3rd International Conference on Al Alloys, Vol. 1, p. 519, 1992.

Dutta, I., Mitra, S., and Cooper, J.H., "Process-Dependence of Microstructure and Properties of Sintered Aluminum Nitride Substrate Materials for Electronic Packagings of the MRS Spring Meeting, November 1992.

Healey, A.J., "Experimental Verification of Autonomous Underwater Vehicle Behavior Using the NPS AUV II," Maneuvering and Control of Marine Craft, Computational Mechanics Publications, ISBN No. 1-56252-109-8, Section 4, pp. 217-236.

Healey, A.J., Bahrke, F., and Navarrete, J., "Failure Diagnostics for Underwater Vehicles: A Neural Network Approach," *Maneuvering and Control of Marine Craft, Computational Mechanics Publications, ISBN No. 1-56252-109-8, 1992, Section 5, pp. 293-306.*

Healey, A.J. and Marco, D.B., *"Experimental Verification of Mission Planning by Autonomous Mission Execution and Data Visualization using the NPS AUV II," proceedings of IEEE Oceanic Engineering Society Symposium on Autonomous Underwater Vehicles, AUV-92, pp. 65-73, 2-3 June 1992, Washington, D.C.*

Healey, A.J., *"A Neural Network Approach to Failure Diagnositcs for Underwater Vehicles," proceedings of the IEEE Oceanic Engineering Society Symposium on Autonomous Underwater Vehicles, AUV-92, pp. 131-135, 2-3 June 1992, Washington, D.C.*

Healey, A.J. and Marco, D.B., *"Slow Speed Flight Control of Autonomous Underwater Vehicles: Experimental Results with NPS AUV II," proceedings of the 2nd International Offshore and Polar Engineering Conference, 14-19 July 1992, San Francisco.*

Kwon, Y.W. and Serttunc, M., *"Static and Dynamic Buckling of a Fiber Embedded in a Matrix with Interface Debonding," Recent Advances in Structural Mechanics 1992, ASME PVP-Vol. 10, pp. 41-48.*

Kwon, Y.W., *"Elastoplastic Crack Closure Analysis of a Composite Plate in Bending," Composite Material Technology 1992, ASME-PD-Vol. 45, pp. 245-252, 1992.*

McNelley, T.R. and Kalu, P.N., *"Thermomechanical Processing and Ductility Enhancement of a 6061 Al - Al_2O_3* Metal Matrix Composite," in advanced Synthesis of Engineered Structural Materials, Proceedings of the International Conference, J.J. Moore (ed.), ASM International, Materials Park, OH, 1992.

Mukutmoni, D., Kelleher, M.D., and Joshi, Y.K., "Computations of Liquid Immersion Cooling for a Three-by-Three Array of Chips in a Rectangular Enclosure," proceedings of the NEPCON West '92 Conference, Anaheim, CA 1992.

Mukutmoni, D., Kelleher, M.D., and Joshi, Y.K., "Many Routes to Chaotic Rayleigh-Benard Convection in a Small Aspect Ratio Box," proceedings of the ASME Winter Annual Meeting, 1992.

Nelson, K.W., Shin, Y.S., and Kwon, Y.W., "Failure of Aluminum Cylinder from Underwater Shock Effects," 63rd Shock & Vibration symposium, pp. 83-95, Las Cruces, New Mexico, October 1992.

Sarpkaya, T., and Putzig, C., "Vortex Trajectories Around a Circular Cylinder in Oscillatory Plus Mean Flow," proceedings of the International Conference on Offshore Mechanics and Arctic Engineering, Vol. 1, pp. 69-77, Calgary, Canada, 7-11 June 1992.

Sarpkaya, T., "Interaction of Turbulent Vortex with a Free Surface," proceedings of the Nineteenth Symposium on Naval Hydrodynamics, pp. 163-174, National Academy Press, August 1992.

Sarpkaya, T., "Forty Years of Fluid Loading - The Past and Beyond," proceedings of the International Conference on the Behavior of Offshore Structures, Vol.1, pp. 283-293, July 1992.

Sarpkaya, T., "Instability and Transition on a Cylinder in Periodic flow," proceedings of the International Union of Theoretical and Applied Mechanics Symposium on Bluff-Body Wakes, Dynamics and Instabilities, Vol. 1, pp. 234-243, Gottingen, Germany, 7-11 September 1992.

Sarpkaya, T., Putzig, C., and Gordon, D., "Numerical Analysis of Wave and Current Induced Flow About a Circular Cylinder," proceedings of the Offshore Technology Conference, Vol. 1, pp. 456-463, Houston, TX, 4-7 May 1992.

Sarpkaya, T., "Offshore Hydrodynamics -- Research Trends and Opportunities," proceedings of the International Conference on Offshore Mechanics and Arctic Engineering, Vol. 1, pp. 78-89, Calgary, Canada, 7-11 June 1992.

Wroblewski, D. and Joshi, Y., "Liquid Immersion Cooling of a Substrate Mounted Protrusion in a Three-Dimensional Enclosure: The Effects of Protrusion Aspect Ratios and Enclosure Boundary Conditions," proceedings of the ASME National Heat Transfer Conference, San Diego, CA August 1992.

Wroblewski, D. and Joshi, Y., "Transient Natural Convection from a Leadless Chip Carrier in a Liquid Filled Enclosure: A Numerical Study," proceedings of the ASME/JSME joint Electronics Packaging Conference, Milpitas, CA April 1992.

Xia, Q., Yang, K.T., and Mukutmoni, D., "Effect of Imposed Wall Temperature Oscillations on the Stability of Natural Convection in a Square Enclosure," proceedings of the ASME Winter Annual Meeting, 1992.

CONFERENCE PRESENTATIONS

Crooks, R., McNelley, T.R., and Kalu, P.N., "Process Control for Superplasticity in an Al-Mg-Zr Alloy," International Conference on Advanced Synthesis of Engineered Structural Materials, San Francisco, CA, 30 August - 2 September 1992.

Dutta, I., "Impact of Residual Stresses on Uniaxial Deformation of Sic Whisker Reinforced Aluminum-Matrix Composites," 3rd Annual Navy R&D Information Exchange Conference, Silver Spring, MD, April 1992.

Fox, A.G. and Tabbernor, M.A., "The Structure Factors, Charge Density and Debye-Waller Factors of Martensitic Ni-Rich ßNial," International Conference on Martensite Transformations, Monterey, CA, 20-24 July 1992.

Fox, A.G. and Tabbernor, M.A., "The Measurement of Small Structure Factors by the Critical Voltage Effect in HEED. The Superlattice Reflections in ßNial, ßCoAl and Tial," 50th Annual Meeting of EMSA, pp. 1174-1175, Bosrton, MA, 16-22 August 1992.

Fox, A.G., "High Voltage electron Diffraction and its Contribution to Understanding the Bonding Mechanisms in Elements and Alloys," presented at the Microstructure of Materials' symposium in honor of Professor Gareth thomas' sixtieth birthday, Lawrence Berkeley Laboratory, University of California, Berkeley, 22-23 October 1992.

Fox, A.G., Mikalac S., and Vassilaros, M.G., "the Microstructure and Mechanical properties of a HSLA-100 Steel and HSLA-100 with Increased Copper in Plate Form," presented at the Gilbert R. Speich Symposium on the Fundamentals of Aging and Tempering of Bainitic and Martensitic Steel Products, Montreal, Quebec, Canada, pp. 155-161, 1992.

Kalu, P.N. and McNelley, T.R., "The Effect of Thermomechanical processing on the Elevated Temperature Properties of 6061 Al - Al_2O_3 Composites,' in the General Abstract Session on Composites, 21st Annual Meeting of TMS, San Diego, CA, 1-5 March 1992.

Kwon, Y.W., "Analysis of Metal Matrix Composites," Third Annual R&D Information Exchange Conference, Naval Surface Warfare Center, Silver Spring, MD, 8-10 April 1992.

Kwon, Y.W., "Material Nonlinear Analysis of Composites," Naval Surface Warfare Center, Carderock Division, Bethesda, MD, September 1992.

Marto, P.J. and Memory, S.B., "The Influence of Oil on boiling Hysteresis of R-114 from Enhanced Surfaces," Pool and External Flow Boiling, V.K. Dhir and A.E. Bergles (Eds), ASME, New York, pp. 63-71, 1992.

Marto, P.J., Memory, S.B., and Chilman, S.V., "Nucleate Boiling Characteristics of a Small Enhanced Tube Bundle in a Pool of R-113," Two-Phase Flow and Heat Transfer, J.H. Kim, R.A. Nelson and A. Hashemi (Eds), ASME HTD-Vol. 197, New York, pp. 129-138, 1992.

Marto, P.J., Memory, S.B., and Mazzone, R.W., "Enhanced Laminar Film Condensation of R-113 Using Wire-Wrap on a Horizontal Roped Tube Bundle, Heat Transfer, Vol. 1, Institution of Chemical Engineers, Symposium Series No. 129, Warwickshire, U.K., pp. 249,-262, 1992.

McNelley, T.R. and Kalu, P.N., "The Influence of Processing Strain on the Low-Temperature Superplastic Response of an Al-10Mg-0.1Zr Alloy," in the General Abstract Session on Effects of Deformation on Microstructure, 121st. Annual Meeting of TMS, San Diego, CA 1-5 March 1992.

McNelley, T.R. and Kalu, P.N., "Thermomechanical processing and Ductility Enhancement of a 6061 Al - Al_2O_3 Metal Matrix Composite," International Conference on Advanced Synthesis of Engineered Structural Materials, San Francisco, CA, 30 August - 2 September 1992.

McNelley, R.R., Crooks, R., Kalu, P.N., and Rogers, S.A., "Precipitation and Recrystallization During Processing of a Superplastic Al-Mg-Zr-Alloy," Grain Boundary and Interface Phenomena in the High Temperature Plasticity of Solids, Berkeley, CA, 16 October 1992.

McNelley, T.R., crooks, R., Kalu, P.N., and Rogers, S.A., "Precipitation and Recrystallization During Processing of a Superplastic Al-Mg-Zr Alloy," Grain Boundary and Interface Phenomena in the High Temperature Plasticity of Solids, Berkeley, CA, 16 October 1992.

McNelley, T.R., Crooks, R., and Kalu, P.N., "Low Temperature Superplasticity and Microstructural Dynamics of an Al-Mg Alloy," in Advances in Superplasticity and Superplastic Forming, Annual Fall Meeting of TMS and ASM International, Chicago, IL, 2 November 1992.

Mukumoni, D. and Yand, K.T., "Thermal Convection in a small Box for High Prandtl Number Fluids," presented at the National Heat Transfer Conference, 1992.

Mukherjee, R. and Chen, D., "Stabilization of Free-flying Under-Actuated Mechanisms in Space, American Control Conference, 1992.

Sarpkaya, T., Cady, M., and Hooper, R., "Transition to Turbulence on a Cylinder in Axial Oscillatory Flow," AIAA Paper No. 92-0739 presented at the 30th Aerospace Sciences Meetings of AIAA in Reno, NV, 6-10 January 1992.

Sarpkaya, T. and Lundblad, W., "Three-Dimensional Interactions of Vortices with a Free Surface," AIAA Paper No. 92-0739 presented at the 30th Aerospace Sciences Meeting of AIAA in Reno, NV, 6-10 January 1992.

Sarpkaya, T., "Forty Years of Fluid Loading - The Past and Beyond," invited leading lecture presented at the Internaitonal Conference on the Behavior of Offshore Structures on 7-10 July 1992 at the Imperial College, London.

Sarpkaya, T., "Surface Scars due to turbulent Vortices," presented at the ONR Workshop, 24-26 February 1992.

Shin, Y.S., "Underwater Explosions and Their Responses to Structures," presented at 63rd Shock and Vibration Symposium, Las Cruces, NM, October 1992.

Shin, Y.S., "Underwater Explosion Research in NPS and Future Direction," presented at ONR workshop on Underwater Explosion Effects on Structures and Shock Mitigation, University of Maryland, MD, 21-22 September 1992.

Shin, Y.S. and Kwon, Y.W., "Nonlinear Dynamic Responses of Naval Structure to Underwater Explosion," ONR Workshop on Underwater Explosion Effects on Structures and Shock Mitigation, University of Maryland, College Park, MD, 21-22 September 1992.

BOOK CONTRIBUTIONS

Brown, P.J., Fox, A.G., Maslen, E.N., O'Keefe, M.A., Sabine, T.M., and Wills, T.M., "Interpretation of Diffracted Intensities," contribution to the International Tables for for Crystallography, Volume C, Mathematical, Physical and Chemical Tables, published by (Kluwer Academic Publishers, Dordrecht/Boston/London), Section 6. Subsection 6.1.1 "X-ray Scattering," by **Maslen, E,N,, Fox, A.G., and O'Keefe, M.A.**, pp. 476-511, 1992.

Nakamura, Y. and Mukherjee, R., "Nonholonomic Path Planning of Space Robots via a Bi-Directional Approach, Space Robotics: Dynamics and Control, pp. 101-130, Takeo Kanade and Yangsheng Xu (Eds), (Kluwer Academic Press).

Shin, Y.S., "Overview of Underwater Shcok and DDAM," contributed short course notes, (133 pages)), and presented at 63rd Shock and Vibration Symposium, Las Cruces, NM, 26 October 1992.

Yang, K.T. and Mukutmoni, D., "Computational Aspects of Studies of Buoyant Enclosure Flows," pp. 21-39, Computers and Computing in Heat Transfer Science and Engineering, W. Nakayama and K.T. Yang, Editors, (Bigell House Inc., New York, N.Y., 1992).

DEPARTMENT OF METEOROLOGY

Professor R.L. Haney
Chairman



DEPARTMENT OF METEOROLOGY

The research program in the Department of Meteorology directly supports the Department's mission of providing a high quality, Navy-relevant graduate education to its officer students. Department faculty conduct basic and applied research in all subdisciplines include synoptic and mesoscale dynamics, numerical modeling and prediction, environmental analysis and visualization, satellite and ground-based remote sensing, in-situ observational systems, boundary layer meteorology and air-sea interaction. Geographical areas of study include the global atmosphere as well as tropical, polar and coastal regions. A brief summary follows.

CYCLOGENESIS

Considerable research has been carried out on the operationally important and scientifically challenging problem of rapid cyclogenesis over the ocean. Both observational studies and numerical model diagnostic studies have been conducted by Meteorology faculty including **R. Elsberry, P. Hirschberg, T. Holt, W. Nuss, P. Pauley and C. Wash.** The studies made use of special data sets collected during the international GALE and ERICA field programs in the western North Atlantic, and a variety of atmospheric mesoscale models including those of the Navy (NRL and NORAPS) National Center for Atmospheric Research (NCAR) /Penn State and the National Meteorological Center (NMC). The studies address the role of physical processes such as surface (ocean) heat exchange, latent heat release, low-level baroclinity, upper-level forcing, and several practical issues including predictability, observational requirements (including satellite remote sensing) and model forecast skill. Additional studies are in progress or planned for the near future because of the quality of these data sets, the potential for improving numerical forecast models, and the importance of oceanic cyclogenesis to the operational Navy.

TROPICAL METEOROLOGY

Another important area of research in the Department is the broad subject of tropical meteorology. A number of faculty are involved, including **L. Carr, C.P. Chang, J.M. Chen, G. Dunnavan, R. Elsberry, P. Harr, T. Murphree, M. Peng, F. Williams and R. Williams.** Theoretical and data analysis studies are being carried out on the dynamics of tropical synoptic and planetary scale motions, tropical and equatorial oceans, and diagnostic analyses of oceanic tropical weather systems using the Navy's global model. One comprehensive research project is investigating the structure and mechanisms of weather disturbances in the tropical and subtropical coastal regions, particularly those regions under the Asian-African monsoon influences, including the Philippine Sea, South China

Sea, Bay of Bengal and Arabian Sea. Another large multi-year basic research program, involving field observations and theoretical and modeling studies, to understand the dynamics of tropical cyclone motion is continuing with a new focus on cyclone structure changes. Other efforts are directed at transitioning the new knowledge of tropical cyclone motion into Fleet operations.

COASTAL METEOROLOGY

Coastal meteorology in midlatitudes, another increasingly important research area for the Navy of the future, is also an area of active research in the Department. Observational and modeling/analysis studies in the coastal region are being conducted by **K. Davidson, T. Holt, W. Nuss and C. Wash.** Ongoing research includes the observation, analysis (data assimilation) and visualization of the sea/land breeze phenomenon, and modeling studies of the dynamics and predictability of mesoscale features forced by coastal topography. The Department's research in this area is expected to increase during the next few years because of the growing importance of coastal meteorology in our curricula and in the operational Navy.

NUMERICAL MODELING

Many of the studies on rapid cyclogenesis, tropical meteorology, and coastal meteorology noted above use numerical modeling as a tool in their investigations. Other on-going modeling efforts in the Department include the development and testing of numerical procedures (finite element and semi-Lagrangian) for improved mesoscale forecasts in global and regional weather prediction models by **R. Williams and M. Peng,** the development of improved methods of objective analysis of meteorological data by **W. Nuss and P. Pauley,** and data assimilation studies of the dynamics and prediction of mesoscale variability in the coastal ocean off Central California by **R. Haney.**

BOUNDARY LAYER STUDIES

A variety of atmospheric boundary layer studies are in progress, in addition to those related to oceanic cyclogenesis and the sea breeze phenomenon noted above. Collaborative field experiments by **K. Davidson, P. Guest and C. Wash** have involved meteorological measurements from ships, towers, aircraft and buoys. Analyses are being performed on boundary layer data collected in the Arctic, off the coast of the Netherlands, near a sea-surface temperature front in the western North Atlantic, off the California coast, and off the Florida Keys. The research is aimed at improving atmospheric boundary layer models and measurement systems, and at developing and testing models for the distribution of marine aerosols. The studies are also designed to improve our understanding of optical turbulence, Atmospheric refraction, and air-sea fluxes of heat and momentum at the sea surface.

ATMOSPHERIC REMOTE SENSING

The Department has an active research program in atmospheric remote sensing, which is a subject of importance to the interdisciplinary space curricula as well as to air-ocean sciences. Examples of present efforts in the Department include global studies of stratospheric aerosols, investigations of the interaction between aerosols, cloud-brightness and radiative effects, the development of methods to estimate optical extinction in the marine boundary layer due to atmospheric aerosols, and classified research of strategic importance by **P. Durkee.** Additional remote sensing research in the Department includes developing methods to distinguish between clouds, precipitation and snow using multi-channel satellite data by **C. Wash,** and field measurements to identify and verify mechanisms responsible for scaterometer and synthetic aperture radar (SAR) images of the ocean surface by **K. Davidson.**

TROPICAL AND MONSOON STUDIES

C.-P. Chang, Professor
R.T. Williams, Professor
Deaprtment of Meteorology
Sponsor and Funding: National Science Foundation

OBJECTIVE: The purpose of this project is to study the structure and behavior, including the dynamical and thermodynamic mechanisms, of large- and cyclone-scale atmosphere motion systems in the tropics and subtropic, particularly those in the western Pacific and its vicinity.

SUMMARY: A Multiple-set Canonical Correlation Analysis (MCCA) is developed to diagnose the sequential structure of several types of tropical disturbances, both stationary and propagating. The MCCA resolves the previous difficulties of the traditional super-matrix method and applies physical considerations in the configuration of the various data fields. In the mean time, it guarantees orthogonality for each individual field and maximum correlations between them. The data used are the analyzed fields of the Naval Operational Global Atmospheric Prediction System (NOGAPS) for May-September 1989-1991, and the Tropical Global Band Analysis for the winters of 1974-1988. Preliminary application of the technique on the 850 hPa v at different stages revealed the coherent structure of the winter monsoonal cold surges over the South China Sea, and the summer synoptic waves over the tropical western Pacific. Other fields in the NOGAPS data are being analyzed to study the dynamics and thermodynamics of these disturbances.
We are planning to use the technique to study global- and meso-scale climate dynamics. Preparation is under way to analyze high resolution geostationary satellite data over the Asia-Pacific region for 1978-1992, and long-term general circulation model outputs produced by low-resolution NOGAPS and GFDL models. The passage of a front over a long symmetric ridge was studied with a two- dimensional numerical model. 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 results were extended to an asymmetric mountain. The effect of topography on fronts in a three-dimensional baroclinic model was determined for five finite mountain ranges with various orientations and shapes. The fronts were strongly distorted by the mountains, but they returned to their original shape after leaving the mountain region. Another study examined the three-dimensional flow of a stratified barotropic current over isolated topography. A variety of flows were obtained which depended on the scale and Froude number of the flow.

PUBLICATIONS: Chang, C.-P. and J.M. Chen, "A Statistical Study of Winter Monsoon Cold Surges over the South China Sea and the Large-Scale Equatorial Divergence" *Journal of Meteorological Society of Japan*, 70-1, 287-302, 1992.

Chang, C.-P., J.M. Chen and L.C. Quah, "Synoptic Scale Propagating Disturbances in the Tropical Western Pacific during the Northern Summer Monsoon of 1989-1991," Proceedings International Symposium on Asian

Monsoon, 55-56, 1992.

Williams, R. T., M. S. Peng and D. A. Zankowski, "Effect of Topography on Fronts," *Journal of the Atmospheric Sciences*, 49, 287-305, 1992.

Chang, C.-P., T.-C. Yeh and J.-M. Chen, "Effects of Terrain on the Surface Structure of Typhoons over Taiwan," *Monthly Weather Review*, Accepted for publication, December 1992.

Chen, J.-M. and C.-P. Chang, "Multiple-set Canonical Correlation Analysis of Winter Monsoon Cold Surges over the South China Sea", *East Asia and Western Pacific Meteorology and Climate II*, Accepted for publication, December 1992.

CONFERENCE PRESENTATION:

Chang, C.-P., and J.-M. Chen, "Winter Monsoon Cold Surges and the Equatorial Divergence over the South China Sea," Second International Conference on East Asia and Western Pacific Meteorology and Climate, Hong Kong, 11-14 September 1992.

Chang, C.-P., J.-M. Chen and L.-C. Quah, "Synoptic Scale Propagating Disturbances in the Tropical Western Pacific during the Northern Summer Monsoon of 1989-1991," International Symposium on Asian Monsoon, Tsukuba, Japan, 21-25 September 1992.

Peng, M. S. and R. T. Williams, "Effects of Mountain Asymmetry on a Passing Front," Fifth Conference on Mesoscale Processes, Atlanta, GA, 5-10 January 1992.

Peng, M. S., S.-W. Li, S. W. Chang and R. T. Williams, "Flows over Mountains: Coriolis Force, Transient Trough and Three Dimensionality," Second International Conference on East Asia and Western Pacific Meteorology and Climate, Hong Kong, 11-14 September 1992.

Li, S.-W., M. S. Peng and R. T. Williams, "Three-dimensional Studies of the Effects of Topography on Fronts," Sixth Conference on Mountain Meteorology, Portland, OR, 29 September - 2 October 1992.

THESIS DIRECTED:

Yeh, T.-C., "Effects of Taiwan Orography on the Motion and Structure of Fronts", Ph.D., December 1992.

Li, S.-W., "A Three-Dimensional Study of the Influence of Mountains on a Front," Doctoral Dissertation, December 1992.

AIR SEA INTERACTION AND REMOTE SENSING

K. L. Davidson, Professor
P. A. Fredrickson, Physical Scientist
T. Neta, Computer Analyst
Department of Meteorology

Sponsor: Office of Naval Research (1121RS)
Funding: Naval Postgraduate School

OBJECTIVES: The objective of this research is to continue our studies into data analysis and interpretation studies to investigate the relationships between near surface wind and wind stress and between wind stress and radar backscatter for both equilibrium and non-equilibrium wind and sea conditions.

SUMMARY: The wind and surface data under study were obtained in the Frontal Air Sea Interaction Experiment (FASINEX), in the Humidity Exchange Main Experiment (HEXMAX), and in the Norwegian Continental Shelf Experiment (NORCSEX). FASINEX results show that a SST front enhancement of the Ku-band backscatter is supported by variations of the surface wind stress (Weissman et al., forthcoming). They also have provided coupled data for a new Ku-band model functions that clearly distinguishes between the friction velocity and the neutral wind speed. HEXMAX results show that a drag coefficient can be established for shallow water regimes (Davidson et al., 1992) but that wave stage as well as wind speed has to be included as a defining parameter (Smith et al., 1992). NORCSEX shipboard wind stress results that good correlation occurs between wind stress and radar backscatter changes (Davidson, et al, forthcoming).

PUBLICATIONS: Davidson, K.L., P.J. Boyle, and P. S. Guest, "Atmospheric Boundary Layer Properties Affecting Wind Forecasting in Gulf and Coastal Regions," *Journal of Applied Meteorology*, 31, 983-994, August 1992.

Smith, S.D., R. Anderson, W. A. Oost, C. Kraan, N. Maat, J. DeCosmo, K. B. Katsaros, K. L.. Davidson, K. Bumke, L. Hasse, and H. M. Chadwick , "Wind Stress and Drag Coefficients during HEXMAX," *Journal of Geophysical Research*, 60, 109-142, 1992.

FORMULATION AND VERIFICATION OF A MARINE VERTICAL AEROSOL MODEL (NOVAM)

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F. K. Jones, Physical Scientist
T. Neta, Computer Analyst
Department of Meteorology

Sponsor: Naval Command Control and Ocean Surveillance Center, RDT&E Division (NRaD)
Funding: Naval Postgraduate School and Naval Research and Development, Code 54

OBJECTIVE: Objectives of continuing data analyses/ interpretation and experimental preparation efforts were to: a) formulate and evaluate existing computer based models (NAM and NOVAM) for estimation of profiles of aerosol extinction from surface based measurements, b) formulate approaches and models to calculate optical depth and the total extinction coefficients using operational satellite-borne sensors, NOAA AVHRR, and c) design and prepare for participation in experiments to characterize near-surface aerosol distributions and profiles.

SUMMARY: Evaluation of NOVAM on the basis of existing data was performed. Surface layer aerosol data were collected during May of 1992 in conjunction with a evaluation of shipboard applications of a High-Resolution Interferometer Sounder (HIS) in the marine boundary layer. They were also collected in conjunction with airborne aerosol and ship thermal imaging data collection

in July-August 1992. In addition to the aerosol data, meteorological data required by NOVAM were also collected in both cases. Investigation of detection of aerosol properties from satellite remote sensing was carried out by Dr. Mathieu Rouault, an NPS National Research Council (NRC) post-doctoral associate, in collaboration with Dr. P. Durkee of NPS, Rouault and Durkee (1992). Spectral windows that have been found to be positively correlated with aerosol optical depth are in the red-visible , channel 1, (0.58-0.68 microns) and in the near infrared, channel 2 (0.725-1.10 microns). The ratio of measured radiance of these two channels provides a Particle Size Index which could be used to characterize the relative magnitude of submicron particle concentrations. An up-dated acquisition system was developed for PMS-probe data collection.

PUBLICATION: Rouault, M. and P. A. Durkee, "Characterization of Aerosols from Satellite Remote Sensing," Proceedings, 13th International Conference on Nucleation and Atmospheric Aerosols, 24-28 August 1992, Salt Lake City, UT.

SURFACE WIND STRESS IN NORCSEX'91

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F. K. Jones, Physical Scientist
Department of Meteorology
Sponsor: Naval Research Laboratory-Stennis Space Center
Funding: Naval Postgraduate School and Naval Research Laboratory-Stennis Space Center

OBJECTIVES: Objectives of in situ data collection off the Norwegian west coast during November 1991 are to acquire a data set that can be used to calibrate/ validate the use of the ERS-1 SAR to detect winds and atmospheric forcing of the ocean in the data-scarce open-ocean region.

SUMMARY: NPS personnel and equipment participated in the NORCSEX ERS-1 SAR validation experiment with regard to collection and initial analyses of wind forcing. NPS performed continuous measurements of the atmospheric surface layer and regular spaced measurements of the boundary layer profile. This was performed in collaboration with complementary shipboard and satellite retrieval studies by the Nansen Environmental and Remote Sensing Center (NERSC) and the Environmental Research Institute of Michigan (ERIM). Accomplishments were performed in situ shipboard meteorological measurements coincident with ship-based scatterometer and oceanographic measurements during ERS-1 flyovers as well as near continuously from 7 through 29 November 1992, to reduce, edit, summarize and report the data collected in situ and regional analyzed meteorological data. The report is "NORCSEX'91 ERS-1 Validation Experiment Report" NERSC Tech Report No. 53, July 1992, and to prepare preliminary remote / meteorological data with NERSC and ERIM collaborators for postulation of conceptual wind, wave, and frontal algorithms.

PUBLICATIONS: Johannessen, J.A., K.L. Davidson, R.A. Shuchman, "NORCSEX'91 ERS-1 Validation Experiment,

Experiment Report," Nansen Environmental and Remote Sensing Center Technical Report No. 53, 84.

Johannessen, J.A., R.A. Shuchman, K.L. Davidson, O. Frette, D. Digranes, O.M. Johannessen, "Coastal Ocean Studies with ERS-1 SAR During NORCSEX'91," Proceedings, ERS-1 Symposium, November 1992.

METEOROLOGICAL MEASUREMENTS IN SIZEX'92

K. L. Davidson, Professor
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Department of Meteorology

Sponsor and Funding: Naval Research Laboratory-Stennis Space Center

OBJECTIVES: Objectives of in situ data collection in the East Greenland and Barents Seas during January and February 1992 was to acquire a data set that could be used to calibrate/ validate the use of the ERS-1 SAR to detect winds and atmospheric forcing of the Marginal Ice Zone (MIZ) regions.

SUMMARY: NPS personnel and equipment participated in the Seasonal Ice Zone Experiment (SIZEX'92) which was an ice region calibration/validation campaign for the ERS-1 SAR. NPS meteorological measurement and data acquisition systems were installed on one research vessel, R/V Haakon Mosby, in January (SIZEX-I) and on two research vessels, R/V's Haakon Mosby and Polarsyssel, in February (SIZEX-II) 1992. Damaged equipment resulting from the laboratory flooding at the end of SIZEX-I was repaired or replaced so that the SIZEX-II meteorological objectives were able to be achieved. During SIZEX-II, NPS USN officer students (LCDR A.R.Parsons and LT K. Wos) were onboard the ships to monitor sensors and to operate data acquisition systems. The meteorology data collections were performed in collaboration with complementary shipboard and satellite retrieval studies by the Nansen Environmental and Remote Sensing Center (NERSC) and the Environmental Research Institute of Michigan (ERIM). Preliminary editing of the meteorological data from all collection periods began in August of 1991.

EM/EO MODEL CALIBRATION/VALIDATION

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Department of Meteorology

Sponsor and Funding: Naval Command Control and Ocean Surveillance Center, RDT&E Division (NRaD)

OBJECTIVE: To perform analyses on unique in situ data for evaluation of models and approaches under consideration in present and planned EM/EO model development for assessment of: a) Evaporation duct estimation, b) Vertical profiles of aerosol caused optical extinction, and c) Thermal (IR) imaging of ships.

SUMMARY: NPS performed analysis and interpretation tasks on data

collected in past marine atmospheric boundary layer experiments. The analyses/interpretations focused on properties of the boundary layer and surface that influence propagation of electromagnetic (radar) and electro-optical (IR) propagation. The tasks related to activities and data collected in three experiments, the a) Norwegian Continental Shelf Experiment (5-28 November 1991, R/V Haakon Mosby), b) High Resolution Interferometer Sounder (HIS) marine boundary layer calibration experiment (8-11 May 1992, R/V Point Sur), and c) FLIR/AGA thermal imaging experiment (28 July - 3 August, R/V Point Sur).

SINGLE POINT (SHIPBOARD) MEASUREMENT ANALYSES

K. L. Davidson, Professor
C. H. Wash, Professor
P. A. Frederickson, Physical Scientist
F. K. Jones, Physical Scientist,
Department of Meteorology
Sponsor and Funding: Naval Research Laboratory-Monterey

OBJECTIVE: The objectives ofthis research was to conduct detailed analyses and interpretations on surface and mixed layer data to evaluate the; a) influence of the ship presence on evaporation duct height estimates from bulk method, b) affect of different determination of ship heading and speed on vector wind values, and c) methods for merging derived surface layer humidity and temperature profiles with rawinsonde profiles.

SUMMARY: Special analyses / interpretation were performed on shipboard data collected during the High resolution Intererometer Sounder (HIS) experiment conducted off the north central California coast during May 1992. These were performed on the surface layer measured "Bulk" parameters. The sensors, except for the sea surface measurements were mounted on a well exposed platform above the bridge at a level 19 meters above the surface. The surface layer measurements, at the frequency and detail they were performed, were not central to the HIS objectives. Some common measurement difficulties arose during the cruise and the influence of these under different air and sea conditions can be examined. For two measurements periods, sensor contamination by ship exhaust occurred. During one period, upwind obstacles degraded the vector wind estimate. For two periods, up to 6 hours each, a flow obstruction to the sea surface temperature caused too high values.

STRATIFICATION IN THE LOWER MARINE ARCTIC ATMOSPHERE

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P. A. Frederickson, Physical Scientist
Department of Meteorology
Sponsor: Office of Naval Research (ONR-1125AR)
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this study is to understand the relationship between stratification of the lower marine Arctic atmosphere and ocean/atmosphere/ice interaction processes.

SUMMARY: The stratification of the lower atmosphere was found to be important for several processes on time and space scales ranging from local turbulence to global climate change. Factors affecting surface temperature and energy balance in Arctic regions were examined by Guest and Davidson (1992) and Davidson and Guest (1993). Clouds were found to play a crucial role in determining the surface energy budget, Guest and Davidson, (1991) and wind stress, Guest, (1992) over sea ice during dark seasons. Measurements and modeling results showed that stratification in the lower marine arctic atmosphere had an important effect on surface wind stress, Overland and Davidson, (1992) and surface heat flux, Davidson and Guest, (1991). Large changes in lower atmospheric stratification characteristics such as boundary layer depth and surface temperature were found to exist across a marginal ice zone (MIZ) region, Frederickson (1991). These horizontal changes in atmospheric structure in MIZ regions greatly affected air/ice/sea interactions, Frederickson (1992).

PUBLICATIONS: Overland, J.E. and K.L. Davidson, "Geostrophic Drag Coefficients Over Sea Ice," *Tellus*, 44A, pp. 54-66, 1992.

Davidson,. K.L. and P.S. Guest, "The Effect of Stratification in the Lower Marine Arctic Atmosphere on Interactions with the Surface. AGU 1991 Fall Meeting, Program and Abstracts, 9-13 December, 1991, a supplement to EOS, 29 October, p. 237.

Fredericksen, P.A., K.L. Davidson and P.S. Guest, "The Stratification of the Lower Marine Arctic Atmosphere," AGU 1991 Fall Meeting, Program and Abstracts, 9-13 December 1991, a supplement to EOS, 29 October, p. 237.

Fredericksen, P.A., K.L. Davidson and P.S. Guest, "Observations of the Atmospheric Boundary Layer in the Arctic Marginal Ice Zone," Preprints, Third Conference on Polar Meteorology and Oceanography, Portland, Oregon, 29 September - 2 October 1992, p. J16.

Guest, P.S. and K.L. Davidson, "The Effect of Cloudiness on Heat Loss From Pack Ice During Dark Seasons," AGU 1991 Fall Meeting, Program and Abstracts, A supplement to *EOS*, 9-13 December 1991, 29 October 1991, p. 237.

Guest, P.S. and K.L. Davidson, "A Study of the Factors Controlling the Value of the Surface Temperature of Sea Ice. Preprints, Third Conference on Polar Meteorology and Oceanography, Portland Oregon, 29 September - 2 October 1992, p. 50.

DISSERTATION DIRECTED: Guest, P.S.,

"A Numerical, Analytical and Observational Study of the Effect of Clouds on Wind Stress During the Central Arctic Winter," Ph.D. Dissertation, March 1992.

THESIS DIRECTED: Wos, A.W., "A Climatology of Polar Low Occurrences in the Nordic Seas and an Examination of Katabatic Winds as a Triggering Mechanism, Master's Thesis, December 1992.

ANALYSIS OF REGIONAL LEAD FORCING

K. L. Davidson, Professor
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P. A. Frederickson, Physical Scientist
Department of Meteorology
Sponsorand Funding: Naval Research Laboratory, Monterey

OBJECTIVE: The general objectives of this study are to understand the forcing mechanisms responsible for regional lead characteristics and to understand the effects of leads on regional meteorology in the Arctic.

SUMMARY: Participation in a major field program, LEADEX, resulted in the successful measurement of regional-scale lead forcing mechanisms. A buoy array was successfully deployed at the beginning of the experiment and remained operational throughout the field program period and for several months afterward. Ice deformation and lead formation were found to be related to wind stress and pre-existing lead geometries (Overland *et al.*, 1992). The characteristics of the lower atmosphere during LEADEX were examined using data from rawinsondes soundings obtained by the PI's measurement program (Persson *et al.*, 1992). The transfer of momentum was analyzed using the regional buoy information (to be published). Models of radiation and surface energy fluxes over ice were compared with the LEADEX measurements (to be published).

PUBLICATIONS: Persson, P.O.G., D. Ruffieux and K. Davidson, "Characteristics of the Lower Troposphere During LEADEX 92," Preprints from the Third Conference on Polar Meteorology and Oceanography, Portland Oregon, 29 September - 2 October 1992, p. 50.

Overland, J.E., B.A. Walters, and K.L. Davidson, "Sea Ice Deformation in the Beaufort Sea," Preprints from the Third Conference on Polar Meteorology and Oceanography, Portland Oregon, 29 September - 2 October 1992, p.64.

HORIZONTAL VARIATIONS OF WIND STRESS IN MARINE POLAR REGIONS

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P. S. Guest, Meteorologist
Deaprtment of Meteorology
Sponsor and Funding: Naval Research Laboratory, Monterey

OBJECTIVE: The objective is to determine how spatial variations in surface conditions affect wind stress in marine polar regions.

SUMMARY: A numerical model provided by J. Glendening of NRLM was used in conjunction with detailed observations of surface and atmospheric conditions to determine the horizontal variations of wind stress during a period when the surface wind was parallel to an ice edge (Davidson *et al.*, 1992). Variations in wind speed were found to be equally important as surface roughness changes in determining wind stress variations. A paper was prepared which examined measurements and models of wind stress variations across marginal ice zones (MIZs) for situations with a variety of different meteorological and sea ice conditions (Guest *et al.*, 1993). These were the first studies to focus entirely on wind stress variations across an MIZ. They also represent the first attempt at including detailed surface forcing conditions (roughness, temperature, wind vector and ice coverage) based on *in situ* measurements into a numerical model of the atmosphere in the MIZ.

PUBLICATIONS: Davidson, K.L., P. S. Guest and J. W. Glendening, "Determining Realistic Wind Stress Forcing Fields for Marine Arctic Regions," Preprints from the Third Conference on Polar Meteorology and Oceanography, Portland Oregon, 29 September - 2 October 1992.

MARINE STRATOCUMULUS CLOUD REFLECTANCE: IMPLICATIONS FOR AEROSOL-CLOUD INTERACTION AND ENTRAINMENT

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Department of Meteorology
Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: The proposed effort investigated the effects of aerosol variation and cloud-top entrainment on marine stratocumulus cloud reflectance. Previous experimental results were used to examine the signature of variable entrainment. The study will culminate in participation in ASTEX during FY92.

SUMMARY: This program of study was in the third of three years, culminating in participation in the ASTEX field program in June 1992. The primary objective was investigation of the radiative processes that result from cloud and aerosol particle interaction and the effects of cloud-top entrainment. Emphasis was placed on analysis of aerosol and cloud observations to gain insight into the effects of aerosol particles and entrainment on the microphysics of clouds. Investigations focused on cloud types that are most affected by aerosol and cloud interactions, especially in the ASTEX region (Azores/Madiera

Islands). These include marine stratocumulus, especially where variable marine and continental effects are important. Since marine stratocumulus cloud processes are largely driven by radiative heating/cooling, cloud reflectance effects should provide valuable insight into cloud formation / dissipation mechanisms. Specific accomplishments included continued examination of the ASTEX region withemphasis on case studies of aerosol-cloud interactions. LT Karen Ruppe completed her thesis work which focused on analysis of the ASTEX region with comparisons to Tettelbach (1987). Emphasis was be on Saharan dust, North American and European continental sources, and oceanic sources. Planning of observation strategies necessary to examine the effects of aerosol-cloud interaction and entrainment on cloud reflectance was conducted through participation in FIRE/ASTEX Science Team meetings in Denver, CO and Fair Lakes, VA. Plans for collaboration with aircraft, ship and ground-based measurements were developed. Results of the planning efforts are documented in the ASTEX Operations Plan. The field program was conducted in Santa Maria, Azores where operation of a real-time satellite data receiver supported data collection and analysis for mission planning and assessment. The analysis included full analysis capabilities to produce imagery, estimates of aerosol optical depth, aerosol size index, cloud reflectance at 0.63 and 3.7 microns wavelength.

THESES DIRECTED: Ruppe, K., "Aerosol-Cloud Interactions during ASTEX, Master's Thesis, December 1992.

SAGE III SCIENCE TEAM

Philip A. Durkee, Associate Professor
Department of Meteorology
Sponsor and Funding: National Aeronautics and Space Administration

OBJECTIVE: The objectives during phase B of SAGE III development were to examine global aerosol distribution observations from NOAA AVHRR and SAGE I and II measurements and identify regions of potentially high aerosol-climate impact. Primary emphasis was on the upper tropospheric observations available from SAGE I and II. A second objective was to examine case studies of AVHRR-SAGE II comparisons. AVHRR aerosol optical depth was compared to profiles of extinction from SAGE II. Issues such as upper tropospheric cloud contamination were also considered. The goal of this work was to show the usefulness of analyses incorporating SAGE III observations with nadir views from high spectral and spatial resolution radiometers on EOS such as MODIS and HIRIS.

SUMMARY: Global summaries of aerosol optical depth have been prepared for April 1982-84 using NOAA-7 AVHRR. Features such as Saharan dust, continental plumes of anthropogenic pollution, and advected smoke from biomass burning were detected. Also apparent in these analyses was a distinct difference between optical depth in the northern and southern hemispheres. These results are consistent with SAGE I tropospheric

results reported by Kent (1988) and SAGE II results distributed by Kent to the SAGE III Science Team (unpublished). From these results it appears that much of the hemispheric differences observed in the total aerosol optical depth from AVHRR measurements are due to upper tropospheric aerosols advected from continental sources (anthropogenic and terrestrial). Comparisons between SAGE II extinction profiles and AVHRR optical depth are in progress. Cases are being identified from April (peak in Asian dust transport across the Pacific) and July (Saharan dust cases) 1985. The phase C/D efforts will include continued comparison of AVHRR and SAGE II cases. Emphasis will be placed on sources responsible for long range aerosol transport at mid-tropospheric levels. Saharan and Gobi Desert dust events, pollution episodes in eastern Asia and northeastern U.S., and smoke from agricultural and natural burning will all be examined. To the extent that tropospheric aerosols are included in the SAGE III studies, this effort will investigate relationships between various aerosol optical depth regimes and cloud reflectance characteristics. These studies will include examination of multispectral radiative signatures of aerosol features and the impact of MODIS and HIRIS estimates of aerosol characteristics. Also in phase C/D, support of field measurement programs planned under the SAGE III effort will be provided using satellite-based measurements and analyses of spectral optical depth and aerosol transport.

SATELLITE INVESTIGATIONS OF AEROSOL PARTICLE DISTRIBUTIONS ASSOCIATED WITH DMS AND THEIR RELATIONSHIP TO MARINE CLOUD CHARACTERISTICS

Philip A. Durkee, Associate Professor
Department of Meteorology
Sponsor and Funding: National Aeronautics and Space Administration

OBJECTIVE: The objectives of this project are two-fold. First, we have supported the planning, implementation and execution of the field programs under the PSI (Pacific Sulfur/Stratus Investigation). Second, we are continuing our regional and global scale analysis of aerosol and cloud properties.

SUMMARY: Planning of location and timing of field programs were aided by analysis of global scale cloud and aerosol characteristics, particularly plans to participate with JGOFS in the central Pacific Ocean in spring 1992. We are preparing summaries and composites of PSI-1, -2 and -3 aerosol and cloud characteristics from our satellite techniques. These will be compared with ship and aircraft observations. A priority task is to composite our satellite data into on-shore and off-shore cases to assess the impact of continental (anthropogenic and terrestrial) sources. We havestudied our preliminary results of global analyses for April 1982, 1983, and 1984 and have included improvements to our analysis of aerosol optical depth, size index, and cloud reflectance. We are proceeding with summaries of July, October and January 1983 and 1984. We have also finalized our results of comparisons

between satellite composites and plankton blooms detected near Iceland. Results of comparisons during the RITS cruise (April 1988) are also complete and show a strong correlation between aerosol features and cloud reflectance properties. We are beginning and analysis of the RITS 1989 cruise in the eastern Pacific Ocean where we will concentrate on southern latitudes to examine the effects in a relatively clean atmosphere.

SATELLITE STUDIES OF THE TRANSFORMATION DYNAMICS OF MARINE AEROSOLS

Philip A. Durkee, Associate Professor of Meteorology
Sponsor and Funding: Office of Naval Research

OBJECTIVE: Satellite observations of atmospheric aerosol particles will be used to study the transition of particle distributions in support of the ONR initiative on Transformation Dynamics of Marine Aerosols (TDMA). Studies will focus on parameterization techniques for Navy aerosol models and studies of aerosol distributions during ASTEX (Atlantic Stratocumulus Transition Experiment).

SUMMARY: Funding for this project began in April 1992. The highlights of accomplishments are threefold. First, participation in ASTEX during June 1992 in the Azores islands provided excellent validation data for aerosol retrievals and case studies of aerosol transitions. Satellite support of the aircraft-based aerosol transitions studies was begun. Second, M. Rouault completed a theoretical study of aerosol retrieval using NOVAM (Navy Oceanic Vertical Aerosol Model) and a complex radiative transfer model. The results are very encouraging for application of satellite retrieved parameters to NOVAM. Third, the results of Rouault have been incorporated into our regional analysis scheme and summaries of the ASTEX region are proceeding.

PUBLICATIONS: Rouault, M., and P. A. Durkee, "Characterization of Aerosols Above the Ocean from Satellite Remote Sensing," In Nucleation and Atmospheric Aerosols. N. Fukuta and P. E. Wagner (Eds.), DEEPAK Publishing, pp. 357-360, 1992.

THESES DIRECTED: Ruppe, K., "Aerosol-cloud Interactions During ASTEX. Master's Thesis, December 1992.

STUDIES OF THE EFFECTS OF SHIP ACTIVITY ON CLOUD PROPERTIES

Philip A. Durkee, Associate Professor
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Sponsor and Funding: Office of Naval Research

OBJECTIVE: Satellite observations of ship tracks in stratiform clouds will be analyzed and compared to meteorological and aircraft measurements. Phenomenological studies will define the physical, temporal and radiative characteristics of tracks including occurrence statistics. Mechanism studies will incorporate aircraft

measurements to begin to determine formation processes.

SUMMARY: Results from a number of thesis projects are complete. Salvato compared high latitude ship track formation with subtropical regions and found that the Arctic region is significantly more susceptible to track formation. Pettigrew developed the most complete set of ship-ship track collocations to date. It was determined that the ship is typically within 5-10 km of the track head. Evans compiled a set of 60 tracks and analyzed them for physical and radiative characteristics. Giampaolo tested an automated track detection algorithm developed by Nielsen. Lutz completed a study of occurrence statistics for tracks in the eastern North Pacific and showed that tracks are more common the previously thought. Millman developed an analysis technique that allows study of the temporal characteristics of tracks and showed that the dispersion characteristics of tracks are as expected from turbulence models.

THESES DIRECTED: Salvato, G. S., "Comparison Between Arctic and Subtropic Ship Exhaust Effects on Cloud Properties, Master's Thesis, September 1992.

Pettigrew, J. C., "Surface Meteorological Parameters of Identified Ship Tracks, Master's Thesis, September 1992.

Evans, M. E., "Analysis of Ship Tracks in Cloudiness Transition Regions, Master's Thesis, September 1992.

Lutz, J. W., "Ship Tracks: A Geographical and Statistical Study," Master's Thesis, December 1992.

Millman, T. M., "A Temporal Analysis of East Pacific and East Atlantic Ship Tracks, Master's Thesis, December 1992.

TROPICAL CYCLONE MOTION STUDIES

Russell L. Elsberry, Professor
Patrick A. Harr, Adjunct Professor
Lester E. Carr, III, Assistant Professor
Department of Meteorology
Sponsor and Funding: Office of Naval Research

OBJECTIVE: The objective of this continuing project is to improve understanding of synoptic-scale, mesoscale and large-scale environmental influences on tropical cyclone motion. A long-term goal is to improve the accuracy of tropical cyclone track predictions for the Fleet as well as to extend the period of skillful track forecasts from 72 h to 120 h.

SUMMARY: A summary (Elsberry and Abbey 1991) of the advances in understanding of tropical cyclone motion during the ONR Accelerated Research Initiative was prepared. Clarification of the role of environmental steering on tropical cyclone motion has been achieved (Elsberry and Abbey 1992). Analyses by Rucker (1992) reveal a surprisingly complex pattern of outflow jets that evolve dramatically as Supertyphoon Flo approaches and crosses the subtropical ridge. Three

types of tropical cyclone outflow interactions with adjacent upper-level lows have been documented. Mass outflow and eddy momentum fluxes through 6 degrees lat. radius are occasionally (but not always) correlated with the departures of the intensification rate from the steady rate expected for the favorable conditions associated with high sea-surface temperatures and moisture contents. Similar calculations will be made with the multi-quadratic and final TCM-90 analyses. Dobos (1992) has demonstrated that the new radar wind profiler technology applied during TCM-90 produced wind observations within about 2 m/s of nearby rawinsondes. Comparisons of the profiler observations at the top of the boundary layer with the surface sustained winds and gusts provides new insights into the vertical structure of typhoons. Nighttime boundary layer structures depart significantly from daytime structures unless the winds exceed 25 m/s.

Decomposition of the TCM-90 wind fields into three components has been tested with operational analyses (Bohner 1992; Elsberry and Bohner 1992). The derived propagation components agree at times (with notable exceptions at low latitudes when the cyclones were weak) with the theoretical expectations. It remains to be determined from the final analyses whether the decomposition technique will provide an accurate separation of the asymmetric and large-scale environmental changes necessary to understand the interaction of the tropical cyclone with adjacent synoptic-scale circulations.

A field program summary (Dunnavan et al. 1992) of the TCM-92 mini-field experiment (Elsberry et al. 1992) has been prepared. The data sets are described for potential use by other researchers. McKinley (1992) contrasts the satellite imagery and aircraft observations from the most dramatic MCS observed during TCM-92 with a less organized MCS. Both MCSs had a midtropospheric cyclonic vortex with cooler (warmer) air below (aloft). The more dramatic MCS had a cyclonic vortex at 700 mb in the aircraft data and a cyclonic circulation signature in the cumulus clouds in the satellite imagery. Although deep moist columns were present on the edge of this vortex (a requirement for tropical cyclogenesis), the central vortex region had a classical dry mesoscale unsaturated downdraft signature. This dry air, plus the vertical shear, appeared to account for the lack of cyclogenesis in association with the dramatic MCS.

PUBLICATIONS:

Carr, L.E., III, and R. L. Elsberry, "Analytical Tropical Cyclone Asymmetric Circulation for Barotropic Model Initial Conditions," *Monthly Weather Review*, 120, 644-652, March 1992.

Elsberry, R.L., M. DeMaria, G. J. Holland, H. Gerrish, C. P. Guard, and K. Emanuel, "Is There any Hope for Tropical Cyclone Intensity prediction? -- A panel discussion," *Bulletin American Meteorological Society*, 73, 264-275, March 1992.

Dunnavan, G.M., E.J. McKinley, P.A. Harr, E.A. Ritchie, M.A. Boothe, M. Lander and R.L. Elsberry, "Tropical Cyclone Motion (TCM-92) Mini-field Experiment Summary," NPS Technical Report, NPS-MR-93-001, 1992.

Elsberry, R.L., "Tropical Cyclone Motion," *Naval Research Reviews*, Office of Naval Research, Arlington, VA 22217, XLIV, 5-16, 1992.

Elsberry, R.L. and R.F. Abbey, Jr., "Recent Advances in Understanding Tropical Cyclone Motion." NPS Technical Report, NPS-MR-92-001, 1991.

Elsberry, R.L. and R.F. Abbey, Jr., "Typhoon Motion and Environmental Steering." Technical Document, WMO/TD-No.472, World Meteorological Organization, Geneva, Switzerland, III-1--III-19, 1992.

Elsberry, R.L., G.M. Dunnavan and E.J. McKinley, "Operations Plan for the Tropical Cyclone Motion (TCM-92) mini-field experiment," NPS Technical Report, NPS-MR-92-002, 1992.

CONFERENCE PRESENTATIONS: Chen, J.-M. and P.A. Harr, "On the Interpretation of Extended Empirical Orthogonal Function Analysis," Preprints, Fifth International Meeting on Statistical Climatology, Toronto, Ontario, Canada, 237-240, 1992.

Elsberry, R.L., "Update on the Tropical Cyclone Motion (TCM-90) field experiment," 1992 Tropical Cyclone Conference, Tokyo, Japan, 11-14 February 1992.

Elsberry, R.L., "Progress report on the Tropical Cyclone Motion (TCM-90) data set and research activities," Joint Session of WMO Typhoon Committee and Panel on Tropical Cyclones, Pattaya, Thailand, 18-21 February 1992.

Elsberry, R.L., "Review of Advancements in Unmanned Aircraft Technology with Potential Application to Tropical Cyclone Reconnaissance," Joint Session of WMO Typhoon Committee and Panel on Tropical Cyclones, Pattaya, Thailand, 18-21 February 1992.

Elsberry, R.L., "Final Analysis of the TCM-90 Experiment and Preliminary results of the TCM-92 mini-field experiment." Invited lecture, Typhoon Committee meeting, Zhuhai, PRC, 8-11 December 1992.

Elsberry, R.L. and R. H. Bohner, Jr., "Three-component Decompositions of Tropical Cyclone Wind Fields: Relation to Tropical Cyclone Motion." Invited talk, International Symposium on Tropical Disasters, Beijing, PRC, 12-16 October 1992.

Holland, G.J. and R. L. Elsberry, "Tropical Cyclones as Natural Hazards: A challenge for the IDNDR," Invited lecture, International Symposium on Tropical Cyclone Disasters, Beijing, PRC, 12-15 October 1992.

THESES DIRECTED: Bohner, R.H. Jr., "Definition of Mean Environmental Steering Flow for TCM-90 Tropical Cyclones," Master's Thesis, 1992.

Dobos, P.H., "Evaluations of 404 MHz Radar Wind Profiler Observations at Okinawa during TCM-90," Master's Thesis, 1992.

McKinley, E.J., "An Analysis of Mesoscale Convective Systems Observed During the 1992 Tropical Cyclone Motion Field Experiment," Master's Thesis, 1992.

Rucker, J.H., "Upper-tropospheric Forcing of the Intensification Rates of Tropical Cyclones Flo and Ed Based on TCM-90 Observations," Master's Thesis, 1992.

FEASIBILITY STUDY OF A WEST COAST PICKET FENCE SPECIFICATION OF UPSTREAM BOUNDARY CONDITIONS FOR STORM

Russell L. Elsberry, Professor
Paul A. Hirschberg, Adjunct Professor
Richard J. Lind, Meteorologist
Department of Meteorology
Sponsor and Funding: National Science Foundation

OBJECTIVE: The basic objective of this new project is to demonstrate that a "picket fence" of extra rawinsonde stations along the U.S. west coast will improve the time and spatial resolution of the mass, momentum, heat, kinetic energy and moisture carried by jet streaks and short waves entering the U. S. from the data-sparse Pacific Ocean. A consequence of this improved specification of the "upstream boundary" conditions will be a more accurate forcing of the mesoscale weather systems that develop over the central U.S.

SUMMARY: The feasibility of this concept was tested during the STORM-Fronts Experiment Systems Test (FEST) during 1 February to 15 March 1992 (Lind et al., 1992). A series of seven special rawinsonde sites were interspersed among the seven regular rawinsonde sites along the west coast from Port Hardy, British Columbia to San Diego, California. In addition to the improved spatial resolution, rawinsondes were launched every 3 h at all 14 sites to improve the time resolution during four Intensive Observing Periods. The observations at the regular sites were accomplished via a cooperative effort with the National Weather Service, Air Force and the Atmospheric Environmental Service of Canada. Naval groups at the Naval Oceanography Command in San Diego, Pacific Missile Test Center at Pt. Mugu, California, Submarine Group Nine and the Naval Postgraduate School provided personnel for the special sites. In addition, university participation included the Oregon State University, University of Washington, and University of California at Davis. Data from the regular and special sites have been collected, put into a common format and delivered to the STORM-FEST Data Management Center and to the participants. An extensive quality of the observations in the vertical, and via time and spatial cross-sections along the west coast, has been completed. Thus, the logistical feasibility of making special observations as jet streaks and short waves propagate over the west coast has been demonstrated. Preliminary analyses indicate that the enhanced observations captured features that would have been poorly sampled by the along the west coast. A description of the four Intensive Observing Periods is given in the Field Program Summary (Lind et al. 1992).

PUBLICATION: Lind, R.J., P. A. Hirschberg, D. W. Titley and R. L. Elsberry, "West Coast Picket Fence Feasibility Study During STORM-FEST. I. Field program summary," NPS Technical Report, NPS-MR-92-003, 1992.

CONFERENCE PRESENTATION: Hirschberg, P.A., R.L. Elsberry and R.J. Lind, "Picket Fence Analysis and Research Plans," STORM-FEST Workshop, Longmont, CO, 4-6 November 1992.

OBSERVATIONAL-NUMERICAL STUDIES OF SEVERE SYNOPTIC WEATHER PHENOMENA

Russell L. Elsberry, Professor
Patrick A. Harr, Adjunct Professor
Department of Meteorology
Sponsor: Naval Oceanographic and Atmospheric Laboratory
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this ongoing research project is improved numerical prediction of severe synoptic-scale weather features that have a large impact on Fleet operations.

SUMMARY: The potential increase in utility of numerical forecasts of maritime sea-level cyclones was investigated via comprehensive examination of a large data base that describes the error characteristics of the numerical forecasts. Harr et al. (1992) showed that the quality of the numerical forecasts is very dependent upon several physical factors such as the cyclone location, movement and large-scale environment. Numerical forecast errors for certain types of maritime cyclones can be quite different from the systematic errors defined from an average of many cyclone types. Harr et al. (1992) also conclude that the variability in numerical forecast accuracy and its dependence upon several physical factors precludes the use of many statistical approaches for increasing the utility of the numerical forecast to the general user.

PUBLICATION: Clune, W.M., P.A. Harr and L.R. Brody, "The Man-Machine Mix in Operational Product Quality Control and Verification at Fleet Numerical Oceanography Center," *Weather and Forecasting*, 7, No. 2, 280-287, June 1992.

Harr, P.A., R.L. Elsberry, T. Hogan and W.M. Clune, "Forecasts of North Pacific Maritime Cyclones with the Navy Operational Global Atmospheric Prediction System," *Weather and Forecasting*, 7, No. 3, 456-467, September 1992.

EDDY GENERATION MECHANISMS IN EASTERN BOUNDARY CURRENT REGIONS

Robert L. Haney, Professor
Department of Meteorology
Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: The broad objective of this research is to explore the structure and dynamics of cold filaments over the continental rise and slope in eastern boundary current regions using model-data assimilation. A multi-level primitive equation ocean model, and data from the CTZ and EBC hydrographic/ADP surveys, will be used to address questions about the observed filaments that can not be answered with the data alone.

SUMMARY: As a first step to study the effects of bottom topography on cold filaments in the coastal oceans, a study was completed last year which

documents the numerical resolution and methods required to accurately model flow over steep coastal topography (Haney 1991). The data assimilation studies are in progress at the present time, and only preliminary results are available (Haney and Stanton, 1992). Our approach is to use static data assimilation and dynamic initialization to determine the best estimate of the structure and currents of the cold filaments at the time of each hydrographic survey. The results are being analyzed to test the following hypotheses: (1) the 3-D circulation in coastal jets and filaments departs significantly from quasi-geostrophic (QG) theory due to nonlinearity, (2) strong vertical circulations occur at entrance and exit regions of coastal jets, (3) strong vertical circulations occur between crests and troughs of meandering coastal jets, and (4) the vertical circulations associated with these features extend deep enough to transport biota and other trace material out of the surface layer and into the deeper ocean. We will make the three-dimensional mass conserving currents obtained from the data assimilation analyses available to all CTZ and EBC investigators.

PUBLICATIONS: Strub, P.T. and 21 more authors (including R.L. Haney), "The Nature of Cold Filaments in the California Current System," *Journal of Geophysical Research*, 96, 14743-14768, 1992.

Haney, R.L., "On the Pressure Gradient Force over Steep Topography in Sigma Coordinate Ocean Models," *Journal of Physical Oceanography*, 21,61 619, 1992.

CONFERENCE PRESENTATION: Haney, R.L. and T. P. Stanton, "The Three Dimensional Current Structure Associated with a Cold Filament in the California Coastal Current," AGU Ocean Sciences Meeting, New Orleans, LA, 27-31 January 1992.

ESTIMATING SUBPYCNOCLINE DENSITY FLUCTUATIONS IN THE CALIFORNIA COASTAL REGION FROM UPPER OCEAN OBSERVATIONS

Robert L. Haney, Professor
Department of Meteorology
Sponsor and Funding: Office of Naval Research

OBJECTIVE: The objective of this study is to test and verify a method for estimating density fluctuations in and below the ocean pycnocline from observations in the upper ocean alone. The method consists of modeling an observed density profile in the upper few hundred meters of the ocean as a climatological mean plus a weighted sum of the first N empirical vertical modes (EOFs).

SUMMARY: The problem being considered is that of constructing the best estimate for the density profile below a certain depth D, given the observed density profile above that depth. For this purpose, the estimated disturbance profile is modeled as a weighted sum of the first N empirical vertical modes (EOFs). At the present time, the mean density profile and the EOFs have been computed from the surface to 2500 m in the California coastal region using a large number of independent CTD stations (courtesy of Curt Collins,NPS). Separate

computations have been made for each of two "seasons", the upwelling season (April - October) and the rest of the year. For each "season" the first four EOFs have been shown to be robust (i.e., statistically significantly different from one another) and to explain approximately 80% of the variance above 2500 m. For each observed density profile, the EOF weights that determine the estimated profile are obtained by performing successive least square fits of the disturbance density profile above the depth D to the first four EOFs. The estimated profile is then verified against the observed profile over the full water column. This is being done by computing the correlation between the observed and modeled profiles, and the percent of variance explained by the modelled profiles, as a function of the depth D. This study is primarily interested in the results when D is of the order of several hundred meters, a feasible depth for operational shipboard observations.

COASTAL ATMOSPHERIC MESOSCALE MODELING STUDIES

T.R. Holt, Assistant Professor
Department of Meteorology
Sponsor: Naval Research Laboratory-West
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project is to investigate, evaluate and develop coastal atmospheric mesoscale models that could be implemented operationally. The primary tasks outlined to achieve this goal are numerical simulations using the NRL mesoscale model under varying synoptic and coastal flows, use of these simulations to aid in the investigation and identification of important coastal physical processes, and development and verification of a mixed layer model capable of predicting mesoscale variability in the coastal environment based on important coastal mesoscale processes.

SUMMARY: Numerical simulations using the NRL mesoscale model examined the 2-3 May 1990 case study of changing synoptic flow regimes along the West Coast of the United States. Initial research investigated NRL model simulations and their sensitivity to complex coastal terrain, focusing on three specific mesoscale coastal phenomena: the land-sea breeze, the Catalina Eddy and the topographically trapped southerly surge. Comparison of observations (including high resolution NPS Doppler wind profiler and RV Point Sur data) with model simulations indicated the model successfully replicated the overall general horizontal and vertical structure of each of the phenomena. Extensive comparison of cross-sections and profiles confirmed that the model was capable of providing detailed mesoscale forecasts. Although the model did quite well in simulating the timing and strength of the lower limb of the sea breeze, the upper return flow was not captured as effectively. Also, the strength and vertical extent of the circulation associated with the Catalina Eddy was well simulated but the location of the Eddy vortex differed by approximately 50-100 km from observed. The timing of the southerly surge was well predicted but the strength and northward extent was under predicted. Also, the model has difficulty in consistently resolving the low-level marine

inversion, in part due to the fact that the model lacks cloud/radiative interaction. This problem is crucial in the prediction of the southerly surge in particular, and the mesoscale flow pattern in general. Hence, additional model simulations incorporating cloud/radiative processes were performed. Results indicate that the updated model with the radiative / cloud parameterization yielded a more accurate simulation of layer temperatures, geopotential heights, cloud cover, and radiative processes as verified from synoptic, mesoscale and satellite observations than simulations without radiative/cloud effects. Subsequently, the updated model also forecast a more realistic diurnal evolution of the land-sea breeze, Catalina Eddy, and the southerly surge.

PUBLICATIONS: Holt, T.R. and S. Raman, "Three-Dimensional Mean and Turbulence Structure of a Coastal Front Influenced by the Gulf Stream," *Monthly Weather Review*, Vol. 120, pp. 17-39, January 1992.

Holt, T.R. and F.J. Grandau, "A Numerical Investigation of Topographic and Coastal Influences on Mesoscale Structure along the West Coast of the United States," Preprint Volume, Sixth Conference on Mountain Meteorology, 29 September - 2 October 1992, Portland, OR.

Holt, T.R. and S.W. Chang, "A Numerical Investigation of the Effects of Timing of Diabatic Processes in the Coastal Cyclogenesis of GALE IOP 2," forthcoming in *Monthly Weather Review*, (Vol. 121, No. 3), 23 pp., March 1993.

CONFERENCE PRESENTATIONS: Holt, T.R. and F.J. Grandau, "A Numerical Investigation of Topographic and Coastal Influences on Mesoscale Structure along the West Coast of the United States," Sixth Conference on Mountain Meteorology, 29 September - 2 October 1992, Portland, OR.

THESES DIRECTED: Grandau, F.J., LCDR, USN, "Evaluation of the Naval Research Laboratory Limited Area Dynamical Weather Prediction Model: Topographic and Coastal Influences along the West Coast of the United States," Master's Thesis, March 1992.

Stewart, P.C., LT, USN, "Incorporation of a Radiation Parameterization Scheme into the Naval Research Laboratory Limited Area Dynamical Weather Prediction Model," Master's thesis, September 1992.

MODELING OF ATMOSPHERIC MESOSCALE PROCESSES

T.R. Holt, Assistant Professor
Department of Meteorology
Sponsor and Funding: Naval Research Laboratory

OBJECTIVE: The goal of this project was to understand the importance and interaction of physical processes occurring in the marine boundary layer using Observing System Simulation Experiments (OSSE) for cases of coastal and oceanic cyclogenesis during the Genesis of Atlantic Lows Experiment (GALE) and the Experiment on Rapidly Intensifying Cyclones over the Atlantic (ERICA).

SUMMARY: A series of observing

system simulation experiments (OSSE) and real data assimilation experiments were conducted to assess the impact of assimilating SSM/I estimated rainfall rates, surface wind speeds, and integrated water vapor on limited area model predictions of intense winter cyclones. A number of OSSE were conducted for GALE IOP 2 cyclogenesis in which the "observed" rainfall rates were assimilated into the degraded "forecast" model. A similar design was carried out for ERICA IOP 4 surface wind speed and integrated water vapor. Various data frequencies, different vertical profiles, with various assimilation windows, and with prescribed systematic errors were assimilated to test the sensitivity of the impact. It was found that assimilation of rainfall rates in general improves the forecast in terms of sea-level pressure S1 scores when either the "observed" or model-determined vertical heating profiles were used. The improvement was insensitive to the error in rainfall magnitude estimates but was sensitive to errors in geolocation of the precipitation. More frequent observations (additional sensors in orbit) had positive but gradually diminishing benefits. Similar conclusions were drawn for assimilation of surface wind speeds. Real SSM/I measured rainfall rates were assimilated for the ERICA IOP 4 marine cyclone. Results of the assimilation experiments indicated that the assimilation in general leads to better intensity forecasts. The best forecast with assimilation predicted a 24-hour minimum surface pressure of 943 mb, cutting the forecast error of the "no sat" forecast by 50%. This most efficient assimilation was carried out with the assimilation of two time SSM/I observations using the swath method. Further analysis indicated the assimilation also resulted in better track and structure forecasts.

PUBLICATIONS: Chang, S.W., T.R. Holt, and K.D. Sashegyi, "A Numerical Study of the ERICA IOP-4 Marine Cyclone," Proceedings of the Second International Conference on East Asia and Western Pacific Meteorology and Climate, 7-10 September 1992, Hong Kong.

THESIS DIRECTED: Schulz, W.J., Jr., LT, USN, "Wind Speed and Moisture Sensitivity Tests of the NRL Limited Area Dynamical Weather Prediction Model: An OSSE Study of ERICA IOP 4," Master's Thesis, March 1992.

GLOBAL AND TROPICAL SYSTEMS

Tom Murphree, Research Assistant Professor
C.-P. Chang, Professor
J.M. Chen, Research Assistant Professor
Department of Meteorology
Sponsor and Funding: Naval Research Laboratory

OBJECTIVES: This continuing project is designed to: (1) identify the dominant mechanisms of short term climate change in the atmosphere and ocean; (2) evaluate the tropical atmosphere and ocean systems produced by operational analyses and forecasts; and (3) improve atmosphere and ocean forecast systems.

SUMMARY: We have pursued six main

research topics during the last year.

1. We have continued our modeling studies with Dr. R. Gelaro of NRL. We used the Navy Operational Global Atmospheric Prediction System (NOGAPS) model to identify the mechanisms which govern variability in the midlatitude responses to tropical thermal forcing. Our main experiment was a test of the sensitivity of the midlatitude response to intraseasonal variations in the ambient flow. We found that the waveguiding and barotropic instability characteristics of the subtropical jets were major factors governing the response. This suggests that fluctuations in the subtropical jets may explain why the response to a tropical heating event (e.g., an El Niño event) can vary considerably over the course of an individual event, and from one event to the next.

2. We have explored such jet fluctuations using analyzed and modeled fields. The jets were found to be well correlated with the tropical heating in several key tropical locations. The correlations were strongest for heating fluctuations that were located equatorward and to the west of a jet core, and which led the jet by three to ten days. Our preliminary results indicate that tropical heating fluctuations force the midlatitudes mainly by varying the waveguiding and instability characteristics of the jets.

3. We have also examined, in a series of experimental NOGAPS forecasts, the global impacts of an individual typhoon. Our experimental procedure involved selectively applying various versions of the NOGAPS tropical cyclone bogus procedure, including a negative bogus that effectively eliminates individual cyclones. We found that a single typhoon may significantly impact the circulation over the North Pacific-North America-North Atlantic region one to two weeks after the storm's formation. The midlatitude impacts of the typhoon are dynamically very similar to those produced by larger and longer term tropical heating events (e.g., El Niños).

4. Our fourth main research activity was a study of the large scale tropical air-sea interactions during the 1991-92 El Niño event. In the first part of this study, we analyzed surface atmosphere and upper ocean data from an array of equatorial Pacific buoys. We identified two major air-sea interaction regimes within the tropical Pacific, which are determined by the strength and direction of the zonal wind. We also demonstrated that the westerly winds associated with several typhoons in the western Pacific played major roles in the development of the 1991-92 El Niño in the central and eastern Pacific ocean.

In the second part of this tropical air-sea study, we developed and applied an equatorial ocean model with embedded mixed layer physics to explore the dynamics of the ocean's response to westerly wind events during the 1991-92 El Niño. This modeling effort was conducted in collaboration with Prof. R. Garwood, Ms A. Guest, and Prof. R. Haney. The model results confirmed that relatively infrequent and short-lived typhoon forcing was a major forcing process for both the local and remote parts of the basin.

5. We have also examined instability waves in the tropical ocean in collaboration with Prof. A. Semtner and Mr. M. McCann of NPS, and Dr. P. Flament of the University of Hawaii. Our work focused on a comparison of observed instability waves with those calculated by an ocean general circulation model. The model waves have a distinct three

dimensional circulation involving strong interactions with the South Equatorial Current, North Equatorial Countercurrent, and Equatorial Undercurrent. Comparisons with satellite, cruise, and buoy data indicate that the thermodynamics and dynamics of the model waves are quite realistic. In particular, both the observed and model waves show that baroclinic instability is a major factor in the waves' development.

6. In our studies of tropical weather systems, we conducted spectral analyses of the NOGAPS analyses and 48-hr forecasts for the tropical western Pacific during the 1991-92 winter. The meridional wind at 850 hPa was the main parameter. Over the Marshall and Caroline Islands, the spectral characteristics of both the analyses and the forecasts near the dominant period (4-8 d) were found to be in good agreement with radiosonde observations. Westward propagating synoptic scale waves deduced from cross-spectra were well represented in the NOGAPS analyses and forecasts. However, the correspondence between the observations and the 48-hr forecasts was found to deteriorate over the extreme western region of the tropical Pacific and the South China Sea.

PUBLICATIONS: Gelaro, R. and T. Murphree, "Mechanisms for Intraseasonal Variations of North American Climate," *California Water Resources Bulletin*, forthcoming.

CONFERENCE PRESENTATIONS: Murphree, T., Chen, J.M., Harr, P., and Gelaro, R., "Short Term Climate Variations in the Pacific-North American Region,", Climate Variations Conference, October 1991.

Murphree, T. and R. Gelaro, "Waves, Instabilities, and Climate Variations," Nonlinear Dynamics Colloquium, December 1991.

Murphree, T., M. McCann, and P. Flament, "Tropical Pacific Currents and Waves: Comparisons of Modeled and Observed Fields," Ocean Sciences Meeting, January 1992.

McCann, M. and T. Murphree, "Remotely Sensed Sea Surface Temperature Compared With Surface Temperature From a Global Ocean Circulation Model," Ocean Sciences Meeting, January 1992.

Murphree, T., "Global Impacts of the 1991-1992 El Niño," Pacific Climate Workshop, April 1992.

Gelaro, R. and T. Murphree, "Intraseasonal Variations of North American Climate," Pacific Climate Workshop, April 1992.

Murphree, T., "Tropical Impacts on North American Climate Variations," North American Drought Colloquium, April 1992.

THESES DIRECTED: Cooper, G., "An Observational Study of the Local and Remote Response of the Equatorial Pacific to Westerly Wind Events During the 1991-92 El Niño," Master's Thesis, December 1992.

Miller, E., "The Impact of a Typhoon on the Global Atmosphere," Master's Thesis, December 1992.

Neith, M., "Intraseasonal Relationships Between Tropical Heating and Extratropical Jets," Master's Thesis, December 1992.

Whitney, C., "Modeling the Tropical Ocean Response to Westerly Wind Forcing," Master's Thesis, December 1992.

OTHER: McCann, M. and Murphree, T., "Motions of the Global Ocean and Atmosphere," video produced May 1992.

BOUNDARY LAYER MODELING IN EXPLOSIVE CYCLOGENESIS

Wendell A. Nuss, Assistant Professor
Department of Meteorology
Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: The long-range goal of this ongoing research is to understand the role of boundary layer processes in frontogenesis 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: During 1992, the results from model simulations of the Genesis of Atlantic Lows Experiment (GALE) ocean cyclone of Feb. 24-26, 1986 that included the effects of ocean wind-generated waves in the boundary layer were analyzed for publication and a manuscript was partially prepared. As reported for 1991, the results from using this wind-wave parameterization were very encouraging as more realistic cyclone intensification and structure occurred when using the wind-wave parameteriztion. The primary effort during 1992 was to complete the analysis of these model simulations for publication and to extend these results to additional cases. A manuscript is partially prepared and the effort to extend these results to new cases has been hampered by numerical modeling difficulties with the new cases.

Considerable effort was made to model the ERICA IOP2 cyclone and the large air-sea temperature differences present in that case contributed to highly unstable model conditions. Initial efforts to alleviate the problems included increasing the time step and adjusting the analysis of moisture using multiquadric interpolation. Efforts are continuing to complete this simulation. Collaborative efforts on the simulation of The ERICA IOP4 cyclone are underway as well.

PRESENTATIONS: Nuss, W.A., "Boundary Layer Influences on the Location, Timing and Mesoscale Structure of Ocean Cyclones," Presented at the Cyclone Workshop, Val Morin, Quebec Canada, October 1992.

MESOSCALE AIR-SEA INTERACTION STUDIES

Wendell A. Nuss, Assistant Professor
Department of Meteorology
Sponsor and Funding: Office of Naval Research

OBJECTIVE: The primary long-term goal of this ongoing project is to understand how mesoscale sea surface temperature features interact with developing synoptic-scale cyclones. An associated secondary goal is to produce forecast criteria that indicate when strong interaction will occur to aid in forecasting cyclogenesis at sea. The objectives during FY92 were to complete the detailed analysis of the ERICA IOP 2 cyclone and describe the mesoscale air-sea interaction that occurred during its development. The aim was to complete 20km objective surface analyses from which surface fluxes could be calculated.

SUMMARY: During FY92 analyses of the ERICA IOP2 cyclone were completed using multiquadric interpolation techniques developed by this investigator. These analyses were used to calculate surface interaction in this cyclone. This study has found that the boundary layer and surface interaction during the IOP 2 cyclogenesis contributed significantly to the initial cyclogenesis through PBL frontogenesis and continually forced the warm frontal region of the cyclone throughout its lifecycle. The pattern of surface heat fluxes prior to cyclogenesis rapidly established a boundary layer front along the north wall of the Gulf Stream. The subsequent initial cyclogenesis occurred in a region where the surface heat flux was a maximum along this front and where convection was possibly being forced by these strong fluxes. Interestingly this pattern of strong heating along the warm front and in the warm sector was found to persist through much of the cyclogenesis. We hypothesize that this heating pattern contributed significantly to the convection along the warm front and probably was important to the overall development of the cyclone. The contribution to the overall cyclogenesis is currently being tested through model simulations. This pattern of surface heating and moistening suggests that air flowing into the frontal updraft region from the southeast and east is continually heated and moistened by surface fluxes in much the same manner as air flowing into a hurricane.

SENSITIVITY OF NUMERICAL FORECASTS OF RAPIDLY INTENSIFYING EXTRATROPICAL CYCLONES TO PRECIPITATION PARAMETERIZATION

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Sponsor and Funding: Office of Naval Research--Marine Meteorology

OBJECTIVE: To investigate the influence of cumulus parameterization on numerical forecasts of rapid oceanic cyclogenesis. Diagnoses 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 on storm development.

SUMMARY: This research grant expired 31 December 1991. The primary activity for Fiscal Year 1992 was to prepare and present vorticity budget results at the Fifth Conference on Mesoscale Processes in January 1992. These results were based on output from eight numerical forecasts (four experiments each for two cases) run on the PSU/NCAR mesoscale model at the National Center for Atmospheric Research. The only difference between these experiments was in the computation of latent heat release; they include the Arakawa-Schubert, Kuo, and Explicit cumulus computations, as well as a dry forecast with no latent heating. Results showed that the Arakawa-Schubert and Explicit experiments yielded similar results, with the Kuo and Dry experiments yielding weaker cyclones. Spin-up was primarily a result of convergence at low-levels, with mid- and upper-level spin-up showing the influence of the enhanced vertical motions and therefore tilting and vertical advections. Significant differences in 300 mb jet streaks were also apparent, with implications for the development of the surface system. A thesis student at NPS will be examining these model forecasts further, with refereed publications planned.

CONFERENCE PRESENTATIONS: Pauley, P.M., "Sensitivity of Forecasts of Rapid Oceanic Cyclogenesis to the Parameterization of Convective Latent Heat Release, Fifth Conference on Mesoscale Processes, Atlanta, GA, 6-10 January 1992.

A COMPARISON OF VERTICAL MOTIONS OBTAINED FROM THE FLATLAND ST RADAR AND FROM A GENERALIZED OMEGA EQUATION

Patricia M. Pauley, Research Assistant Professor
Department of Meteorology
Sponsor and Funding: National Science Foundation
(Subcontract through the University of Wisconsin-Madison)

OBJECTIVE: 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).

SUMMARY: This research grant expired 31 October 1991. The primary activity for Fiscal Year 1992 was to prepare a paper for refereed publication. This paper compared horizontal motions measured by the Flatland ST radar with opposing beams and compared the Flatland measurements with those in operational NMC analyses for the period July-November 1990. The beam-to-beam comparison allowed a discussion of the internal consistency and relative precision of the radar system. Implications of this comparison for the radar-measured vertical velocities were also discussed. The comparison with NMC analysis winds demonstrated that differences between the two were of a similar magnitude to results from other studies which compared profiler winds and rawinsonde measurements. A second paper discussing the vertical motion comparison is in the planning stage.

PUBLICATIONS: Pauley, P.M., R.L.

Creasey, W.L. Clark, and G.D. Nastrom, "Comparisons of Horizontal Winds Measured by Opposing Beams With the Flatland ST Radar and Between Flatland Measurements and NMC Analyses, Conditionally accepted for publication in *Journal of Atmospheric Oceanic Technology*.

Nastrom, G.D., W.L. Clark, R. Creasey, K.S. Gage, P.M. Pauley, T.E. VanZandt, and J.M. Warnock, "Case Studies of the Vertical Velocity Seen by the Flatland Radar Compared with Indirectly Computed Values, Conditionally accepted for publication in *Journal of Atmospheric Oceanic Technology*.

CASE STUDIES OF THE ABILITY OF THE NAVY MULTIVARIATE OPTIMUM INTERPOLATION TO DEPICT MESOSCALE PHENOMENA

Patricia M. Pauley, Research Assistant Professor
Department of Meteorology
Sponsor and Funding: Naval Research Laboratory, Monterey

OBJECTIVE: To examine the performance of the Navy MVOI analysis and to use the MVOI analyses to investigate atmospheric behavior for a case from November 1991 with strong surface winds in Southern California and strong jet-level winds.

SUMMARY: This research grant began 1 July 1992. Activities during Fiscal Year 1992 include setting up computer codes to read the NRL analyses, generate charts of two-dimensional fields from the analyses, and compute divergence, vorticity, and vertical motions, The NRL analyses were also compared visually compared against printed analyses with plotted observations from the National Meteorological Center (NMC). This comparison revealed an inconsistency in the depiction of jet-level winds at one of the analysis times. A request for high-quality ACARS aircraft winds for this case has been made to NMC (and approved); once obtained, these winds will be used in a re-analysis of this case, which will be used to initialize model forecasts with the Navy's regional model, NORAPS. Plans for the coming year include presenting results at a conference in August, and writing a manuscript for refereed publication.

IMPROVEMENT OF TROPICAL CYCLONE FORECAST USING REMOTELY-SENSED DATA

M. S. Peng, Research Associate Professor
Department of Meteorology
Sponsor and Funding: Naval Research Laboratory, Washington, D.C.

OBJECTIVE: To study the impact of remotely-sensed data on the forecast of tropical cyclones. This is an ongoing project.

SUMMARY: One of the main difficulties encountered in tropical cyclone forecast using a numerical model is the lack of sufficient data initially. With the increasing availability of remotely-sensed data recently, it is naturally to study the impact of these data on the tropical cyclone forecasts that are

very important to Navy's operation. This project is concentrated on the usage of SSM/I (Special Sensor Microwave/Imager) on the DMSP. The SSM/I is of particular value in obtaining information on vertically integrated rainfall rates and vertically integrated water vapor content for tropical storm systems. Incorporation of this information can help in determining the size and intensity of the storm as well as the large-scale circulation. Dynamic initialization will be used.

EVALUATION OF HIS CONTINUOUS TEMPERATURE AND MOISTURE PROFILING OF THE MARINE ATMOSPHERE

Carlyle H. Wash, Professor
Kenneth L. Davidson, Professor
P. A. Fredrickson, Physical Scientist
F. K. Jones, Physical Scientist
Department of Meteorology
Sponsor and Funding: Naval Research Laboratory, Monterey

OBJECTIVE: This effort will evaluate the ability of the High resolution Interferometer Sounder (HIS) to make continuous temperature and moisture profiles of the marine atmosphere. The measurements will be conducted on a measurement cruise on the R/V Pt. Sur during May 1992.

SUMMARY: The following tasks were completed in support of this project. A successful cruise was carried out 8-11 May 1992 using the R/V Pt Sur. Data measurements made included: continuous upper air profiles from the University of Wisconsin HIS instrument, continuous surface measurement systems for temperature, dew point, sea surface temperature, winds and other meteorological variables, upper air profiles from mini-rawinsonde systems on R/V Pt Sur, and aerosol measurements of the particle size distribution. The HIS profiles were evaluated in the M.S. thesis of CAPT Steve Rugg, USAF

THESIS DIRECTED: Rigg, S.A., CPT, USAF, "An Investigation of the High-Resolution Interferometer Sounder (HIS) in a Coastal Marine Environment," Master's Thesis, December 1992.

RESEARCH SUPPORT FOR THE OFFICE OF NAVAL RESEARCH'S UNIVERSITY RESEARCH INITIATIVE, "REAL-TIME ENVIRONMENTAL INFORMATION NETWORK AND ANALYSIS SYSTEM (REINAS)"

C. H. Wash, Professor
P. A. Hirschberg, Adjunct Professor
Department of Meteorology
Sponsor: University of Santa Cruz, Santa Cruz, CA
Funding: Office of Naval Research

OBJECTIVE: This effort will provide research support of the Office of Naval Research's University Research Initiative, "Real-Time Environmental Information Network and Analysis System (REINAS)" at University of California, Santa Cruz.

SUMMARY: NPS is helping to define the REINAS system requirements. NPS scientists will participate in workshops to define the REINAS system requirements, sensor data delivery issues, and features and events that would be useful to "visualize" with the system. Project staff is being hired and NPS is aiding in defining duties of project staff and recruiting environmental staff positions. NPS is coordinating REINAS activities with other NPS, NRL, and other field measurement programs in Monterey Bay.N P S i s working to prepare preliminary Monterey Bay mesoscale displays for:

i. Regional data
ii. Satellite data
iii. Mesoscale surface data
iv. Profiler data
v. Ocean and CODAR data

RAPID MARITIME CYCLOGENESIS STUDIES.

C.H. Wash, Professor
R. L. Elsberry, Professor
P. M. Pauley, Adjunct Professor
W. A. Nuss, Assistant Professor
P. A. Hirschberg, Adjunct Professor
Department of Meteorology
Sponsor: Office of Naval Research-Marine Meteorology
Funding: Naval Postgraduate School

OBJECTIVE: To understand the physical processes that lead to rapid cyclogenesis at sea using Genesis of Atlantic Lows Experiment (GALE) and Experiment on Rapidly Atlantic (ERICA) data.

SUMMARY: Case studies have been completed for ERICA IOP-2, IOP-5 and IOP-5A cyclones utilizing experimental and operational data and new data sources such as SSM/I satellite microwave analyses of precipitation rates. A series of papers addressing the role of upper-level process on rapid development have been published and provide the foundation for present ERICA studies. Investigations of the boundary layer forcing for the IOP 2 & 5 cyclones have been completed ERICA data. Professor Pauley's work during 1992 on research done in collaboration with thesis work by LT Marcia DeCaria and LT James Berdeguez, who graduated in December. LT. DeCaria's work compared model forecasts by NMC's Nested Grid Model for the ERICA IOP-5 storm, made with and without high-resolution sea-surface temperatures. LT. Berdeguez' work examined NGM forecasts of the ERICA IOP-4 case performed at operational resolution (approx. 90 km grid and 16 levels) and double resolution (approx. 45 km grid and 32 levels). The latter work also included an implementation of the vertical circulation diagnostics proposed by Prof. D. Keyser (SUNY-Albany). Professor Hirschberg continued collaborative analytical and numerical model research studies under this initiative with Professor J. Michael Fritsch of Penn State University, and Mr. Rolf H. Langland of the Naval Research Laboratory (NRL-Monterey).

PUBLICATONS: Wash, C.H., R. A. Hale, P. H. Dobos and E. J. Wright, "Study of Explosive and Nonexplosive Cyclogenesis During FGGE, *Monthly Weather Review*, 120, No.1 pp 40-51, 1992.

Hirschberg, P.A., and J. M. Fritsch, Reply (to comments by D. O. Staley). *Monthly Weather Review*, 120, 2402-2404, 1992.

Hirschberg, P.A. and J.M. Fritsch, "An Analytic Modeling Study of the Development of Extratropical Cyclones, Part I: The Effects of Stratospheric Structure," *Journal of Atmospheric Science*, 50, 311-327, 1992.

CONFERENCE PRESENTATIONS: Berdeguez, J. and P.M. Pauley, "The Sensitivity of Ageostrophic Circulations to Model Resolution: A Case Study Using NGM Forecasts of ERICA IOP-4, Eighth Extratropical Cyclone Workshop, 12-16 October 1992, Val-Morin, Quebec. (Presented by P.M. Pauley).

Hirschberh, P.A. and R.H. Langland, "The Effects of a Mesoscale Tropopause Undulation in a Numerical Simulation of the Cyclogenesis Event During ERICA IOP 5A, Fifth Conference on Mesoscale Processes, 5-10 January 1992, Atlanta, Georgia, pp.97-102, 1992.

Wash, C.J., C. Motell and B. Almario, "SSM/I Precipitation Analyses of ERICA Ocean Cyclones, Proceedings of the AGU 1992 Ocean Sciences Meeting, New Orleans, La. American Geophysical Union, January 1992. Abstract Published in *EOS*, 17 December 1991.

Frailey, L. and C. Wash, "Integrated Microwave and Infrared Precipitation Analyses," Proceedings of the AGU 1992 Ocean Sciences Meeting, New Orleans, LA, American Geophysical Union, January 1992. Abstract published in *EOS*, 17 December 1991.

Hirschberg, P.A., "Tropopause Undulations and Development of Extratropical Cyclone or Sutcliffe/Petterssen Development Theory Revisited," Eighth Extratropical Cyclone Workshop, 12-16 October, 1992, Val-Morin, Quebec.

THESES DIRECTED: Berdeguez, J., LT, USN, "The Sensitivity of Model Forecasts of Rapid Oceanic Cyclogenesis to Model Resolution", Master's Thesis, December 1992.

DeCaria, M., LT, USN, "The Sensitivity of Model Forecasts of Rapid Oceanic Cyclogenesis to the Specification of Sea Surface Temperature", Master's Thesis, December 1992.

Spinelli, J., LT, USN, "An Investigation of the ERICA IOP-5A Cyclone", Master's Thesis, December 1992.

DEVELOPMENT OF THE "INTRODUCTION TO FORECASTING" COURSE

C.H. Wash, Professor
F.R. Williams, Adjunct Professor
Department of Meteorology
Sponsor and Funding: Naval Oceanographic Office, Stennis Space Center, MS

OBJECTIVE: The goal of this project is to revise and update the FORECASTING FOR THE MIDLATTITUDES course currently used by the Naval Oceanographic Office and Naval Oceanography Command to train enlisted and junior officer forecasters.

SUMMARY: Two case studies of east coast cyclogenesis over North America and Asia1 have been selected. Both of these cases occurred in December 1993 and all conventional and satellite data have been saved to support the development of exercises for the text. The overall outline of the new manual is complete and sections are currently being rewritten.

REGIONAL SYNOPTIC FORECASTING (PHILIPPINES)

F. R. Williams, Adjunct Professor
Department of Meteorology
Sponsor: Naval Research Laboratory, Monterey
Funding: Naval Postgraduate School and NRL, Monterey

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 providing newly arriving naval personnel with examples of the accuracy of the Navy Observational Global Atmospheric Prediction System in the area. The current handbook covers the Philippine Islands and surrounding waters.

SUMMARY: (Following the data-gathering trip in 1990, 142 pages were prepared in 1991.) During 1992, the final 192 pages were completed. The analysis and forecasting of atmospheric and oceanic conditions important to air/sea operations in the Philippine Islands area were described. The covered area included the islands - Luzon, Visayas (the central islands) and Mindanao - from 4.7 degrees N to 21.5 degrees N and from 117 degrees E to 127 degrees E; and the Philippine Sea, Luzon Strait, South China Sea and Sulu Sea. Seasonal climatologies of the southwest and northeast monsoons and tradewind regime were presented. Oceanographic parameters for the four surrounding ocean areas were included. Appendices provided additional climatologies, a tropical cyclone characteristic study, climatic normals for 60 Philippine stations, and percent frequencies of wave heights. Five case studies examined the current accuracy of the Navy Operational Global Atmospheric Prediction System (NOGAPS) model analyses and prognoses. Tropical cyclone bulletins issued by the Joint Typhoon Warning Center, Guam, were identified and described; forecast philosophies were discussed. Interaction of Typhoon Yunya and the eruption of Mount Pinatubo volcano in June 1991 was described, and the dangers posed to aviation by volcanic ash were discussed.

PUBLICATIONS: Williams, F.R. and G. H. Jung, "Forecasters Handbook for the Philippine Islands and Surrounding Waters." Forthcoming publication by NRL Monterey.

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: Tropical cyclone prediction requires high spatial resolution around the tropical cyclone, but the environment does not need such high resolution. For this reason limited area models are often used in which a high resolution numerical model is matched with a global model. Recently spectral models have been used for this by subtracting a known function which makes the boundary conditions periodic. We have analyzed this procedure by integrating the linear advection equation with various numerical schemes. The Tatsumi (1986) Fourier series regional model does not give exponential convergence to the exact solution because the higher derivatives are not periodic at the boundaries. This Gibbs phenomenon does not occur with Chebyshev series models which do not require periodic boundary conditions. The motion of tropical vortices in east-west mean flows was studied with the barotropic vorticity equation on the beta-plane. The vortex was embedded in a linear shear flow and in a parabolic jet. With linear shear the vorticities moved in the same direction as the no mean flow case when the advection by the mean current was removed. The anti-cyclonic current, however, gave longer trajectories. With the parabolic jet the Earth's vorticity gradient was more important than the relative vorticity gradient in determining the northward vortex movement.

PUBLICATIONS: Kuo, H.-C. and R. T. Williams, "Boundary Effects in Regional Spectral Models," *Monthly Weather Review*, 120, 2986-2992, 1992.

CONFERENCE PRESENTATION: Williams, R.T., "Tropical Vortex Dynamics," ONR Workshop on Tropical Cyclone Motion, Monterey, CA, 22-24 September 1992.

DEPARTMENT OF METEOROLOGY

1992
Faculty Publications and Presentations

TECHNICAL REPORTS

Dunnavan G.M., Mckinley E.J., Harr P.A., Ritchie E.A., Boothe M.A., Lander M., and Elsberry R.L., "Tropical Cyclone Motion (TCM-93) Mini-field Experiment Summary," NPS Technical Report, NPS-MR-93-001, 1992.

Elsberry R.L. and Abbey R.F. Jr., "Typhoon Motion and Environmental Steering," Technical Document, WMO/TD-No. 472, World Meteorological Organization, Geneva, Switzerland, III-1-111-19, 1992.

Elsberry R.L., Dunnavan G.M., and McKinley E.J., "Operations Plan for the Tropical Cyclone Motion (TCM-92) Mini-field Experiment," NPS Technical Report, NPS-MR-92-002, 1992.

Fritsch, J. M., P. A. Hirschberg, D. W. Titley, and R. L. Elsberry, "West Coast Picket Fence Feasibility Study During STORM-FEST I. Field Program Summary, NPS Technical Report, NPS-MR-92-003, 1992.

Lind, R.J., Hirschberg P.A., Titley D.W., and Elsberry R.L., "West Coast Picket Fence Feasibility Study During STORM-FEST. I. Field program summary," NPS Technical Report, NPS-MR-92-003, 1992.

JOURNAL ARTICLES

Carr, L.E.,III, and Elsberry, R.L., "Analytical Tropical Cyclone Asymmetric Circulation for Barotopic Model Initial Conditoins," *Monthly Weather Review,*" 120, 644-652, March 1992.

Chang, C. P. and J. M. Chen, "A Statistical Study of Winter Monsoon Cold Surges over the South China Sea and the Large-Scale Equatorial Divergence" *Journal of Meteorological Society of Japan,* 70-1, 287-302, 1992.

Davidson, K. L., and P. J. Boyle, and P. S. Guest, "Atmospheric Boundary Layer Properties Affecting Wind Forecasting in Gulf and Coastal Regions," *Journal of Applied Meteorology,* 31, 983-994, August 1992.

Elsberry, R.L., DeMaria, M., Holland, G.J., Gerrish, H., Guard, C.P., and Emanuel, K., "Is There any Hope for Tropical Cyclone Intensity Prediction? -- A panel discussion," *Bulletin American Meteorological Society,* 73, 264-275, March 1992.

Elsberry, R.L., "Tropical Cyclone Motion," *Naval Research Reviews,* Office of Naval Research, Arlington, VA 22217, XLIV, 5-16, 1992.

Fritsch, J.M., Kapolka, J., and P.A. Hirschberg, "The effects of Subcloud-layer Diabatic Processes on Cold-air Damming," *Journal of Atmospheric Science,* 49, pp. 49-70, 1992.

Harr, P. A., R. L. Elsberry, T. F. Hogan and W. M. Clune, "Forecasts of North Pacific Maritime Cyclones with the Navy Operational Global Atmospheric Prediction System," *Weather and Forecasting*, pp. 453-467, 7, September 1992.

Hirschberg, P.A. and J.M. Fritsch, ""Reply to Comments by D.O. Staley," *Monthly Weather Review*, 120, 2402-2404, 1992.

Holt, T. R., and S. Raman, "Three-Dimensional Mean and Turbulence Structure of a Coastal Front Influenced by the Gulf Stream," *Monthly Weather Review*, 120, 17-39, 1992.

Kuo, H. C., and R. T. Williams, "Boundary Effects in Regional Spectral Models," *Monthly Weather Review*, 120, 2986-2992, 1992.

Overland, J.E., and K.L. Davidson, "Geostrophic Drag Coefficients Over Sea Ice," *Tellus*, 44A, 54-66, 1992.

Pauley, P. M., and S. J. Nieman, "A Comparison of Quasi-geostrophic and Non-quasi-geostrophic Vertical Motions for a Model-simulated Rapidly Intensifying Marine Extratropical Cyclone, *Monthly Weather Review*, 120, 1108-1134, 1992.

Pauley, P. M., and B. J. Bramer, "The Effect of Resolution on the Depiction of Central Pressure for an Intense Oceanic Extratropical Cyclone, *Monthly Weather Review*, 120, 757-769, 1992.

Smith, S. D., R. Anderson, W. A., Oost, C. Draan, N. Maat, J. DeCosmo, K. B. Datsararos, K. L. Davidson, K. Bumke, L. Hasse, and A. M. Chadwick, "Wind Stress and Drag Coefficients during HEXMAX," *Boundary-Layer Meteorology*, 60, 109-142, 1992.

Wash, C. H., R. Hale, P. H. Dobos and E. J. Wright, "Study of Explosive and Nonexplosive Cyclogenesis during FGGE," *Monthly Weather Review*, 120 40-51, January 1992.

Wash, C. H., R. De Souza, M. Ramamurthy, A. Andersen, J. Justus and P. Samson, "Teaching with Interactive Computer Systems: A Report on Unidata/COMET/STORM Workshop on Synoptic/Mesoscale Instruction," *Bulletin American Meteorological Society*, 73, 1440-1447, September 1992.

Williams, R.T., M.S. Peng and D. A. Zankowski, "Effect of Topography on Fronts," *Jounal of the Atmospheric Sciences*, 49, 287-305, 1992.

CONFERENCE PUBLICATIONS

Chang, S.W., T.R. Holt, and K.D. Sashegyi, "A Numerical Study of the ERICA IOP-4 Marine Cyclone. Proceedings of the Second International conference on East Asia and Western Pacific Meteorology and Climate, 7-10 September 1992, Hong Kong.

Davidson, K.L., P.S. Guest, and J.W. Glendening, "Determining Realistic wind Stress Forcing Fields for Marine Arctic Regions," Proceedings, Third conference on Polar Meteorology and Oceanography, pp. 44-47, October 1992.

Frederickson, P.A., K.L. Davidson, and P.S. Guest, "The Stratificatoin of the Atmospheric Boundary Layer in the Arctic Marginal Ice Zone," Proceedings, Third Conference on Polar Meteorology and Oceanogrphy, pp. J16-J19, October 1992.

Gelaro, R., and T. Murphree, "Mechanisms for Intraseasonal Variatons of North American Climate," California Water Resources Bulletin, accepted September 1992.

Guest, P.S. and K.L. Davidson, "A Study of Factors Controlling the Value of the Surface Temperature of Sea Ice," Proceedings, Third Conference on Polar Meteorology and Oceanography, pp 54-57, October 1992.

Hirschberg, P.A., and R.H. Langland, "The Efffects of a Mesoscale Tropopause Undulaton in a Numerical Simulation of the Cyclogenesis Event During ERICA IOP 5A, Fifth conference on Mesoscale Processes, 5-10 January 1992, Atlanta, Georgia, pp. 97-102.

Holt, T. R. and F.J. Grandau, "A Numerical Investigation of Topographic and Coastal Influences on Mesoscale Structure along the West coast of the United States," Preprint Volume, Sixth conference on Mountaim Meteorology, 29 September - 2 October 1992, Portland, OR.

Johannessen, J. A., R. A. Shuchman, K. L. Davidson, O. Frette, D. Digranes, and O. M. Joahannessen, "Coastal Ocean Studies with ERS-1 SAR during NORCSEX '91," Proceedings, ERS-1 Symposium, November 1992, 5 pp.

McCann, M., T. Murhpree, "Remotely Sensed Sea Suface Temperature Compared With Surface Temperature From a Global Ocean Curculation Model," Proceedings of the Ocean Sciences Meeting, January 1992.

Murphree, T., M. McCann, and P. Flament, "Tropical Pacific currents and Waves: Comparisons of Modeled and Observed fields," Proceedings of the Ocean Sciences Meeting, January 1992.

Overland, J.E., B.A. Walter, and K.L. Davidson, "Sea Ice Deformaton in the Beaufort Sea," Proceedings, Third Conference on Polar Meteorology and Oceanography, pp 64-67, October, 1992.

Persson, P.O., D. Ruffieux, and K.L. Davidson, "Characteristics of the Lower Toposphere during LEADEX 92," Proceedings, Third conference on Polare Meteorology and Oceanography, 1992, 50-53 pp.

CONFERENCE PRESENTATIONS

Chang, C.P., J.M. Chen and L.C. Quah, "Synoptic Scale Propagating Disturbances in the Tropical Western Pacific During the Northern Summer Monsoon of 1989-1991,", Proceedings International Symposium on Asian Monsoon, 55-56, 1992.

Chang, S.W., T.R. Holt, and K.D. Sashegyi, "A Numerical study of the ERICA IOP-4 Marine Cyclone," Proceedings of the Second International Conference on East Asia and Western Pacific Mereorolgy and Climate, 7-10 September 1992, Hong Kong.

Chang, C.P. and J.M. Chen, "Winter Monsoon cold Surges and the Equatorial Divergence Over the South China Sea," Second International Conference on East Asia and Western Pacific Meteorology and Climate, Hong Kong, 1992.

Chang, C.P., J.M. Chen and L.C. Quah, "Synoptic Scale Propagating Disturbances in the Tropical Western Pacific During the Northern Summer Monsoon of 1989-1991," International Symposium on Asian Monsoon, Tsukuba, Japan, 21-25 September 1992.

Chen, J.M. and P.A. Harr, "On The Interpretation of Extended Empirical Orthogonal Function Analysis, 5th International Meeting on Statistical Climatology, Toronto, Canada, 237-240, 1992.

Davidson, K.L., P.S. Guest, and J.W. Glendening, "Determining Realistic wind Stress Forcing Fields for Marine Arctic Regions," Proceedings, Third conference on Polar Meteorology and Oceanography, pp. 44-47, October 1992.

Durkee, P.A., K.E. Nielsen, and W.P. Morgan, "Multispectral Analysis of Smoke and Dust," Presented at the Sixth AMS Conference on Satellite Meteorology and Oceanography, 5-10 January 1992, Atlanta, GA.

Elsberry, R.L., "Research on Tropical Cyclones at the Naval Postgraduate School," 1992 Tropical Cyclone Conference, 11-14 February 1992, Tokyo, Japan.

Elsberry, R.L., "Feasibility of Tropical Cyclone Reconnaissance with Remotely Piloted Vehicles," 1992 Tropical Cyclone Conference, 11-14 February 1992, Tokyo, Japan.

Elsberry, R.L., "Some Reflections on CSU's Contribution to Tropical Cyclone Studies and Especially TCM-90," Symposium on Current Problems and Future Challenges in Atmospheric Science Research and Education, Ft. Collins, CO, 5-6 May 1992.

Elsberry, R.L., "Lectures in NWP on Tropical Cyclone Motion," NWP Short course 1992, Central Weather Bureau, Taipei, Taiwan, April 1992.

Elsberry, R.L., "Convection in the Maritime Tropics, Invited lecture series for Cooperative Program for Operational Meteorology, Education and Training (COMET), Bolder, CO 80307, 23 October 1992.

Frederickson, P.A., K.L. Davidson, and P.S. Guest, "The Stratification of the Atmospheric Boundary Layer in the Arctic Marginal Ice Zone," Proceedings, Third Conference on Polar Meteorology and Oceanogrphy, pp. J16-J19, October. 1992.

Haney, R.L. and T.P. Stanton, "The Three Dimensional Current Structure Associated with a Cold Filament in the California Coastal Current," AGU Ocea Sciences Meeting, New Orleans, LA, 27-31 January 1992.

Hirschberg, P.A. and R.H. Langland, "The Effects of a Mesoscale Tropopause Undulation in a Numerical Simulation of the Cyclogenesis Event During ERICA IOP 5A. Fifth Conference on Mesoscale Processes, 5-10 January 1992, Atlanta, Georgia, pp. 97-102.

Johannessen, J.A., R.A. Shuchman, K.L. Davidson, O. Frette, D. Digranes, and O.M. Johannessen, "Coastal Ocean Studies with ERS-1 SAR during NORCSEX '91," ERS-1 Symposium, Cannes, France, 4-6 November 1992.

Li, S.W., M.S. Peng and R.T. Williams, "Three-dimensional Studies of the Effects of Topography on Fronts," Sixth Conference on Mountain Meteorology, Portland OR, 29 September - 2 October 1992.

Murphree, T., "Tropical Impacts on North American Climate Variations," North American Drought Colloquium, April 1992.

Murphree, M. McCann, and P. Flament, "Tropical Pacific Currents and Waves: Comparisons of Modeled and Ovserved fields," Ocean Sciences Meeting, January 1992.

McCann M., and T. Murphree, "Remotely Sensed Sea Surface Temperature compared With Suface Temperature From a Global Ocean Circulation Model," Ocean Sciences Meeting, January 1992.

Nielsen, K.E., and P.A. Durkee, "A Robust Algorithm for Locating Ship Track Cloud Features using 3.7 Micron Satellite Data. Presented at and in the preprint volume of the Sixth AMS Conference on Satellite Meteorology and Oceanograhy, Atlanta, GA, 5-10 January 1992.

Nuss, W. A., "Boundary Layer Influences on the Location, Timing and Mesoscale Structure of Ocean Cyclones, Presented at the Cyclone Workshop, Val Morin, Quebec Canada, October 1992.

Overland, J.E., B.A. Walter, and K.L. Davidson, "Sea Ice Deformaton in the Beaufort Sea," Proceedings, Third Conference on Polar Meteorology and Oceanography, pp 64-67, October, 1992.

Pauley, M., S. Low-Nam, and Y. H. Kuo, "Sensitivity of Forecasts of Rapid Oceanic Cyclogenesis to the Parameterization of Convective Latent Heat Release," Fifth Conference on Mesoscale Processes, Atlanta, GA, American Meteorological Society, 5-10 January 1992.

Peng, M.S., and R.T. Williams, "Effects of Mountain Asymmetry on a Passing Front," Fifth Conference on Mesoscale Processes, Atlanta, GA, 5-10 January 1992.

Peng, M.S., S.W. Li, S.W. Chang and R.T. Williams, "Flows Over Mountains: Coriolis Force, Transient Trough and Three Dimensionality," Second International Conference on East Asia and Western Pacific Meteorology and Climate, Hong Kong, BCC, 11-14 September 1992.

Teh, T.-C. and R.L. Elsberry, "Physical Processes Involved in Typhoon Track Deflectios Caused by the Taiwan Orography," Second International conference on East Asia and Western Pacific Meteorology and Climate, Hong Kong, BCC, 7-10 September 1992.

BOOK CONTRIBUTIONS

Haney, R.L., "Maritime Meteorology," in Encyclopedia of Science and Technology, 7th Edition, pp. 484-489, Macgraw Hill, 1992.

Rouault, M., and P. A. Durkee "Characterization of Aerosols Above the Ocean from Satellite Remote Sensing, Nucleation and Atmospheric Aerosols, N. Fukuta and P. E. Wagner (Eds.), (DEEPAK Publishing, pp. 357-360, 1992).

Williams, R.T., "Weather Prediction, Numerical," Encyclopedia of Earth Science, 4, pp. 483-491, 1992.

WORKSHOP PRESENTATIONS

Harr, P. A., J. M. Chen and T. Murphree, "Relationships of Western Pacific Monsoon and Tropical Cyclone Activity to North American Climate Anomalies," Proceedings of the Eighth Annual Pacific Climate PACLIM Workshop, Technical Report 31 of the Interagency Ecololgical Studies Program for the Sacramento-San Joaquin Estuary, 99-106.

Hirschberg, P.A., R.L. Elsberry, and R.J. Lind, "Picket Fence Analysis and resarch plans," STORM-FEST Workshop, Longmont, CO, 4-6 November 1992.

Hirschberg, P. A., "Tropopause Undulations and the Development of Extratropical Cyclones of Sutcliffe/ Petterssen Development Theory Revisited," Eighth Extratropical Cyclone Workshop, Quebec, Canada, 12-16 October 1992.

Murphree, T., "Global Impacts of the 1991-1992 El Nino," Pacific Climate Workshop, April 1992.

Murphree, T., J.M. Chen and P.A. Harr, "The Anomalies in North American Climate: The South Asian-Tropical West Pacific Connections," Proceedings of the Eighth Annual Pacific Connections, Proceedings of the Eighth Annual Pacific Climate Workshop, Technical Report 31 of the Interagency Ecological Studies Program for the Sacramento-San Joaquin Estuary, 179-186, 1992.

Peng, M.S., and R.T. Williams, "Tropical vortex dynamics," ONR Workshop on Tropical Cyclone Motion, Naval Postgraduate School, Monterey CA, 22-24 September 1992.

DEPARTMENT OF NATIONAL SECURITY AFFAIRS

Professor T.A. Bruneau
Chairman



DEPARTMENT OF
NATIONAL SECURITY AFFAIRS

The research conducted by the NPS National Security Affairs (NSA) Department in 1992 covered an increasingly broad spectrum of interdisciplinary areas and supported sponsors in both the USG and DOD policy arenas, as well as advancing knowledge in the broad security studies academic community. As a testament to NPS/NSA Department "uniqueness," readership and appreciative reviews of NSA research from the White House, OSD, the Chairman of the Joint Chiefs of Staff, the Congress, Service Headquarters Staffs, Unified CINC Staffs, and various professional military groups and academic organizations were received in 1992. Unique and relevant NSA Department research activities also sponsored conferences on Conventional Deterrence (**Professors Wirtz and Yost, CDR Brown**), an annual CINC Planners and Strategists meeting for Navy, Marine and Coast Guard planners (**CDR Brown**), academic conferences on the New U.S. Reconstitution Strategy (**Professors Tritten, Stockton, Wirtz, Breemer Grassey**) and a conference on "Border Issues of Soviet Successor States in Asia" (**Professor Magnus**), all of which substantially involved NPS faculty and students. In addition NSA Department faculty presented papers and participated in a wide variety of other conferences, including co-chairmanship of the 60th annual Military Operations Research Society (MORS) Conference held at NPS in June 1992 (**Professor Tritten**), and featured speaker at the JCS Joint Staff (J-5) Second Long Range Strategy Symposium held at the National Defense University in September 1992 (**Professor Stockton**).

The 1992 Reimbursable Research sponsors for NPS/NSA Department projects included the Office of the Secretary of Defense (Office of Net Assessment and Strategy and Resources), the Defense Nuclear Agency, the Naval Security Group, the Army Research Institute, the Joint Cruise Missile Project Office, the Office of Naval Intelligence, the U.S. Special Operations Command, RAND, and the Johns Hopkins University Applied Physics Laboratory. Navy Direct Funds (NPS) research was primarily sponsored and reviewed by the Deputy Chief of Naval Operations, Plans, Policy and Operations, (N3/5) and the CNO Executive Panel. All NSA Department research efforts and products were tailored to meet the specific goals of its various research sponsors.

The NSA Department research and conference support activity reflected an added breadth of subject coverage, including its prior emphasis on Strategic Planning, Area Studies, and Intelligence, as well as new emphasis on Special Operations and Low Intensity Conflict, for which a new program began in October 1992, and Resource Planning and Management for International Defense (REPMID), a second new program which began in January 1993.

STRATEGIC PLANNING

In the Strategic Planning area, the Joint Cruise Missile Project Office sponsorship of an August 1992 Conference on Conventional Deterrence in the Post-

Cold War Era enabled NSA **Professors Yost, Wirtz and CDR Brown** to break new ground in a totally unique forum that featured a blending of thirty academics and defense policy experts, and produced thirteen conference papers which will appear in edited book form. Another new edited book by **Professor Jim Tritten** and **Professor Paul Stockton**, which addresses the new Reconstitution Strategy, has drawn considerable interest from both the academic and defense policy communities and was the subject of debate at several off-site conferences. It has also been lauded by the Chairman, Joint Chiefs of Staff. Also, **Professor Jim Wirtz's** book on Intelligence Failure and the Tet Offensive was included in Choice Magazine's List of Outstanding Academic Books for 1993. **Professors Jim Wirtz, Jan Breemer and CDR Brown** have each been successful in supporting VADM Bill Owens, USN, Director, Warfare Requirements, Resources and Assessments (N-8), in his efforts to coalesce Navy staff thinking about crucial restructuring goals for the Naval Service and inter-Alliance policies. **Professor Rod Minot** has gained new interest from the Clinton administration for his Security and the Environment project, and **Prof Paul Stockton's** forthcoming book on how the demise of the Soviet threat is changing the way American government works also shows strong promise to "make a difference."

AREA STUDIES

In the Area Studies NSA Professors Thomas Bruneau, David Yost and [illegible] **Abenheim** have successfully supported OSD in Iberian Defense Policy Issues, French Security Perspectives, and German Military Security Policy Issues, respectively. NSA **Professors Misha Tsypkin, Ralph Magnus, and Scott Tollefson** have each supported the Naval Security Group with a variety of NPS Technical Reports and trip reports covering developments in Russia, the MidEast/Pakistan/Afghanistan, and Latin America, respectively. **Professor Tollefson's** seminal report entitled "The United States and Brazil: Critical Issues of the Security Relationship" is being used as the focal point for creating a DOD Brazilian Strategy Group, and has been widely acclaimed. Similarly **Professor Roman Laba's** recent book on the Polish Solidarity Movement has won widespread academic acclaim. Also his 1991 and 1992 research in Russia while at the University of Moscow, College of Humanities, which was briefed to OSD, the Joint Staff and the CNO staff received strong praise from the Joint Staff (J-5) as providing a unique contribution to their knowledge, particularly of Ukrainian defense and security perspectives. Other work by NSA **Professors Claude Buss** in China and the Philippines, **David Winterford** in ASEA politics, and **Ed Olsen** in Korean and Japanese security issues has been strongly endorsed by their sponsors. Of note, **Professor Ed Olsen's** article in Foreign Policy may have had significant policy impact. Both **Professors Ed Olsen and Ralph Magnus** reviewed Defense Policy Guidance and Navy Planning Scenario documents for **CDR Mitch Brown** on Major Regional Conflict plans in support of the Johns Hopkins University Applied Physics Laboratory and CNO (N86) for the Joint Littoral Warfare Mission Assessment. **Professor David Yost**, whose research often blends regional and strategic focus, has also received strong OSD backing for his work on the Structural Factors in the Long-Term Competition. He will continue to pursue this unique study area together with **Professor Misha Tsypkin** through the research medium of their new Eurasian Security Program.

INTELLIGENCE

Intelligence support was provided through DALSASP funding for Professor Jim Tritten's trip, with eight NPS students to Russia in the summer of 1992. His subsequent reports on this trip and related Naval Arms Control issues have been the subject of frequent queries and most recently may appear directly uniquely useful to USG and the CNO staff in answering Russian reluctance to sign the START II treaty negotiated between President Bush and President Yeltsin. **Professor Roman Laba's** 1992 research on Russian Republic aspirations may also have a direct bearing on subsequent bipolar developments.

New NSA **Professor Gordon McCormick's** research on the Shining Path Guerilla Movement in Peru is also being well-received in OSD policy arenas, and he has been supported within OSD and USSOCOM for the creation of an NPS/NSA Center For the Study of Political Violence. Likewise, **Professor Dana Eyre's** groundbreaking research for the Army on Peacekeeping stands the NSA Department in good stead vis-a-vis the newest challenges in non-traditional security mission areas, and is being reflected in his teaching of all NSA Department methodology courses. To sum up, the NSA Department has made excellent use of NPS DFR funds and is making good progress toward a broader base of support for reimbursable funding. The list of publications for 1992 in books, chapters, monographs, journal articles, book reviews, papers and conference presentations, and completed student theses is truly impressive. NSA theses are actively sought throughout the military and have been acclaimed for their quality by members of Congress, Unified Commanders and Service Headquarters Flag Officers as well.

GERMAN UNITY AND PROFESSIONALISM IN GERMAN OFFICER CORPS

Donald Abenheim, Associate Professor
Department of National Security Affairs
Sponsor: Chief of Naval Operations, Military-Political Affairs
Funding: Naval Postgraduate School

OBJECTIVE: The present research has sought to assess the impact of the collapse of a Communist military on officer professionalism and examine the efforts of the western Germans to absorb former communists into ranks of a NATO military. Also key to provide insights as to officer professionalism in other USSR style armies and navies.

SUMMARY: The sudden end of the GDR in 1989/90 created the extraordinary situation of one army/navy/air force absorbing most of the officers of a former opponent organizes along the lines of the armed forces of the USSR. Chief among the problems has been the role of political indoctrination in the concept of command and the social welfare of the officers affected. While western ideas of civil-military relations came as foreign to many GDR officers, the several thousand who have adapted to new conditions seem confident of their future once questions of social welfare have been resolved. Explicit communist indoctrination led to a widely different ideal of command. Nonetheless, the western Germans have made important strides and learned lessons applicable to future experience in NATO.

CONFERENCE PRESENTATIONS: Donald Abenheim, Center for International Security and Arms Control, "German Soldier and German Unity, Stanford, 17 January 1992; HQ Mission to NATO, "Refoundation of Bundeswehr?" 20 October 1992.

OTHER: The investigator is preparing a book-length monograph publication with Princeton University Press on the results of this project. Completion is expected in late 1994.

RELATIONSHIP OF WAR AT SEA TO WARFARE ASHORE

Thomas C. Bruneau, Professor
Ralph N. Channell, Adjunct Professor
Department of National Security Affairs
Sponsor: Chief of Naval Operations (N-5)
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project is to conduct continuing research into the interrelationship of war at sea to warfare on land. This relationship is becoming increasingly important as the nation moves into the new era of regional contingency warfare as part of joint operations.

SUMMARY: This is a continuing project that attempts to analyze the relationship of war at sea to warfare ashore, using various analytic methods including the RAND strategy Assessment System (RSAS). The RSAS was well developed in the areas of nuclear warfare and the air/ground battle on the old Central Front, but the naval models were, and still remain, largely in the development

stages. There have been major changes in the world situation, and RAND has made correspondingly major changes in the RSAS to keep it as current as possible. There is an ongoing key project to permit more theater contingency planning and an upgrade of the naval models to include littoral operations (amphibious operations, mining, cruise missile operations, shallow water ASW, etc). The NPS RSAS team has continued to learn the new system, and to use it in support of research into former Soviet naval thinking, the importance of seapower in U.S. strategy, and in assessing various nuclear alternatives. The NPS RSAS team has played a major role in stating requirements for naval aspects of the RSAS and in pointing out inadequacies where they exist. The team has also attempted to assist RAND where possible with comments and evaluations of naval models. This research project is directly related to DOD and U.S. Navy activity. OPNAV (N-5) is the sponsor and has commented favorably on the results thus far. The project has made major contributions to NSA courses in strategic planning, intelligence, and net assessment.

PUBLICATION: NPS Technical Report "Naval Modeling with the RAND Strategy Assessment System."

CONFERENCE PRESENTATIONS: The status of RSAS teaching and research at NPS was presented to the RSAS Working Group in Washington, DC, at quarterly Conferences.

OTHER: Also in draft are reports on the RSAS at NPS, and a preliminary report on the relationship of war at sea to warfare ashore.

IBERIAN DEFENSE POLICIES

Thomas C. Bruneau, Professor and Chairman,
Department of National Security Affairs
Sponsor: N524 and OSD (ISP)
Funding: Naval Postgraduate School and OSD (ISP)

OBJECTIVE: The goal of this project is to identify the emerging issues in the foreign and defense policies of Spain and Portugal and analyze their significance for present and future bilateral relations with the United States.

SUMMARY: The project was initiated in Portugal in September 1992 and will be completed in June of 1993. The research examines the policies and apparent assumptions of the political-military elites in Spain and Portugal in order to be able to identify and assess the opinions for the U.S. Government. The issues include those involving direct bilateral relations with the U.S. and those dealt with in multilateral policy forums. The research is based on a review of all relevant literature in English, Spanish, and Portuguese and extensive interviews with officials and experts.

CONFERENCE PRESENTATIONS: Commentator at conferences in Portugal and Italy: 2-3 October 1992, Institute of International and Strategic Studies, Lisbon; 26-29 November 1992, Institute of International Affairs, Rome.

OTHER: The PI is affiliated with the U.S. embassies in Lisbon and Madrid thereby facilitating some aspects of

the research. The project will result in a series of reports for the sponsors and at least two academic articles.

PEACEKEEPING AND THE UNITED STATES ARMY

Dana P. Eyre, Adjunct Professor
Department of National Security Affairs
Sponsor and Funding: U.S. Army Research Institute

OBJECTIVE: After years of exceptionally limited involvement, the United States now finds itself involved, or on the brink of involvement, in a number of peacekeeping or peace building activities. The dimensions and implications of this potentially profound shift in military missions have not yet been systematically explored. This research is an effort at closing this gap. Three questions are to be addressed: first, how are peacekeeping activities changing, and what are the possible directions and dimensions of U.S. Army involvement? Second, what is the state of our current knowledge concerning peacekeeping and peace building? Finally, what issues need to be addressed (through future research and policy changes) in order to both increase U.S. Army capability to conduct these missions and to sustain current war fighting capabilities. The focus of the research is on the implications of an increased tempo of peacekeeping or peace building activities on force manning concerns, including recruiting and retention; training, leadership, cohesion and morale; family issues; and reserve component roles.

SUMMARY: Research is ongoing and the first report is due to the sponsor at the end of March 1993.

CONFERENCE PRESENTATIONS: Inter-university seminar on Armed Forces and Society in October 1993, American Sociological Association in August 1993.

BORDER ISSUES OF SOVIET SUCCESSOR STATES IN ASIA

Ralph H. Magnus, Associate Professor
Department of National Security Affairs
Sponsor and Funding: U.S. Army War College, Strategic Studies Institute

OBJECTIVE: To examine the current situation of successor states of the former USSR in Asia in the light of cross border issues, historical conflicts and the present potentials as these states establish and renew their international activities. This will be accomplished at a two-day research round table at NPS through presentations and discussions of a number of internationally recognized specialists and an invited audience.

SUMMARY: The research round table was held at the Asilomar Conference Center in Pacific Grove, CA, due to the lack of accommodations in June at NPS. The participants were Stephen Pelletiere and Stephen Blank of the U.S. Army War College, June Teufel Dreyer, University of Miami, Eden Naby, Harvard University, Graham E.

Fuller, RAND Corporation, M. Siddieq Noorzoy, University of Alberta, and myself. Each presentation invited spirited discussion, and in the view of the participants, it accomplished its objective of illuminating the issues for future research. I prepared a report of the proceedings from tape recordings, which were then checked by the participants and published as a NPS technical report. Plans are being discussed for a follow-on conference in 1993.

PUBLICATION: Ralph H. Magnus, editor, "Border Issues of Soviet Successor States in Asia," NPS Technical Report, NPS-NS-92-018, December 1992.

CONFERENCE PRESENTATION: Ralph H. Magnus, "United States Policy in Central Asia," Central Asia and Pakistan: The Future of an Islamic Economic Order, The International University, Lahore, Pakistan, 8 August 1992.

IRAN AND ITS NEIGHBORS: IMPLICATIONS FOR THE UNITED STATES

Ralph H. Magnus, Associate Professor
Department of National Security Affairs
Sponsor and Funding: Naval Security Support Group Activity, Washington, D.C.

OBJECTIVE: This study investigates the foreign policies of the Islamic Republic of Iran from the point of view of major neighboring countries, Turkey, Pakistan, the Gulf States, and Afghanistan. These states have a long history and a great current policy interest in the behavior and policies of Iran, and their views are both directly and indirectly relevant to the United States. Directly, they affect regional friends and allies and indirectly they give clues to Iranian policies toward the United States.

SUMMARY: In February, I attended a conference on Central Asian issues sponsored by the Defense Intelligence College and CENTCON in Tampa. Iranian policies in the region were featured in a number of presentations. In April, I attended another conference on this subject at the Defense Intelligence College in Washington, consisting of three experts on Tajikistan, Uzbekistan and Kazakhstan. In February, I submitted an interim research report entitled: Iran and Its Neighbors: Central Asian Connections. A major research trip in July-August to Turkey, Pakistan and Afghanistan resulted in findings that will be incorporated in a research report along with those obtained during a USIA speaker's tour to Saudi Arabia, Qatar and Abu Dhabi in November. Telephoned reports were given to the sponsor in April, June and October.

CONFERENCE PRESENTATIONS: "Iran as a Potential Threat to the GCC States," Department Directors and Deputies, Ministry of Foreign Affairs, United Arab Emirates, Abu Dhabi, 15 November 1993.

ISLAMIST VIEWS OF THE UNITED STATES IN A POST-COLD WAR ENVIRONMENT

Ralph H. Magnus, Associate Professor
Department of National Security Affairs
Sponsor: N-521
Funding: Naval Postgraduate School

OBJECTIVE: To examine the international viewpoints of four of the leading Islamist movements in the Middle East, i.e., the Jami'at-i-Islami of Pakistan, the Wahhabis of Saudi Arabia, the Egyptian Muslim Brotherhood, and the Islamic Republic of Iran, with particular reference to their views of American foreign policy. The working hypothesis is that the views of these organizations are not uniform and are policy oriented, varying from issues to issue. They are not opposed to all U.S. policies per se.

SUMMARY: In a research trip to Turkey, Pakistan and Afghanistan in July-August 1992. In the course of this trip information was collected regarding Islamist views in each country. Valuable contacts were established with the director of the Organization of the Islamic Conference's History, Art and Culture Research Center in Istanbul. Previous contacts were reinforced in Pakistan with the director of the prime minister's research unit (and a leading Islamist), and in Afghanistan with the governor of Ningrahar province. Due to illness contracted on this trip, the project summary is still in the process of completion. In November, I made a speaking tour of Saudi Arabia, Qatar and the United Arab Emirates.

Although the purpose of the tour was to explain U.S. policy in the Gulf region, I was able to have a number of interesting contacts (including the International Islamic News Agency of the Organization of the Islamic Conference) on this subject, which I will incorporate in the report. I advised LCDR Jayne E. Garland on the preparation of her report requested by OP 611 for RADM Wright, OP 61, on the Islamist Movement in Tunisia. This was very well received, which I learned while briefing RADM Wright on this research project in April.

CONFERENCE PRESENTATION: Magnus, Ralph, H., "Crisis and Conflict in Afghanistan, The View of Jalalabad," 26th Annual Meeting of the Middle East Studies Association, Portland, OR, 30 October 1992.

THESES DIRECTED: Garland, Jayne E., LCDR, USN, "Tunisia, Islam as a Political Force," Master's Thesis, June 1992.

Steetman, Don K., LCDR, USN, "The Islamic Resurgence Factor in the U.S.-Saudi Arabian Relationship," Master's Thesis, June 1992.

CONGRESSIONAL DEFENSE BUDGETING IN THE POST-COLD WAR ERA

Paul Stockton, Assistant Professor
Department of National Security Affairs
Sponsor and Funding: Naval Postgraduate School

OBJECTIVE: With the end of the Cold War, the way Congress makes the defense budget is undergoing profound changes. This project examines how congressional leaders shaped the Fiscal Year 1993 defense budget around their own efforts to formulate U.S. defense and assesses the long-term implications of this budgeting process for DoN and DoD. This effort is targeted to be of particular interest to OP-06, OP-00K and OP-8.

SUMMARY: This project began with a comprehensive review of the proposals on post-Cold War military strategy offered by members of Congress. Particular attention was paid to proposals made by powerful Congressional Committee chairman, including Sen. Nunn and Rep. Aspin. Then, based on published accounts and personal interviews with the appropriate congressional staff members, I examined why legislators have offered their proposals, assessed their potential impact on US security planning, and analyzed how legislators are using them to shape the defense budgeting process on issues of concern to DON.

PUBLICATIONS: Stockton, P. and J. Tritten, Eds., Reconstituting National Defense: The U.S. National Security Strategy (New York: Praeger Publishers, 1992).

"Introduction" and "The Congressional Response," in Stockton and Tritten, Reconstituting Defense.

CONFERENCE PRESENTATION: Keynote address to Long Range Strategy Symposium (J-5, the Joint Staff), National Defense University, 9 September 1992.

Moderator, panel on "New Strategies for the Post-Cold War Era, Conference on "A World Transformed: Foreign Policy Issues in the Post Cold War Era, Stevenson Program on Global Security, University of California, Santa Cruz, 2 May 1992.

THESES DIRECTED: Szczublewski, K., LT, USN, "The V-22: A Turning Point in Congressional Behavior? Master's Thesis, December 1992.

Langdon, T., LT, USN, "The Power of Defense Committee Chairmen in Congress," Master's Thesis, December 1992.

OTHER: The investigator is preparing a book-length manuscript for publication using the results of this project.

CREATING SPACE: ORGANIZING, IDEOLOGY AND LEADERSHIP IN THE PALESTINIAN INTIFADA

Glenn E. Robinson, Assistant Professor
Department of National Security Affairs
Sponsor and Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project is to analyze the continuing Palestinian uprising in the West Bank and Gaza, and its implications for the larger Arab-Israeli conflict.

SUMMARY: The research was conducted primarily through fieldwork (interviews) and analysis of documentation produced by the actors during the uprising. The development of social-cum-political organizations by both nationalist and Islamic factions in the West Bank and Gaza prior to and during the Palestinian uprising was examined in order to demonstrate how the political mobilization of the Palestinian community in the 1980s consolidated the position of an ideologically and economically new elite, which in turn was responsible for the uprising itself. The conjunction of three structural changes (rise of wage labor, enhanced educational access, and land confiscations) with the activities of the new elite led to the outbreak of the uprising and the continued fluidity with which it was conducted. The parallel nascent state structures built by the cadres of both the PLO and the Islamic movement have been critical to the attempts at garnering political loyalty in a fragmented society, and to the struggle for political hegemony within Palestinian society.

PUBLICATIONS: Robinson, Glenn E., "Court Case Challenges Tax Inequality Between Israelis and Palestinians," Washington Report on Middle East Affairs, Vol. 11, No. 5, November 1992.

CONFERENCE PRESENTATIONS: The New Middle Class Reconsidered: The Formation of Political Elites and the Palestinian Intifada. Paper presented at the Middle East Studies Association Annual Conference, Portland, OR, October 1992.

The Islamicist Movement in the West Bank and Gaza Strip. Lecture series on "The Moral Economy of Islamic Movements," Center for Middle Eastern Studies, University of California, Berkeley, October 1992.

To Free the Soul or Free the Nation? Class and Ideology in the Islamicist Movement in Palestine. Paper presented at the American Political Science Association Annual Conference, Chicago, September 1992.

Class and Ideology in Palestinian Politics. Paper presented at a Workshop on "Society and Politics in Contemporary Jerusalem," Hebrew University of Jerusalem, June 1992.

OTHER: Robinson, Glen E., Creating Space: Organization, Ideology and Leadership in the Palestinian Uprising. Book length manuscript being prepared for publication. The University of California Press and Stanford University Press have asked to review the manuscript for possible publication.

THE GERMAN ADVANCE THROUGH DUENABURG, LATVIA, IN JUNE 1941 AND THE POTENTIAL DEFEAT OF THE SOVIET UNION IN JULY: A STUDY OF RATES OF ADVANCE IN MODERN WAR

Russell H.S. Stolfi, Professor of Modern European History
Department of National Security Affairs
Sponsor and Funding: U.S. Army, Concepts Analysis Agency

OBJECTIVE: During the period April-June 1992, funded by U.S. Army Concepts Analysis Agency, Bethesda, MD, Professor Stolfi completed the research and writing of a study on rates of advance in land warfare. The objective of the study was to provide the Army with the concrete, empirical historical factors that determined the advances and halts of a mechanized force in a distance advance during a major offensive in World War II.

SUMMARY: Professor Stolfi examined approximately 11,000 pages of German language war records to piece together a picture of the advance of the 8th Panzer Division in the first 24 days of the German advance toward St. Petersburg in June-July 1941. From these records he was able to reconstruct the reasons for German movements and halts during the attack and to suggest that the reasons discovered would affect rates of advance of ground forces in all times and all places. The researcher, for example, systematically broke down the factors that affect rates of advance into primary, intermediate, and secondary, including for example, command style, applicable principles of war, and road net respectively for inclusion in Army mathematical equations of war fighting movement.

THE UNITED STATES AND BRAZIL: CRITICAL ISSUES IN THE SECURITY RELATIONSHIP

Scott D. Tollefson, Assistant Professor
Department of National Security Affairs
Sponsor and Funding: Office of the Secretary of Defense, International Security Affairs, Inter-American Affairs

OBJECTIVE: The goal of this project was to analyze U.S.-Brazilian security relations, and to make policy recommendations for the United States.

SUMMARY: The project analyzed key issues in the U.S.-Brazilian security relationship, including technology transfers, Brazil's nuclear weapons program, Brazil's space and missile programs, Brazilian arms transfers, and drug trafficking. The project made numerous policy recommendations, with the overall goal of assisting in the consolidation of democracy in Brazil.

PUBLICATIONS: Tollefson, Scott D., "The United States and Brazil: Critical Issues in the Security Relationship," unclassified report prepared for the Office of the Secretary of Defense, International Security Affairs, Inter-American Affairs, 1 May 1992, 60 pages.

Tollefson, Scott D., "Critical Issues in U.S.-Brazilian Security Relations," unclassified report

submitted to the director of the Inter-American Region, International Security Affairs, in the Office of the Secretary of Defense, in preparation for briefing to Secretary of Defense, Richard Cheney, prior to his trip to Brazil in February 1992. Report submitted 17 January 1992.

CONFERENCE PRESENTATION: Scott D. Tollefson, "U.S. Security Relations with Brazil: Implications for Civil-Military Relations in Brazil," as part of panel on "Civil-Military Relations in the Changing World Order," XVII Conference of the Latin American Studies Association, Los Angeles, 24 September 1992.

THESIS DIRECTED: Kitchener, Roy Ian, LT, USN, "The Brazilian Military: Its Role in Counter-Drug Activities," June 1992. **Main advisor.** Second reader: Thomas C. Bruneau.

OTHER: The investigator is preparing journal articles based on the reports submitted to OSD.

BRAZIL'S NATIONAL STRATEGY: IMPLICATIONS FOR HEMISPHERIC SECURITY

Scott D. Tollefson, Assistant Professor
Department of National Security Affairs
Sponsor and Funding: Naval Security Group Support Activity

OBJECTIVE: The goal of this three-year project is to investigate Brazil's national strategy (development, security, and foreign policies), and the implications of that strategy for Brazilian, Latin American, and U.S. security.

SUMMARY: Key issues in Brazil's national strategy are being examined, including the nuclear programs; arms industry and weapons transfers; ballistic missile program; border projects; and drug-trafficking. The research includes travel to Latin America and Washington, D.C.

PUBLICATIONS: Tollefson, Scott D., "Brazil - International Relations," in *Handbook of Latin American Studies* (Social Sciences, Vol. No. 51), Austin: University of Texas Press.

Tollefson, Scott, D. The United States and Brazil: Critical Issues in the Security Relationship," unclassified report prepared for the Office of the Secretary of Defense, International Security Affairs, Inter-American Affairs, 1 May 1992, 60 pages.

Tollefson, Scott D., "El Condor Pasa: The Demise of Argentina's Ballistic Missile Program," chapter accepted for publication in International Missile Trade and Nonproliferation, edited by William Potter.

CONFERENCE PRESENTATION: Tollefson, Scott D., "Os Estados Unidos e Suas Relações de Segurança com o Brasil: Implicações Para a Dinamica Civil-Militar no Brasil," Paper presented at the XV Conference of the Associação Nacional de Pós-Graduação e Pesquisa em Ciências Sociais (ANPOCS); Grupo de Trabalho Forças Armadas, Estado e Sociedade; Caxambu, Minas Gerais, Brazil, 21 October 1992.

THESIS DIRECTED: Kitchener, Roy Ian, LT, USN, "The Brazilian Military: Its Role in Counter-Drug Activities," June 1992. **Main advisor.** Second reader: Thomas C. Bruneau.

OTHER: The investigator is preparing (a) a book manuscript on Brazilian armaments transfers and foreign policy; (b) a book manuscript on Brazil's national security policy; (c) articles on Brazil and Mercosur (the integration scheme between Brazil, Argentina, Uruguay, and Paraguay); (d) and articles on civil-military relations in Brazil. The investigator (a) travelled to Panama, 25 July-1 August 1992, and met with numerous officials from SOUTHCOM, CINCLANTFLT, U.S. Embassy, Brazilian Embassy, etc.; (b) met with Brazilian ambassador to the United States, Rubens Ricupero, at the University of California, Berkeley, 14 May 1992; and (c) travelled to Brazil to conduct research, October 1992.

DEFENSE ADVANCED LANGUAGE AND AREA STUDIES PROGRAM (DALASP)

James J. Tritten, Associate Professor
Department of National Security Affairs
Sponsor and Funding: Naval Intelligence Command (NIC-12),
Headquarters, Department of the Army,
Deputy Chief of Staff for Intelligence,
Intelligence Plans & Integration Directorate (DAMI-PII-T)

OBJECTIVE: Defense Advanced Language and Area Studies Program (DALASP) for field study in Russia and the Ukraine.

SUMMARY: Research into the emerging military doctrine, strategy, and roles and missions in the [former Soviet] Republics and Commonwealth of Independent States. Research into the revised roles and missions for the Armed Forces of Russia and other [former Soviet] republics in the new international security environment. Focus on navies as set into the context of new international security environment, strategic missions, military doctrines, and strategies.

PUBLICATIONS: Tritten, J.J., "Observations on a Recent Trip to the Former Soviet Union," NPS Technical Report, NPS-NS-92-102, 26 August 1992.

Tritten, J.J., "Observations on a Recent Trip to the Former Soviet Union," Conference Final Report: Program on Stability and the Offense/Defense Relationship, Vol. II, Thomas J. Marshall & Jonathan M. Gill, Eds., McLean, VA: SAIC, 16 October 1992, 141-152.

Tritten, J.J., "DALASP Summary Report," NPS Technical Report, NPS-92-014-PR, October 1992.

Tritten, J.J., Ed. "Project Report on Russian Navy Circa 2000," NPS Technical Report, NPS-NS-92-015PR, November 1992.

CONFERENCE PRESENTATIONS: McIlmail, J.F., "The Future of the Russian Navy," at a seminar at the Artillery, Engineering, and Signal Troops Museum, St. Petersburg, Russia, 7 July 1992.

Tritten, J.J., "America's New Regionally-focused Military Doctrine and Strategy," to the faculty and students of the Department of Political-Military Affairs, Institute for U.S.A. and Canada Studies, Moscow, Russia, 13 July 1992.

Tritten, J.J., "America's New Regionally-focused Military Doctrine and Strategy," to the faculty and staff of the Institute for Military

History, Moscow, Russia, 13 July 1992.

Tritten, J.J., "America's New Regionally-focused Military Doctrine and Strategy," to the faculty of the Department of Disarmament, Institute for World Economy and International Relations (IMEMO), Moscow, Russia, 14 July 1992.

Tritten, J.J., "America's New Regionally-focused Military Doctrine and Strategy," at a symposium with faculty of the Frunze Military Academy, held in Smolensk, Russia, 16 July 1992.

Tritten, J.J., "America's New Regionally-focused Military Doctrine and Strategy," at a symposium with the Deputy Minister of Defense of the Ukraine and faculty of the Vasilevsky Military Air Defense Academy of the Army, Kiev, Ukraine, 23 July 1992.

Tritten, J.J., "Observations on a Recent Trip to the Former Soviet Union," at the 7th Conference on Crisis Stability and the Offense/Defense Relationship: A Quest for Today's Questions, 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, Monterey, CA, August 1992.

Tritten, J.J., "Observations on a Recent Trip to the Former Soviet Union," Royal Roads Military College, Victoria, British Columbia, September 1992.

Tritten, J.J., "Observations on a Recent Trip to the Former Soviet Union," broadcast on KBOQ-FM, Monterey, CA, November and December, 1992.

THESIS DIRECTED: McIlmail, J.F. and J. Jaworski, "The Russian Military in the Year 2000," Master's Thesis, December 1992.

OTHER: There is considerable work in progress as a follow-on to this project due to the contacts made while in Russia. These include joint research on military art with the Department of the History of Military Art of the Frunze Academy and joint research on naval arms control with the Department of Disarmament at the Institute for World Economy and International Relations (IMEMO). All of the students who went to Russia are working with me on their theses and there will be follow-on research conducted in my FY-93 direct research project.

SOVIET VIEWS OF DESERT STORM/SHIELD LESSONS LEARNED

James J. Tritten, Associate Professor
Department of National Security Affairs
Sponsor: Assistant for Soviet Studies (OP-922), Office of the Chief of Naval Intelligence
Funding: Naval Postgraduate School

OBJECTIVE: Analysis of Soviet views of lessons learned from Operations DESERT STORM/SHIELD.

SUMMARY: Analysis of Soviet views of the lessons learned from Operations DESERT STORM, and DESERT SHIELD, the

impact that these lessons have on the debate over Soviet military doctrine and strategy, and Soviet views on a technological revolution that might change the nature of warfare. Focus on the Soviet Navy as set into the context of strategic missions assigned to the varying Soviet Armed Forces and the evolving roles and missions of the U.S. armed forces especially the U.S. Navy, as the Soviets perceive they have or will change as a result of Operations DESERT STORM and DESERT SHIELD.

PUBLICATIONS: Tritten, J.J., "The Changing Role of Naval Forces: The Russian View of the Persian Gulf War," NPS Technical Report, NPS-NS-92-011, June 1992.

CONFERENCE PRESENTATIONS: Tritten, J.J., "The Future of the [former Soviet] Commonwealth and Republic Armed Forces," presented at a Composite Group of the 60th Military Operations research Society (MORS) SYMPOSIUM, at the Naval Postgraduate School, Monterey, CA, June 1992.

THESES DIRECTED: Jordan, M.W., "Soviet Antilanding Doctrine: Does it Matter?" Master's Thesis, December 1991.

Stanley, S.M., "Assessing the Impact of Reasonable Sufficiency on the Structure and Missions of the Former Soviet Navy," Master's Thesis, June 1992.

THE RUSSIAN NAVY IN A NEW MILITARY-POLITICAL ENVIRONMENT: MILITARY FORCE AND RUSSIAN NATIONAL SECURITY

Mikhail Tsypkin, Associate Professor
Department of National Security Affairs
Sponsor and Funding: Naval Security Group Support Activity

OBJECTIVE: Investigate the trends in Russian national security policy regarding use of military force.

SUMMARY: Russia is slowly turning towards the realization that military force will be an integral element of its national security policy. Many in the Russian military see only the alternatives between a *Pax Americana* mono-polar world and a multi-polar world in which influence devolves to several major regional powers. In a mono-polar world, as the Russian military tend to see it, Russian sovereignty is liable to be violated: First Deputy Chief of General Staff Col. Gen. Mikhail Kolesnikov has publicly stated that NATO might use armed force to settle conflicts on the territory of the former USSR and to prevent Russia from becoming a regional power. Even such a well known pro-Western liberal as Russian Ambassador to the U.S. Vladimir Lukin is now talking about Russian national interest as something that must be realized through Russia's "natural" pre-eminence in the former Soviet republics, and its power balancing act in Europe (against the growing German influence) and in Central Asia (to contain the power vacuum there). Obviously, the rejection of reliance on military power, which was the natural reaction to the Soviet regime's abuse of military power, is running out of steam. Moscow is beginning a difficult search for a match between new Russia's national

security policy ends and its military means.

CONFERENCE PRESENTATION: Tsypkin, M., Military Power and Russian Foreign Policy at the 24th annual convention of the American Association for the Advancement of Slavic Studies, Phoenix, AZ, 19-22 November 1992. Attended by about 30 people.

THESIS DIRECTED: Melton, R.E., "Beyond the Warsaw Pact: Russian Foreign Policy in East Central Europe in the 1990's," Master's Thesis, December 1992.

EXPANDING CHINESE NAVAL POWER AND MARITIME SECURITY IN SOUTHEAST ASIA

David Winterford, Adjunct Professor
Department of National Security Affairs
Sponsor: Chief of Naval Operations
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this research was to investigate Chinese strategic perceptions of Southeast Asia, China's new maritime strategy, China's evolving naval capabilities and the impact of Chinese naval capabilities on the security order in the region. This research examined implications of these developments for the U.S. Navy in the Pacific. This is part of a larger continuing project which examines Chinese, Japanese and Indian naval rivalries in Asia.

SUMMARY: The unfolding post Cold War era is dramatically affecting security and stability in Southeast Asia. During the past decade, the old Soviet Union and its regional ally, Vietnam, were the chief threats to Southeast Asian security. However the collapse of communism in the Soviet Union, the collapse of the Soviet Union itself, the retrenchment of Russian external military power and now the sharp cutback in Russian aid to Vietnam have all worked to reduce drastically a Russian or Russian/Vietnamese threat to the region. Nevertheless, the end of East-West competition for global preeminence is unleashing powerful forces for strategic change in the Asia-Pacific region. A reconfiguration of the regional security balance may be taking place, especially a resurgent naval rivalry, as aspiring hegemons--notably China, Japan and India--jostle for leadership roles. This research examined the central role being played by China in the unfolding security changes in Asia. Chinese naval modernization was analyzed within the context of China's Southeast Asian maritime interests, its new maritime strategy, and its evolving naval capabilities.

This research also examined implications for the United States, especially for U.S. naval planning, of China's burgeoning regional naval capability. The research resulted in recommendations concerning the U.S. naval presence in Asia; the need to protect American economic and political interests in the region; the desirability of creating a loose yet textured and inclusive multilateral set of security relations in the Asia-Pacific region; and the need to initiate a Sino-

American naval reapproachment as a prelude to enhanced regional naval cooperation. In view of China's maritime strategy and its naval capabilities, this research indicated a pressing need to reassure America's friends in the region through a continuing American naval deterrence.

PUBLICATION: Winterford, David, "Expanding Chinese Naval Power and Maritime Security in Southeast Asia," NPS Technical Report, NPS-NS-92-001.

CONFERENCE PRESENTATIONS: Winterford, David, "Changing American Perspectives on U.S. Naval Presence in the Pacific," Seminar on security in Southeast Asia, Institute for Southeast Studies, Singapore, 18 April 1992.

Winterford, David, "Advanced Telecommunications and Economic Restructuring," Center for Asian-Pacific Studies, Hong Kong, 21 November 1992.

THESES DIRECTED: Lacaze, Jeffrey, LT, USN, "Russian-Japanese Accommodation: A Threat to America's Strategic Thinking in the Pacific Rim?" Master's Thesis, June 1992.

Naught, William, LT, USN, "The Strategic Impact Upon the United States of Future Naval Rivalries in South and Southeast Asia," Master's Thesis, December 1992.

Young, William, LT, USN, "Japan's Comprehensive Security: A Japanese Viewpoint," Master's Thesis, June 1992.

OTHER: The results of this research have been submitted in article format to the Journal of American-Asian Studies where it is currently under review for publication. The investigator is also preparing a book-length manuscript for publication on Economic Forces and Strategic Realities: The New Geo-Economic Order in Asia. Chicago: Imprint Publishers, contracted *completion/publication, July 1992.*

LEADERSHIP PERCEPTIONS AND NATIONAL SECURITY IN ASIA: CONSEQUENCES FOR U.S. STRATEGIC PLANNING IN THE PACFIC

David Winterford, Professor
Claude A. Buss, Adjunct Professor
Edward A. Olsen, Professor
Department of National Security Affairs
Sponsor: Chief of Naval Operations
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project is to examine the potential impact of pending Asian leadership changes on regional strategic perceptions, security alignments and U.S. force presence. This research examines these issues in order to provide U.S. strategic planners with a detailed analysis, assessment, and appraisal of evolving strategic perceptions, policies, and plans of key countries in the Asian-Pacific region. This analysis is of direct utility to U.S. defense planners and USCINCPAC strategists as they seek to determine the changing mix, location, and type of U.S. military presence that may be required to protect vital U.S. national interests in East and Southeast Asia.

SUMMARY: The emerging post Cold War era is dramatically affecting security and stability in East and Southeast Asia. Unfolding political, economic, and military changes in Asia have unleashed powerful new forces that portrend potentially fundamental changes in regional strategic and security perceptions. This research investigates the significant strategic perceptions, plans and policies of key countries in the region, the changing threat assessment of the national leadership in these countries, and the receptivity of regional leaders to continuing American leadership in the Pacific. By utilizing published and unpublished reports, studies, papers and documents and by interviewing regional governmental and academic security analysts and specialists, this project would analyze and assess the following issues: (1) the strategic perceptions, plans and policies of key countries in the Asian-Pacific region; (2) pending changes in political leadership in key countries in the region and the potential impact of emerging new Asian leadership on shifting regional security perceptions, plans and policies; (3) new issues affecting regional force development; (4) emerging economic trends and tensions; (5) changing regional threats and challenges to stability; and (6) the problems, prospects and potential that shifting Asian strategic and security perceptions pose for United States security policy in Asia and for U.S. naval employment options.

OTHER: The three principal investigators anticipate that the results of this research will be published in 1994 as a book, Leadership Perceptions and National Security in Asia.

CONVENTIONAL DETERRENCE IN THE POST-COLD WAR ERA

James J. Wirtz, Assistant Professor
CDR Richard M. Brown, OP-06 Chair of Strategic Planning
Department of National Security Affairs
Sponsor and Funding: OP-06/CMPO

OBJECTIVE: The purpose of this project was to sponsor a conference to stimulate a wide-ranging discussion of central issues in conventional deterrence, with particular attention to long-range high-accuracy strike systems.

SUMMARY: Over forty academics, officers and DoD officials attended the conference held at NPS in Monterey between 13-14 August 1992. Ten papers and four presentations were delivered and discussed. Papers and several of the presentations delivered at the conference were distributed to participants and interested commands throughout DoD.

OTHER: Wirtz, James J., one of the principle investigators, has finished initial editing of the papers delivered at the Conference. This manuscript should be under review for publication as an edited book by 1 April 1993.

DETERRENCE AFTER THE COLD WAR

James J. Wirtz, Assistant Professor
Department of National Security Affairs
Funding and Sponsor: DNA/OP-65

OBJECTIVE: This project explores (1) naval strategies, capabilities, and potential target sets needed to reconstitute rapidly a theater nuclear deterrent in Europe; (2) strategies and capabilities needed by U.S. forces to deter Third World nuclear threats; (3) the nature of multipolar deterrence; (4) alternate TRIAD structures to accommodate possible changes in strategic force levels in a post-Start environment.

SUMMARY: Nine papers and presentations were produced. Many of these research reports were forwarded to interested commands throughout DoD.

PUBLICATION: Wirtz, James J., "Strategic Anti-Submarine Warfare: Risk, Leverage and Coupling in the Post-Cold War Era," DNA-TR-92-77.

CONFERENCE PROCEEDINGS: James J. Wirtz, "Strategic Anti-Submarine Warfare: Risk Leverage and Coupling in the Post-Cold War Era," (U), proceedings of the Fifth Submarine Technology Symposium, 12-14 May 1992, JHU/APL STD-R-2121.

THESES DIRECTED: Gellene, David, LT, "Deterring Nuclear Armed Third World Dictators: A Targeting Strategy for the Emerging Threat," Master's Thesis, June 1992.

Waldrip, Randall, LCDR, "Verifying the Chemical Weapons Convention," Master's Thesis, December 1991.

STRUCTURAL FACTORS IN THE LONG-TERM COMPETITION

David S. Yost, Professor
Department of National Security Affairs
Sponsor and 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 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 crises in Eastern Europe and the former 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: Yost, D.S., "France [and Arms Control]," in Fen Hampson, Harald von Riekhoff, and John Roper, eds., The Allies and Arms Control (Baltimore: Johns Hopkins University Press, 1992), pp. 162-188.

Yost, D.S., "The History of NATO

Theater Nuclear Force Policy: Key Findings from the Sandia Conference," *Journal of Strategic Studies*, vol. 15, No. 2 (June 1992), pp. 228-261.

Yost, D.S., Les États-Unis et la sécurité européenne (Paris: Centre d'Étude des Relations entre Technologies et Stratégies (CREST), Ecole Polytechnique, 1992), 77 pp.

CONFERENCE PRESENTATIONS: Yost, D. S., "France's Defense Policy," at "The Defense Policies of Nations" conference at the Air Force Academy, Colorado Springs, Colorado, 9-11 February 1992.

Yost, D.S., "French Defense Policy Today," National War College, National Defense University, Washington, D.C., 5 March 1992.

Yost, D.S., "European Security and Regional Organizations -- NATO, EC, WEU, and CSCE," Monterey Institute of International Studies, 31 March 1992.

Yost, D.S., "French Lessons Learned," at the "Gulf War Lessons Learned: Europe" workshop sponsored by the Center for National Security Studies, Los Alamos National Laboratory, Washington, D.C., 7 May 1992.

Yost, D.S., "NATO and Conventional Deterrence" at the "Conventional Deterrence in the Post-Cold War Era" conference at the Naval Postgraduate School, Monterey, California, 14 August 1992.

Yost, D.S., "Nuclear Weapons Issues in Europe," at the "Managing Nuclear Weapons in a Changing World" conference at Lawrence Livermore National Laboratory, Livermore, California, 17 November 1992.

THESES DIRECTED: Mikatarian, D., LT, USN, "West European Defense Identity: Implications for U.S. Security Policy," Master's Thesis, June 1992.

Valenzuela, J.J., LT, USN, "Non-Nuclear Deterrence in U.S. Strategic Policy: Incentives and Limitations," Master's Thesis, June 1992.

Fuller, D.G., LT, USN, "NATO's Out-of-Area Disputes: Prospects for Common Western Strategies in the Middle East," Master's Thesis, December 1992.

Dixon, T.A., First LT, USAF, "Nuclear Proliferation: Lessons Learned from the Iraqi Case," Master's Thesis, December 1992.

Gunning, E.G., Jr., LT, USN, "Germany and the Future of Nuclear Deterrence in Europe," Master's Thesis, December 1992.

Heron, C.M., LCDR, USN, "Probable Trends in Terrorism in Western Europe" Master's Thesis, December 1992.

Cochran, P.M., LT, USAF, "U.S. Interests in European Security Following the Cold War," Master's Thesis, December 1992.

DEPARTMENT OF NATIONAL SECURITY AFFAIRS

1992 Faculty Publications and Presentations

TECHNICAL REPORTS

Abenheim, D., "United Germany, Nationalism, and Militarism," Technical Report, NPS-NS-92-006, April 1992.

Magnus, R.H., editor, "Border Issues of Soviet Successor States in Asia," Technical Report, NPS-NS-92-018, December 1992.

Tollefson, S.D., "Critical Issues in U.S.-Brazilian Security Relations," unclassified report prepared for the director of the Inter-American Region, International Security Affairs, in the Office of the Secretary of Defense, in preparation for briefing to the Secretary of Defense, Richard Cheney, prior to his trip to Brazil in February 1992, January 1992.

Tollefson, S.D., "The United States and Brazil: Critical Issues in the Security Relationship," unclassified report prepared for the Office of the Secretary of Defense, International Security Affairs, Inter-American Affairs, May 1992.

Tritten, J.J., "The Submarine's Role in Future Naval Warfare," Technical Report, May 1992.

Tritten, J.J., "Observations on a Recent Trip to the Former Soviet Union," NPS-NS-92-012, Technical Report, NPS-NS-92-012, August 1992.

Tritten, J.J., "DALASP Summery Report," Project Report, NPS-NS-92-014PR, October 1992.

Tritten, J.J., "Project Report on Russian Navy Circa 2000," Project Report, NPS-NS-92-015PR, Novembe. 1992.

Tritten, J.J., "A New Case for Naval Arms Control," Technical Report, NPS-NS-92-016, December 1992.

Winterford, D., "Expanding Chinese Naval Power and Maritime Security in Southeast Asia," Technical Report, NPS-NS-92-001.

Wirtz, J.J., "Strategic Anti-Submarine Warfare: Risk, Leverage and Coupling in the Post-Cold War Era," Report DNA-TR-92-77.

JOURNAL ARTICLES

Breemer, J., "The Submarine After the Cold War," *Maritime Patrol Aviation*, September 1992.

Breemer, J., "Deterrence, Naval Presence and the Submarine Fleet," *Submarine Review*, October 1992.

Looney, R., "An Assessment of Pakistan's Attempts at Economic Reform," *Journal of South Asian and Middle Eastern Studies*, Vol. XV, No. 3 (Spring 1992), pp. 1-28.

Looney, R., "Deducing Budgetary Priorities in Saudi Arabia: The Impact of Defense Expenditures on Allocations to Socio-Economic Programs," *Journal Public Budgeting and Financial Management*, Vol. 4, No. 2, 1992, pp. 311-326.

Looney, R., "Economic Development in Iraq: Factors Underlying the Relative Deterioration of Human Capital Formation," *Journal of Economic Issues*, Vol. XXVI, No. 2 (June 1992), pp. 615-622.

Looney, R., "Effect of Economic Environment on Arab Industrialization," *The Middle East Business and Economic Review*, Vol. 4, No. 1 (January 1992), pp. 26-40.

Looney, R., "Employment Creation in an Oil-Based Economy: Kuwait," *Middle Eastern Studies*, Vol. 28, No. 3 July 1992, pp. 565-576.

Looney, R., "Guns and Butter in the Middle East: Paradoxes Surrounding the Economic Impact of Defense Expenditures," *Japanese Journal of Middle East Studies*, No. 15, 1992, pp. 57-73.

Looney, R., "Infrastructure and Private Sector Investment: The Case of Pakistan's Transportation and Communications Sector," *Rivista Internazionale di Scienze Economiche e Commerciali*, Vol. XXIX, No. 9 (September 1992), pp. 771-792.

Looney, R., "Infrastructural Constraints on Transport and Communications: The Case of Pakistan," *International Journal of Transport Economics*, Vol. XIX, No. 3 (October 1992), pp. 287-306.

Looney, R., "Manpower Options in a Small Labor-Importing State: The Influence of the Ethnic Composition on Kuwait's Development," *International Migration*, Vol. XXX, No. 2 (June 1992), pp. 175-200.

Looney, R., "Real or Illusory Growth in an Oil-Based Economy: Government Expenditures and Private Sector Investment in Saudi Arabia," *World Development*, Vol. 20, No. 9 (September 1992), pp. 1367-1376.

Looney, R., "Review Essay: Recent Writings on Third World Industrialization," *Scandinavian Journal of Development Alternatives*, Vol. XI No.1, pp. 108-111.

Looney, R., "The Economic Consequences of Labour Exportation in the Middle East, 1975-85," *Middle East Technical University Studies in Development*, Vol. 18, No. 3 1991, pp. 221-236.

Looney, R., "The Economics of Third World Defense Expenditures: A Survey of Recent Findings on the Contrasting Patterns of Impact and Determinants," *Journal of Third World Studies*, Vol. VIII, No. 2, pp. 219-241.

Looney, R., "The Impact of Military Expenditures on Human Capital Development in the Arab World," *International Journal of Manpower*, Vol. 13, No. 3, 1992, pp.35-48.

Looney, R., "The Political Economy of Defense Budgetary Tradeoffs in the Middle East," *New Political Science*, No. 21-22 (Spring Summer 1992), pp 207-228.

Looney, R., "Factors Affecting Employment in the Arabian Gulf Region, 1975-85," *International Journal of Social Economics 19*, No. 2 (1992), pp.43-59.

Magnus, R.H., "Border Issues of Soviet Successor States in Asia-An Introduction," in op. cit.

Magnus, R.H., "Asian Border Issues and United States Interests," in op. cit.

Olsen, E.A., "Defining the Japanese Challenge/Target Japan as America's Economic Foe," *Orbis*, Fall 1992.

Olsen, E.A. and Ellings, R.L., "A New Pacific Profile," *Foreign Policy*, Winter 1992-93.

Robinson, G.E., "Court Case Challenges Tax Inequality Between Israelis and Palestinians," *Washington Report on Middle East Affairs*, Vol. 11, No. 5, November 1992.

Tritten, J.J., "What is Going on at the Naval Institute?" *U.S. Naval Institute Proceedings*, 118, No. 4, p. 96-98, April 1992.

Tritten, J.J., "60th MORS Symposium," *Phalanx*, 25, No. 2, p. 18-19, June 1992.

Tritten, J.J., "Address to the Submarine Technology Symposium 12 May 1992: The Submarine 's Role in Future Naval Warfare," *The Submarine Review*, p. 16-28, July 1992.

Tritten, J.J., "The Changing Role of Naval Forces: The Russian View of the Persian Gulf War," *Journal of Soviet Military Studies*, 5, No. 4, p 575-610, December 1992.

Tsypkin, M., "Will the Military Rule Russia?" *Security Studies*, Vol. 2, No. 1, Autumn 1992.

Wirtz, J.J., "Constraints on Intelligence Collaboration: The Domestic Dimension," *Defense Analysis*, Vol. 8, No. 3, 1992.

Wirtz, J.J., "The Future of the Attack Submarine," *Strategic Review*, Vol. XX, No. 4, Fall 1992.

Yost, D.S., "The History of NAO Theater Nuclear Force Policy: Key Findings from the Sandia Conference," *Journal of Strategic Studies*, Vol. 15, No. 2, pp. 228-261, June 1992.

CONFERENCE PUBLICATIONS

Wirtz, J.J., "Strategic Anti-Submarine Warfare: Risk Leverage & Coupling in the Post-Cold War Era," (U), Proceedings of the 5th Submarine Technology Symposium, May 1992.

CONFERENCE PRESENTATIONS

Breemer, J., "Where Are the Submarines? Deterrence, Naval Presence, and the Submarine Fleet," Paper presented at the 1992 Submarine Technology Symposium, Applied Physics Laboratory, Johns Hopkins University, Laurel, MD, April 1992.

Breemer, J., "Conventional Wisdom, Conventional Deterrence, and the Submarine Fleet." Paper presented at the conference on Conventional Deterrence, Monterey, CA, August 1992.

Breemer, J., "The New American Navy." Paper presented at the Annual Conference of the International Studies Association, Phoenix, AZ, November 1992.

Looney, R., "The Budgetary Impact of Defense Expenditures in the Middle East" International Conference on Business and Economic Development, Malta, May 1992.

Looney, R., "Deterioration in Human Capital Formation in Iraq," 1992 Meetings of the Association for Evolutionary Economics, New Orleans, January 1992.

Looney, R., "The Economics of Middle East Arms Races," 1992 Meetings of the Middle East Economic Association, New Orleans, January 1992.

Magnus, R.H., "United States Policy in Central Asia," Central Asia and Pakistan: The Future of an Integrated Islamic Economic Region, The International University, Lahore, Pakistan, August 1992.

Magnus, R.H., "Crisis and Conflict in Afghanistan, The View of the Ningrahar Mujahidin," The Search for a Solution to the Crisis in Afghanistan Panel, 26th Annual Middle East Studies Association Annual Meeting, Portland, OR, October 1992.

Magnus, R.H., "The State of the Art of Political Science Studies on Afghanistan," State of the Art of Afghan Studies Panel, 26th Annual Meeting, Middle East Studies Association, Portland, OR, October 1992.

Robinson, G.E., "The New Middle Class Reconsidered: The Formation of Political Elites and the Palestinian Intifada." Paper presented at the Middle East Studies Association Annual Conference, Portland, OR, October 1992.

Robinson, G.E., "The Islamicist Movement in the West Bank and Gaza Strip." Lecture series on "The Moral Economy of Islamic Movements," Center for Middle Eastern Studies, University of California, Berkeley, October 1992.

Robinson G.E., "To Free the Soul or Free the Nation?" Class and Ideology in the Islamicist Movement in Palestine. Paper presented at the American Political Science Association Annual Conference, Chicago, September 1992.

Robinson, G.E., "Class and Idealogy in Palestinian Politics." Paper presented at a Workshop on "Society and Politics in Contemporary Jerusalem," Hebrew University of Jerusalem, June 1992.

Stockton, P., "Post-Cold War Security in Europe: the Role of the United States," Graduate School of Public Affairs, University of Washington, Seattle, WA, November 1992.

Stockton, P., "Rethinking Defense," Op-02 Submarine Flag Officers Meeting, June 1992.

Stockton, P., "The Future of the U.S. Military," Alaska World Affairs Council, Anchorage, AK, January 1992.

Tollefson, S.D., "Os Estados Unidos e Suas Relacoes de Seguranca com o Brasil: Implicacoes Para a Dinamica Civil-Militar no Brasil," paper presentee t the XV Conference of the Associacao Nacional de Pos-Graduacao e Pesquisa em Ciencias Sociais (ANPOCS); Grupo de Trabalho Forcas Armadas, Estado e Sociedade; Caxambu, Minas Gerais, Brazil, October 1992.

Tollefson, S.D., "U.S. Security Relations with Brazil: Implications for Civil-Military Relations in Brazil," as part of panel on "Civil-Military Relations in the Changing World Order," XVII Conference of the Latin American Studies Association, Los Angeles, September 1992.

Tritten, J.J., "Naval Disarmament," at the Centre D'Estudis Internacionals, (Diplomatic School of Barcelona, Spain), January 1992.

Tritten, J.J., "America's New National Security Strategy amd its Impact on NATO," at the Ministry of Defense's Institute for Strategic Analysis, [Spanish] National War College, Madrid, Spain, January 1992.

Tritten, J.J., Arms Control, Naval Arms Control, Nuclear Deterence Theory, Current U.S. and NATO politico-military strategy, and the teaching of strategic planning with the political science faculty of the Madrid Complutense University, Madrid, Spain, January 1992.

Tritten, J.J., "America's New National Security Strategy and its Impact on NATO," at the French Secretariate General de la Defense Nationale (General Secretariate for National Defense) - SGDN, Paris, France, January 1992.

Tritten, J.J., "America's New National Security Strategy and its Impact on NATO," at the Fondation pur les Estudes de Defense (Foundation for the Study of National Defense) - FEDN, Paris, France, January 1992.

Tritten, J.J., "Emerging Military Doctrine and Strategy in the [former Soviet] Republics of the Commonwealth of Independent States," at a roundtable at the U.S. Information Service Offices, Paris, France, January 1992.

Tritten, J.J., "America's New National Security Strategy and its Impact on NATO," presentation as part of the "The Future of Europe" series broadcast on Television Espanol (TVE) in Madrid, Spain, February 1992.

Tritten, J.J., "The New Regional Defense Strategy," at the Monterey Bay Symposium on Globa Transformation - "A World Transformed, A World Threatened: Foreign Policy Issues in the Post Cold War Era," sponsored by the University of California at Santa Cruz Stevenson College Program on Global Security and the Monterey Institute of International Studies, May 1992.

Tritten, J.J., "The Submarine's Role in Future Naval Warfare," at the Submarine Technology Symposium - 1992, sponsored by the Naval Submarine League and the Johns Hopkins University/Applied Physics Laboratory for the benefit of the Assistant Chief of Naval Operations (Undersea Warfare), May 1992.

Tritten, J.J., "The Most Important Piece of Advice I Can Give You," presented at a General Session of the 60th Military Operationis Research Society (MORS) Symposium, at the Naval Postgraduate School, Monterey, CA, June 1992.

Tritten, J.J., "The Future of the [former Soviet] Commonwealth and Republic Armed Forces," presented at a Composite Group of the 60th Military Operations Research Society (MORS) Symposium, at the Naval Postgraduate School, Monterey, CA, June 1992.

Tritten, J.J., "Force Planning," presented at a Working Group of the 60th Military Operations Research Society (MORS) Symposium, at the Naval Postgraduate School, Monterey, CA, June 1992.

Tritten, J.J., "America's New Regionally-focused Military Doctrine and Strategy," to the faculty and students of the Department of Political-Military Affairs, Institute for U.S.A. and Canada Studies, Moscow, Russia, July 1992.

Tritten, J.J., "America's New Regionally-focused Military Doctrine and Strategy," to the faculty and staff of the Institute for Military History, Moscow, Russia, July 1992.

Tritten, J.J., "America's New Regionally-focused Military Doctrine and Strategy," to the faculty of the Department of Disarmament, Institute for World Economy and International Relations (IMEMO), Moscow, Russia, July 1992.

Tritten, J.J., "America's New Regionally-focused Military Doctrine and Strategy," at a symposium with faculty of the Frunze Military Academy, held in Smolensk, Russia, July 1992.

Tritten, J.J., "America's New Regionally-focused Military Doctrine and Strategy," at a symposium with the Deputy Minister of Defense of the Ukraine and faculty of the Vasilevsky Military Air Defense Academy of the Army, Kiev, Ukraine, July 1992.

Tritten, J.J., "Observations on a Recent Trip to the Former Soviet Union," at the 7th Conference on Crisis Stability and the Offense/Defense Relationship: A Quest for Today's Questions, 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, Monterey, CA, August 1992.

Tritten, J.J., "The Nature and Impact of the New U.S. National Strategy and Projected Budget Cuts on Maritime Security in the Asia-Pacific Region," at the Asia-Pacific Dialogue on Maritime Security and Confidence-building Measures, sponsored by the School of Marine Affairs at the University of Washington and the Institute for Global Security Studies, Seattle, WA, September 1992.

Tritten, J.J., "America's New Regionally-focused Military Doctrine and Strategy," Royal Roads Military College, Victoria, British Columbia, September 1992.

Tritten, J.J., "Observations on a Recent Trip to the Former Soviet Union," Royal Roads Military College, Victoria, British Columbia, September 1992.

Tritten, J.J., "The Impact of America's New Regionally-focused Military Doctrine and Strategy on the Asia-Pacific Region," University of Victoria, Victoria, British Columbia, September 1992.

Tritten, J.J., "The New National Military Strategy," at the International Security Studies Section and International Studies Association - West Conference, Phoenix, Arizona, November 1992.

Tritten, J.J., "Observations on a Recent Trip to the Former Soviet Union," broadcast on KBOQ-FM, Monterey, California, November and December 1992.

Tsypkin, M., "Military Power and Russian Foreign Policy," at the 24th Annual Convention of the American Association for the Advancement of Slavic Studies, Phoenix, AZ, November 1992.

Winterford, D., "Changing American Perspectives on U.S. Naval Presence in the Pacific," Seminar on Southeast Asian Security, Institute for Southeast Studies, Singapore, April 1992.

Winterford, D., "Advanced Telecommunications and Economic Restructuring," Center for Asian-Pacific Studies, Hong Kong, November 1992.

Yost, D.S., "France's Defense Policy," at "The Defense Policies of Nations " conference at the Air Force Academy, Colorado Springs, CO, February 1992.

Yost, D.S., "French Defense Policy Today," National War College, National Defense University, Washington, D.C., March 1992.

Yost, D.S., "European Security and Regional Organizations--NATO, EC, WEU, and CSCE," Monterey Institute of International Studies, March 1992.

Yost, D.S., "French Lessons Learned," at the "Gulf War Lessons Learned: Europe" workshop sponsored by the Center for National Security Studies, Los Alamos National Laboratory, Washington, D.C., May 1992.

Yost, D.S., "NATO and Conventional Deterrence" at the "Conventional Deterrence in the Post-Cold War Era" conference at the Naval Postgraduate School, Monterey, CA, August 1992.

Yost, D.S., "Nuclear Weapons Issues in Europe," at the "Managing Nuclear Weapons in a Changing World" conference at Lawrence Livermore National Laboratory, Livermore, CA, November 1992.

Wirtz, J.J., "Strategic Anti-Submarine Warfare: Risk Leverage and Coupling in the Post-Cold War World," paper delivered at the Submarine Technology Symposium, Johns Hopkins University Applied Physics Lab/Naval Submarine League, Laurel, MD, May 1992.

Wirtz, J.J., "Military Intelligence Sharing: Making the Machines Work Right," paper delivered at the Annual Meeting of the International Studies Association, Atlanta, GA, 31 March - 4 April 1992.

Wirtz, J.J., "Deterrence After the Cold War," paper delivered at the Annual Meeting of the Midwest Political Science Association, Chicago, IL, April 1992.

BOOKS

Tritten, J.J., "Our New National Security Strategy: America Promises to Come Back," (New York, NY: Praeger Publishers, 1992).

BOOK CHAPTERS

Abenheim, D., "Hingabe und Anspruch: Traditionalism stuetzen ein Modell" in Ein Modell im Dialog: Staatsbuerger in Uniform, (Bonn, 1992).

Breemer, J., "U.S. Forces in Europe: The Search for a Mission," in J.J. Tritten and P.N. Stockton (Eds), Reconstituting America's Defense: The New U.S. National Security Strategy, (New York, Praeger, 1992).

Bruneau, T.A., "Catholicism and Political Action in Brazil: Limitations and Prospects," with W.E. Hewitt, in Edward L. Cleary and Hannah Stewart-Gambino, Eds., *Conflict and Competition: The Latin American Church in a Changing Environment*, (Boulder: Lynne Rienner Publisher, 1992).

Looney, R., "Latin American Military Expenditures and Arms Production: The Environmental Consequences," Conversion and the Environment, edited by Nils Petter Gleditsch (Oslo: PRIO Report, No. 2, May 1992). Proceedings of a seminar in Perm, Russia, 24-27, 1991, pp. 209-230.

Looney, R., "Fiscal Stress in Saudi Arabia: Budgetary Adjustments in an Era of Declining Oil Revenues," The Oil Market in the 1980s: A Decade of Decline, edited by S. Shojai and B. Katz (New York: Praeger Publishers, 1992), pp. 59-70.

Looney, R., "The Impact of Military Expenditures on Human Capital Development in the Arab Gulf States," Defense, Welfare, and Growth: Perspectives and Evidence, edited by Steve Chan and Alex Mintz (London: Routledge, 1992), pp. 198-210.

Looney, R., "Economics: Mexico" Library of Congress, Handbook of Latin American Studies, Vol. 51 (Austin: University of Texas Press, 1992), pp. 238-261.

Minott, R.K., "Nordic Security at the Turn of the 21st Century," G.E. Zoppo (Ed), Military Studies, No. 117, (Greenwood Press, New York, 1992).

Olsen, E.A., chapter on "South Korea Under Military Rule: Friendly Tyrant?" in Daniel Pipes and Adam Garfinkle, Editors, Friendly Tyrants: An American Dilemma, (Philadelphia & New York: Foreign Policy Research Institute and St. Martin's Press, 1992).

Olsen, E.A., chapter on "Korean Security: Is Japan's Comprehensive Security' Model A Viable Alternative?" in Doug Bandow and Ted Galen Carpenter, Editors, The U.S.-South Korean Alliance: Time for a Change. (New Brunswick: Transaction Publications, 1992).

Olsen, E.A., chapter on "A New American Strategy in Asia?" in James J. Tritten and Paul Stockton, Editors, Reconstituting Defense: Problems in the New United States National Security Strategy, (New York: Praeger Publishers, 1992).

Olsen, E.A., chapter on "Japan" in Magnus Clarke and Moham Malik, Editors, Asian Defence Policies, Great Powers and Regional Powers. (Victoria: Deakin University; Australian Defense and Strategic Studies Program, 1992).

Stockton, P. and Tritten, J., (Eds), "Reconstituting Defense: America's New National Security Strategy," (New York, Praeger, 1992).

Stockton, P. and Tritten, J., (Eds), "Introduction" and "The Congressional Response to the New National Security Strategy," Reconstituting Defense, 1992.

Tritten, J.J., "War Termination: The Maritime Component," *Conflict Termination After Cold War*, Stephen J. Cimbala and Sidney Waldman, Editors. (Greenwood Press, p. 197-217, 1992).

Winterford, D. and Looney, R.E., "Advanced Telecommunications and the Economic Diversification of Bahrain," in E.M. Noam and R.U. Akwle (Eds), Telecommunications in Africa and West Asia, (Columbia University Press, Oxford University Press, 1992).

Wirtz, J. J., "Conclusion," in J. Tritten and P. Stockton (Eds), Reconstituting America's Defense: The New National Security Strategy, Praeger, 1992.

Yost, D.S., "France [and Arms Control]," in Fen Hampson, Harald von Riekhoff, and John Roper, Editors, The Allies and Arms Control. (Baltimore: John Hopkins University Press, pp. 162-188, 1992).

CONTRIBUTION TO ENCYCLOPEDIA

Breemer, J., "Anti-Submarine Warfare," in T.N. Dupuy (Ed), *International Military and Defense Encyclopedia (6 volumes), Washington, D.C.: Brassey's, 1992.*

NEWPAPER ANALYSES

Olsen, E.A., "Steps Leading to Korean Unification," *The Christian Science Monitor,* 18 May 1992.

Olsen, E.A. and Ellings, R.L., "A New Pacific Profile," circulated through the *New York Times Syndicate*, 6 December 1992.

MONOGRAPHS

Olsen, E.A., "The Evolution of U.S. Maritime Strategy in the Pacific," Canberra: Australian National University, Research School of Pacific Studies, Strategic and Defence Centre, 1992.

Olsen, E.A. and Ellings, R.J., "Asia's Challenge to American Strategy," Seattle: National Bureau of Asian Research, 1992.

Yost, D.S., "Les Etats-Unis et la securite europeene (Paris: Centre d'Etude des Relations entre Technologies et Strategies (CREST), Ecole Polytechnique, 1992.

DEPARTMENT OF OCEANOGRAPHY

Professor C.A. Collins
Chairman



DEPARTMENT OF OCEANOGRAPHY

The Oceanography Department has developed a broad research program focused on physical oceanography to meet the anticipated future needs of the Navy. Our priority basic research themes are the development of scientific capabilities to measure, analyze and forecast fields of littoral ocean variables which occur in association with synoptic/mesoscaleprocesses over limited regional and temporal domains. The areas of emphasis include coastal ocean dynamics, air-sea interaction phenomena and boundary currents. Regions of interest include the marginal sea ice zone, coastal ocean regions and strategic straits of the world.

Our priority applied research themes are the application of analyses and forecasts of upper ocean synoptic/mesoscale variability to Naval operations. Areas of emphasis include the impact of littoral processes, eddies and boundary currents on ocean surveillance systems, the effect of coastal ocean response storms on acoustic propogations and ambient noise and the impact that nearshore processes exert on the wave climate and beach character.

These research themes require the development of numerical ocean prediction and synoptic oceanography capabilities. They are achieved through employment of modern dynamical and mathematical principles, numerical and statistical methods, computational and graphical facilities, and in-situ and remote sensing observation.

The diverse talents of the faculty of the department are blended by the use of these various techniques to solve problems of common interest. Our students are actively involved in these research programs and participate in research cruises, conference presentations and as co-authors. Much of our research results, both theoretical and applied, are incorporated into the curricula we support. A summarization of particular research areas follows below.

COASTAL AND NEARSHORE OCEANOGRAPHY

Professors C.A. Collins and **N. Garfield** are involved in the analysis of current velocity data across the continental margin off Pt. Sur. With **Professor Carter** they began RAFOS float measurements of the California Undercurrent. The sponsor for these studies is ONR. **Professors S.R. Ramp, Collins, Garfield** and **L. Rosenfeld** continued collection of hydrographic and current meter data in the region to the west of the Farallons. These studies were sponsored by the EPA and the Western Division, Naval Engineering Facilities Command.

Professor S.R. Ramp has been actively involved in making time series measurements of the current and water mass properties over the continental slope off Pt. Sur since 1989 to study the long-term seasonal and interannual variability of the flow. He is also investigating the mesoscale variability of

weakly nonlinear systems, a five year ONR accelerated research initiative, to study the energy exchanges occuring in eastern boundary currents.

Under sponsorship of ONR, **Professor M.L. Batteen** is utilizing climatiological data bases for wind and thermal forcing in an eddy-resolving, primitive equation model to study the generation of currents and eddies in the California Current System.

Professors R.H. Bourke, J.A. Nystuen and **N. Garfield** have expanded the IDEA satellite imagery library by acquiring SSM/I passive microwave data for the Arctic Ocean. These data were used to support studies of large ice floe automated tracking and frontal dynamics in the Barents Sea. The project is sponsored by the Naval Polar Oceanography Center and NPS.

Professor J.D. Paduan has begun a study to differentiate the circulation pattern of Monterey Bay in the upwelling and non-upwelling regions using high resolution (GPS) drifters and CODAR-derived surface currents. He has also initiated a study of mesoscale eddy variability in eastern boundary currents using satellite-tracked surface drifters. The work in sponsored by ONR and NPS. **Professor J.D. Paduan**, with funding from ONR, is in the second year of a study using multiple satellite-tracked Lagrangean drifters to map the large scale horizontal surface convergence in the northeast Atlantic Ocean.

Professors E.B. Thornton and **T.P. Stanton** are involved in a program to develop a 3-component sediment flux probe with high temporal and spatial resolution that will provide a unique capability to estimate beach sediment load and fluxes.

Professors E.B. Thornton and **T. Lippmann** are developing models to predict the wave-induced three dimensional velocity field and induced sediment transport over arbitrary bathymetry in the nearshore zone under funding from ONR. Under a separate ONR contract they are evaluating wave and current surf zone models that have been transitioned to the fleet Tactical Evnironmental Support System.

Professor S.P. Tucker continued with studies to determine the rate of spreading of the Juan de Fuca Ridge under sponsorship of NPS.

ACOUSTICAL OCEANOGRAPHY

Professors R.H. Bourke and **C.S. Chiu** participated in the Barents Sea Tomography Transmission Test along with scientists from WHOI and SAIC. The purpose of the experiment was to characterize and understand the dynamics of a shallow water front using traditional physical oceanograpic techniques coupled with acoustic tomography to map the oscillations of the front. The research is sponsored by ONR.

Professor R.H. Bourke and **R.G. Paquette** analyzed submarine acquired conductivity-temperature-depth data from the Beaufort Sea to examine the nature of the eddy field and to asses the scientific usefulness of such data sets. The

sponsors are the Arctic Submarine Laboratory and NPS.

Professors R.H. Bourke and **R.G. Paquette**, under the sponsorship of the Naval Oceanographic Office, analyzed the ambient noise data acquired from three ice-mounted drifting buoys off the east coast of Svalbard in the northwest Barents Sea. The importace of migrating storms on the noise field was found to exert a profound effect on acoustic detecton.

Professor C.S. Chiu is studying the circulaton of the Greenland Sea Gyre using inverse techniques and acoustic tomography data collected by WHOI and SIO in the Greenland Sea Project. The effect of varying the acoustic multipath regime on the tomographic inverse solution was examined. This research is sponsored by WHOI.

Professors C. S. Chiu and **A. J. Semtner** are conducting simulation studies of the variability of cross-basin sound transmission using the output of the Semtner-Chervin global eddy-resolving ocean model. This research, designed to detect signs of global warming, is sponsored by ONR.

AIR-SEA INTERACTION AND OCEAN TURBULENCE

Professor T.P. Stanton, with support from **ONR**, is involved in a field program to define the dynamics controlling turbulent fluxes in the ocean mixed layer as Arctic leads refreeze.

Professors R.W. Garwood, Jr., and **P. Chu** are sponsored by ONR and NPS to investigate the thermodynamic and dynamic coupling between the oceanic and atmospheric tubulent boundary layers. A new mechanism for positive feedback between the oceanic mixed layer and cloud formation in the tropics has been discovered and a new theory about El Nino phenomena established.

Professors Garwood and **Chu** have received an NSF grant to study the role of turbulent mixing in the Arctic system of ocean-ice-atmosphere interactions. They have found two forms of conditional instability for deep mixing that may heop explain deep water formation in the polar seas and its impact on the global conveyor belt of deep thermohaline circulation.

Professor J. A. Nystuen is developing in-situ technique for monitoring air/sea interaction processes through ambient sound measurements. He is continuing laboratory analysis of the small scale physics of sound production by raindrops, the results of which were used to successfully predict sound levels of heavy rainfall in the Gulf of Mexico. He is continuing efforts to develop an acoustic drifting buoy to acoustically monitor the ocean in conjuction with satellite measurements. The sponsor is the Naval Research Laboratory Detachment-Stennis Space Center.

NUMERICAL PREDICTION AND DATA ASSIMILATION

Under sponsorship of the National Science Foundation, **Professor A.J. Semtner, Jr.** is implementing and testing a free-surface formulation of a global eddy-resolving ocean model capable of solutions at 1/2 and 1/4 degree grid sizes. For another NSF project he is transitioning his global ocean model onto massively parallel computers for use in ocean heat transport calculations related to climate variability studies

Under sponsorship of ONR, through the Weakly Nonlinear Accelerated Research Initiative on Eastern boundary Currents (EBC) **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 the central California Current System.

Under sponsorship of NSF, **Professor Batteen** has extended her modeling efforts to include thermal as well as wind forcing in the EBC region off Western Australia. This research has resulted in the first eddy-resolving model simulation of the Leeuwin Current and of eddies off Western Australia.

Professor E. Carter continued studies on data assismilation into numerical ocean models with the goal of improving mesoscale ocean forecasts. The sponsors for this work are NPS and ONR.

MARINE OPERATIONS

Mr. P. Jessen 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 Pt. Sur and an additional forty-six 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.

Professor J. R. Clynch, with funding from NISE-West, conducted studies to improve the aircraft landing system in Antarctica using GPS and also evaluated the merging of GPS data with the TACAN system.

MODELING STUDIES OF EDDIES IN EASTERN BOUNDARY CURRENT REGIONS

M. L. Batteen, Associate Professor; C. S. Nelson, CAPTAIN, NOAA

Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: The objective of this project is to better understand the roles of forcing mechanisms in eastern boundary current (EBC) regions, particularly the EBC regions of California, Portugal and Western Australia. The ultimate goal is to understand eddy generation mechanisms in each region well enough to provide a basis for prediction in the EBC and other dynamically similar regions.

SUMMARY: Different types of forcing (e.g., wind and thermal) have been incorporated into an existing primitive equation model. The effects of each mechanism have been analyzed by varying the type of forcing. In particular, we have focused on cases of wind and thermal forcing in a flat-bottomed 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).

PUBLICATIONS: Batteen, B.L., C.N. Lopes Da Costa, and C.S. Nelson, "A Numerical Study of Wind Stress Curl Effects on Eddies and Filaments off the Northwest Coast of The Iberian Peninsula," *Journal of Marine Systems*, Vol. 3, pp. 249-266, March 1992.

Batteen, M.L., M.J. Rutherofrd, and E.J. Bayler, "A Numerical Study of Wind and Thermal Forcing Effects on the Ocean Circulation off Western Australia," *Journal of Physical Oceanography*, Vol. 22, pp. 1406-1433, December 1992.

Batteen, M.L., M.J. Rutherford, and Bayler, E.J., "A Numerical Study of Wind and Thermal Forcing Effects on the Ocean Circulation off Western Australia," Research Activities in Atmospheric and Oceanic Modeling," (George J. Boer, Editor), WMO/JSC Working Group on Numerical Experimentation, in press.

Tisch, T., S. Ramp, R. Haney, C. Collins, and M. Batteen, "Assessing the Energetic Interactions of Subtidal Flow on the Continental Slope off Point Sur, CA. From Moored Current Meter Measurements," Abstracts from the Eastern Pacific Ocean Conference, P. 10, October 1992.

Batteen, M.L., R.P. Mitchell, P.T. Tsai, and C.S. Nelson, "Process-oriented Modeling Studies of Wind Forcing Effects on West Coast Ocean Circulation," Transactions of the American Geophysical Union, Vol. 73, P. 75, October 1992.

CONFERENCE PRESENTATIONS: Tisch, T., S. Ramp, R. Haney, C. Collins, and M. Batteen, "Assessing the Energetic Interactions of Subtidal Flow on the Continental Slope off Point Sur, CA. From Moored Current Meter Measurements," Eastern Pacific Ocean Conference, Mt. Hood, OR, October 1992.

Batteen, M.L., R.P. Mitchell, P.T. Tsai, and C.S. Nelson, "Process-oriented Modeling Studies of Wind Forcing Effects on West Coast Ocean Circulation," American Geophysical Union Fall Meeting, San Francisco, CA, December 1992.

Mitchell, R.P., M.L. Batteen, and

P.T. Tsai, "Visualization of Process-oriented Modeling Studies of Wind Forcing Effects on West Coast Circulations," Transaction of the American Geophysical Union, Vol. 73, Page 75, October 1992.

PROCESS-ORIENTED MODELING STUDIES OF EASTERN BOUNDARY CURRENT REGIONS

M. L. Batteen, Associate Professor; C. S. Nelson, CAPTAIN, NOAA

Sponsor and Funding: Office of Naval Research

OBJECTIVE: The objectives of this project are to provide the physical understanding necessary for high resolution ocean prediction in eastern boundary current (EBC) regions, and to understand the mechanisms responsible for the formation and resolution of eddy structures in EBC regions.

SUMMARY: A high-resolution, multi-level primitive equation, regional ocean model has been to investigate the generation and dynamics of currents and eddies in the California Current System (CCS). During FY92 the process-oriented modeling studies used climatological data bases for wind and thermal forcing for the region, while in FY93 the studies will utilize observed atmospheric and oceanographic data obtained in the EBC region as the data become available.

PUBLICATIONS: Batteen, M.L., R.P. Mitchell, P.T. Tsai, "Process-oriented Modeling Studies of Wind Forcing Effects on West Coast Circulations," Transactions of The American Geophysical Union, Vol. 73, p. 75, October 1992.

Mitchell, R.P., M.L. Batteen, and P.T. Tsai, "Visualization of Process-oriented Modeling Studies of Wind Forcing Effects on West Coast Circulations," Transactions of The American Geophysical Union, Vol. 73, p. 75, October 1992.

Tisch, T., S. Ramp, R. Haney, C. Collins, and M. Batteen, "Assessing the Energetic Interactions of Subtidal Flow on the Continental Slope off Point Sur, CA. From Moored Current Meter Measurements," Abstracts from the Eastern Pacific Ocean Conference, P. 10, October 1992.

CONFERENCE PRESENTATIONS: Tisch, T., S. Ramp, R. Haney, C. Collins, and M. Batteen, "Assessing the Energetic Interactions of Subtidal Flow on the Continental Slope off Point Sur, CA. From Moored Current Meter Measurements," Eastern Pacific Ocean Conference, Mt. Hood, OR, October 1992.

Batteen, M.L., R.P. Mitchell, P.T. Tsai, and C.S. Nelson, "Process-oriented Modeling Studies of Wind Forcing Effects on West Coast Ocean Circulations," American Geophysical Union Fall Meeting, San Francisco, CA, December 1992.

Mitchell, R.P., M.L. Batteen, and P.T. Tsai, ""Visualization of Process-oriented Modeling Studies of Wind Forcing Effects on West Coast Ocean Circulations," American Geophysical Union Fall Meeting, San Francisco, CA, December 1992.

PHYSICAL OCEANOGRAPHY OF THE ARCTIC OCEAN

R.H. Bourke, Professor, Department of Oceanography
R.G. Paquette, Emeritus Professor, Department of Oceanography
Sponsor: Arctic Submarine Laboratory, Naval Undersea Warfare Center
Funding: Naval Postgraduate School and Arctic Submarine Laboratory

OBJECTIVE: The purpose of this project was to analyze the conductivity-temperature-depth (CTD) data collected by a submarine operating in the Arctic Ocean during March and April in order to establish the scientific usefulness of such data and to support procedures that might yield even more useful results.

SUMMARY: Raw CTD data on diskettes have been processed in 6-hour time series and plotted to visually locate interesting oceanographic phenomena such as eddies, fronts, and interbasin variability. The data have been corrected for substantial temperature and salinity errors based on comparison with vertical CTD casts made from a manned-ice camp. Near the ice camp over a period of about 25 days, a series of both warm and cold core eddies have been identified. From the ascents/descents of the submarine, vertical CTD profiles have been constructed. These have assisted in our eddy analysis and in illustrating interbasin differences in water properties. The analysis is continuing during FY93. No publications or presentations have come from his work as yet as we are still in the relatively early stages of this investigation.

ANALYSIS OF UNDERICE AMBIENT NOISE MEASURED BY DRIFTING BUOYS AS PART OF PROJECT CEAREX

R.H. Bourke, Professor
R.G. Paquette, Emeritus Professor
Department of Oceanography
Sponsor and Funding: Naval Oceanographic Office

OBJECTIVE: The purpose of this project was to analyze the ambient noise data acquired from three drifting ice-mounted buoys which drifted with the ice from September to December 1988 passing to the east of the Svalbard Archipelago in the northwest Barents Sea.

SUMMARY: Analysis of the data has been completed. Spectral, temporal and spatial characteristics of the noise field from 5 to 4000 Hz were investigated. The impact of mesoscale storms, ice drift rate and inertial/tidal motion on the noise field were identified. The spatial coherency of the noise field was quite high with median levels varying only by about 3dB. The spectra were comparable to those found in the Eurasian Basin in winter. A twelve hour periodicity was noted in both the noise and ice speed data due to tidal/inertial forcing. At low frequencies wind stress was the most important correlate, followed closely by ice speed. The noise field responded rapidly to the passage of storms which migrated over the study

area. The arrival of the noise peak was associated with the time of passage of the storm front past each buoy.

PUBLICATIONS: Bourke, R.H. and A.R. Parsons, " Ambient Noise Characteristics of the Northwestern Barents Sea," Submitted to *Journal of Acoustical Society of America*

THESIS DIRECTED: Parsons, A.R., "Environmental Forcing of Ambient Noise in the Barents Sea," Master's Thesis, June 1992.

NPS ARCTIC REMOTE SENSING

R. H. Bourke, Professor
J. A. Nystuen, Assistant Professor
N. Garfield, Adjunct Research Professor
Department of Oceanography
Sponsor: Antisubmarine Warfare Center
Funding: Naval Postgraduate School

OBJECTIVE: The objective of this project is to integrate the IDEA Laboratory into the Polar Oceanography Program by initiating studies in areas where the use of satellite data may yield important insights. Daily SSM/I passive microwave data from the DMSP F-8 satellite for the Arctic Ocean are available from July 1987 to June 1989. The Yermak Plateau is an Arctic region where strong diurnal tidal currents have been measured which may generate zones of increases ice convergence, resulting in a detectable change in the ice surface morphology. We propose a detailed examination of this region through the use of SSM/I and AVHRR data.

SUMMARY: Wright (1991) analyzed the National Snow and Ice Data Center (NSIDC) SSM/I CD-ROM data set to test the hypothesis that changes in ice concentration/morphology could be detected by satellite remote sensing. His conclusions were that the SSM/I data could not be used to study motion over short time scales due to the poor spatial resolution. However, long term averages are indicative of ice flow trajectories and can be used, for example, to increase our knowledge of the interannual variability of heat and salinity budgets in specific regions, including Fram Strait, the principal outflow region of the Arctic basin. Coincident AVHRR satellite data was collected in the Barents Sea during the time of the August 1992 research cruise of the USNS Bartlett. These data are presently being processed at the IDEA Laboratory and will be used in the data analyses.

THESIS DIRECTED: Wright, W.A., "Applications of Passive Microwave Satellite Data for Arctic Sea Ice Studies," Master's Thesis, December 1992.

CHAIR IN ARCTIC MARINE SCIENCE

Robert H. Bourke, Professor
Department of Oceanography
Sponsor: Office of Naval Research
Funding: Office of Naval Research and Naval Postgraduate School

OBJECTIVE: To foster oceanographic research in the Arctic, acquaint naval officer students with Arctic problems, reduce results of pure research to operational usage, and publicize Navy interest in the Arctic.

SUMMARY: Professor Bourke served as administrator of the Chair handling such details as selecting Chair candidates, writing IPA's and proposals and setting up visits and seminars for the Chair incumbent. Professor Alan S. Thorndike, Chair of the Physics Department of the University of Puget Sound, was the Chair incumbent during 1992. He had a productive year at NPS providing seminars, teaching lectures in the polar oceanography course, writing papers and organizing and attending conferences/workshops. During his stay at NPS he wrote two papers which have since been published, one on a sea ice growth model, the other on estimating the sea ice thickness. He was the co-convener of the ARCSS workshop, held in Monterey in July 1992, on modeling high-latitude processes as they relate to climate change. He also was a co-organizer of an ice thickness workshop sponsored by NASA in Maryland in November 1991 to develop ideas and methodologies for future research. He assisted three NPS students with their thesis research, serving as co-advisor for one of them.

PUBLICATIONS: Thorndike, A.S., "A Toy Model Linking Atmospheric Thermal Radiation and Sea Ice Growth," *Journal of Geophysical Research*, 98(C6), pp. 9401-9410, 1992.

Thorndike, A.S., "Estimates of Sea Ice Thickness Distribution Using Observations and Theory," *Journal of Geophysical Research*, 97(C8), 12601-12,605, 1992.

BARENTS SEA TOMOGRAPHY TRANSMISSION TEST: SHALLOW WATER VERTICAL ARRAY COMPONENT

Ching-Sang Chiu, Associate Professor
Department of Oceanography
James H. Miller, Associate Professor
Department of Electrical and Computer Engineering
Robert H. Bourke, Professor
Department of Oceanography
Sponsor: Office of Naval Research
Funding: Office of Naval Research and Naval Postgraduate School

OBJECTIVE: In August 1992 a hydrographic-acoustic tomographic experiment was conducted over the steep northwestern slope of the Bear Island Trough, about 100 km east of Bear Island. The purpose of the experiment was to characterize and understand the dynamics of the

Barents Sea Polar Front (BSPF) using traditional physical oceanographic techniques coupled with acoustic tomography to map and study the oscillations of the BSPF.

SUMMARY: The experiment was designed to demonstrate the ability to carry out tomographic measurements in a shallow water (100 m to 400 m) environment. Two moored acoustic transceivers, one moored source and a vertical receiving array were used to separate ray arrivals in both time and angle. In addition, modal arrivals were separated using modal beamforming techniques. CTD data were collected within a 70 X 80 km area at 10 km intervals (shortened to 2.5 and 5 km intervals in the immediate vicinity of the front) during three traverses around the grid; ADCP measurements were made continuously. Three current meters were positioned on each of the three moorings along with three or more temperature loggers. Results from our initial data analysis show that the front is vertical and quite sharp (5 km horizontal scale) and is topographically trapped to the upper slope. A 26 hour CTD time series indicates it oscillates laterally 5-10 km at the diurnal tidal cycle. T-S properties suggest that little cross-frontal exchange was occurring. Tidal current speeds were higher at the NW mooring (40-50 cm/s to the NW) than south of the front (SW mooring, 10-20 cm/s). Acoustic tomographic data indicate the temperature field should be resolvable to 5 km along a cross frontal path.

CONFERENCE PRESENTATION: Bourke, R.H., C.-S Chiu, J.F. Lynch, R.D. Muench, and A.J. Plueddemann, "Initial Results From the Barents Sea Polar Front Experiment," EOS Supplement, (73) 43, 1992.

THESES DIRECTED: Elliott, J.M., "Simulation of Acoustic Multipath Arrival Structure in the Barents Sea," Master's Thesis, June 1992.

Sagos, George, A., "A Three-dimensional Coupled Normal Mode Model for Sound Propagation in Shallow Water with Irregular Bottom Bathymetry," Master's Thesis, December 1992.

GREENLAND SEA TOMOGRAPHY DATA ANALYSIS

Ching-Sang Chiu, Associate Professor
Department of Oceanography
Sponsor and Funding: Woods Hole Oceanographic Institution

OBJECTIVE: As part of the Greenland Sea Project, Woods Hole Oceanographic Institution and Scripps Institute of Oceanography deployed six acoustic tomography transceiver moorings to measure variability of the Greenland Sea gyre through a cooling cycle from September 1988 to August 1989. Using a set of Greenland Sea acoustic tomography data provided by Woods Hole Oceanographic Institution, the importance of incorporating acoustic path changes in the construction of the tomographic inverse solution was investigated.

SUMMARY: A comparison of the inverse solutions for changes in sound speed using non-corrected and corrected acoustic multipaths was conducted. Although the two inverse solutions are qualitatively similar, significant quantitative differences exist. These differences indicate

that it is necessary to account for changes in the acoustic multipaths for the generation of accurate Greenland Sea acoustic tomography maps.

THESIS DIRECTED: English, G.E., "Sensitivity of the Tomographic Inverse Solution to Acoustic Path Variability," Master's Thesis, March 1992.

NAVAL OCEAN ANALYSIS AND PREDICTION

Peter C. Chu, Associate Professor (PI)
Sponsor: Research Administration Office
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project was to develop a new Naval Ocean Analysis and Prediction Lab to meet the Navy's requirement of ocean prediction.

SUMMARY: A new diagnostic system has been developed for three dimensional ageostrophic ocean circulations by using the hydrographic data sets. A new (C-vector) method has proved to be a useful tool for analysis.

PUBLICATIONS: Chu, P.C., "Three Dimensional Pseudovorticity Field in the West Spitsbergen Current," *Polar Meteorology and Oceanography*, 10, 117-120, 1992.

Chu, P.C., "Three Dimensional Eastern Greenland Sea Circulation Computed from a CTD Data Set," *Ocean-Atmosphere-Ice Interaction*, 1, pp. 61-64, 1992.

Chu, P.C., S. Konstandindinis, P. Jessen, and C.A. Collins, "C-Vector Method Derived Three Dimensional Circulation in Farallone National Sanctuary," *EOS* Supplement,89, 1992.

Chu, P.C. and Y.H. Kuo, "South Atlantic Three Dimensional Pseudovorticity Field Computed from Hydrographic and Surface Air data Sets," Southern Hemisphere Meteorology and Oceanography, 4, in press, 1992.

Chu, P.C. and Y.H. Kuo, "Incompatible Wind and Buoyancy Forcing in Ocean Numerical Models," *Advanced Atmospheric Sciences*, 10, in press, 1992.

Collins, C.A. and Chu, P.C.(Ed), The General Circulation of the World Ocean, (Amerind Publishing Company, 1992).

CONFERENCE PRESENTATIONS: Chu, P.C., "C-vector Method and its Applications," Arctic System Workshop, Pacific Grove CA, 13-17 July 1992, invited.

Chu, P.C., "Three Dimensional Circulation in Western Spitsbergen Coast," Third Conference on Polar Meteorology and Oceanography, American Meteorological Society, Portland, OR, 29 September - 2 October 1992.

Chu, P.C., S. Konstandindinis, P. Jessen, and C.A. Collins, "C-Vector Method Derived Three Dimensional Circulation in Farallone National Sanctuary," American Geophysical Union Fall Meeting, San Francisco, CA, 7-11 December 1992.

THESES DIRECTED: Li, W.S., LCDR, "Three Dimensional Ocean Circulation in Eastern Greenland Sea, Master's Thesis, December 1992.

Konstandindinis, S., LT, C-vector Method derived Three Dimensional Circulation in Farallone National Sanctuary, Master's Thesis, December 1992.

Kuo, Y.H., LT, "Errors Caused by Incompatible Wind and Buoyancy Forcing in Ocean General Circulation Models," Master's Thesis, December 1992.

GPS ANTARCTIC LANDING SYSTEM: ACCURACY AND IONOSPHERIC EFFECTS STUDY

J.R. Clynch, Adjunct Professor
Department of Oceanography
Sponsor and Funding: NISE-West, Vallejo

OBJECTIVE: The aircraft landing system at the US bases in Antarctica must be replaced in the next 3-4 years. GPS is the primary candidate system for use in this remote area. There are several special features about the geometry and environment that need to be addressed before a firm decision is made to use GPS for this flight critical application. It was the objective of this work to design and execute experiments and studies to provide the necessary information for that decision.

SUMMARY: An experiment was designed and deployed to McMurdo Antarctica in January 1992. This experiment was set up by Navy personnel at McMurdo and run for one year. The data were returned in late 1992 for analysis. The status of the experiment was monitored through weekly reports generated by the experiment's software. Systems studies were performed and a simulation of the errors in a aircraft landing system begun. It was determined that some auxiliary height system, such as pseudolites, will be required. Assistance was provided for a second experiment involving a prototype GPS aircraft landing system on a C-130. In addition to providing data for GPS landing system evaluation, this data contains information on L-Band scintillations in high latitude regions.

PUBLICATION: Clynch, J.R., G. Thurmond, L. Rosenfeld, and R. Schramm, "Error Characteristics of Differential Positions and Velocities," Proceedings, ION GPS-92, Albuquerque, MN, pp. 16-18, September 1992.

ANALYSIS OF COMMERCIAL GPS RECEIVERS FOR DEFENSE MAPPING AGENCY MONITOR STATION APPLICATIONS

J.R. Clynch, Adjunct Professor
Sponsor: DMA Systems Center
Funding: Defense Mapping Agency

OBJECTIVE: This work supported the development of a specification for new GPS receivers to be used in the DMA GPS Monitor stations and participation in the evaluation of proposals. The advent of encrypted GPS signals was the driving item in procuring new receivers.

SUMMARY: Small system studies were performed to evaluate the minimum number of receiver channels and other factors that impact the quality of an orbit generated from a combination of the DMA monitor sites and the OCS sites. The specification, written mainly by a DMA vendor, was reviewed and changes recommended. This work included membership in the source selection committee that met in December 1992.

SEA-BASED TACAN AND GPS (STAG): CONCEPT EVALUATION / DEMONSTRATION EVALUATION

J.R. Clynch, Adjunct Professor
Department of Meteorology
Sponsor and Funding: NISE-West, Vallejo

OBJECTIVE: The Navy is evaluating a modification to TACAN systems. This system uses the TACAN signal, at a low power level, to transmit the ships position to the aircraft where it is merged with GPS data to produce a TACAN like data. This is an assistance task requested by NISE to aid in the planning and evaluation of tests.

SUMMARY: Utilizing pre-exiting software for analysis of the standard 3A and 3S GPS receivers, the data from two tests sets was used to generate a truth trajectory. This was compared with the values given by the STAG system. A letter report was furnished to NISE on the results.

MARINE OPERATIONS PROJECT

Curtis A. Collins, Professor and Chairman Department of Oceanography
Paul Jessen, Oceanographer
Department of Oceanography
Sponsor: Naval Oceanography Command
Funding: Naval Postgraduate School

OBJECTIVE: To provide administrative and logistical support for shipboard operations necessary for research and instruction.

SUMMARY: The marine operations program supported 40 days at sea in FY92 on the R/V Point Sur. Activities included the Operational Oceanography Course (OC3570) in spring quarter, and Descriptive Physical Oceanography (OC3230) in fall, winter and summer. Current meter moorings were maintained off Point Sur. Current meter and sound source arrays were installed for an Eastern Boundary Current study and a RAFOS float project, respectively.

Research cruises were also carried out on the USNS DeSteiguer and the USNS Bartlett. The former was 18 days long, and involved joint studies of the exchange of water between the Sea of Cortez and the Pacific Ocean with the Mexican Navy. The Bartlett cruise was 28 days long and studied the Barents sea polar front. An additional 16 days of ship support for the Point Sur was provided by EPA for studies related to the location of a dumpsite off San Francisco. The marine operations program maintains equipment which is routinely used at sea: CTDs, XBTs, and a shipboard data acquisition 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 are maintained near the Coast Guard Pier in Monterey Harbor for research vessel use.

PUBLICATIONS:

Baggeroer, A.B., K. Lashkari, J.H. Miller, C.S. Chiu, G. Frogner, P.N. Mikhalevsky, and K. von der Heydt, "Vertical Array Resolution of the Normal Modes from the Heard Island Signals," *Journal Acoustical Society of America*, Submitted.

Bourke, R.H., R.G. Paquette, and R.F. Blythe, "The Jan Mayen Current of the Greenland Sea," *Journal Geophysical Research*, 97(C5), 7241-7250, 1992.

Bourke, R.H. and A.R. Parsons, "Ambient Noise Characteristics of the Northwestern Barents Sea," Submitted to *Journal of Geophysical Research*, in press.

Chiu, C.S., A.J. Semtner, C.M. Ort, J.H. Miller, and L.L. Ehret, "A Ray Variability Analysis of Sound Transmission from Heard Island to California," *Journal Acoustic Socity of America*, Submitted.

Cooper, A.W., P.L. Walker, E.A. Milne, and B.J. Cook, , Dieter Clement and Wendall Watkins, (eds.), Proceedings SPIE, 1687, 147-157, 1992.

Davidson, K.L., P.J. Boyle, and P.S. Guest, "Atmospheric Boundary Layer

Properties Affecting Wind Forecasting in Gulf and Coastal Regions," *Journal of Applied Meteorology*, 31, 983-994, August 1992.

Jessen, P.F., S.R. Ramp, C.A. Collins, N. Garfield, L.K. Rosenfeld, and F.B. Schwing, "Hydrographic and Acoustic Doppler Current Profiler (ADCP) Data From the Farallones Shelf and Slope Study, NPS Technical Report, NPS-OC-92-003, 1992.

Jessen, P.F., S.R. Ramp, C.A. Collins, N. Garfield, L.K. Rosenfeld, and F.B. Schwing, "Hydrographic and Acoustic Doppler Current Profiler (ADCP) Data From the Farallones Shelf and Slope Study, NPS Technical Report, NPS-OC-92-004.

Jessen, P.F., S.R. Ramp, C.A. Collins, N. Garfield, L.K. Rosenfeld, and F.B. Schwing, "Hydrographic and Acoustic Doppler Current Profiler (ADCP) Data From the Farallones Shelf and Slope Study, NPS Technical Report, NPS-OC-92-005.

Jessen, P.F., S.R. Ramp, C.A. Collins, N. Garfield, L.K. Rosenfeld, and F.B. Schwing, "Hydrographic and Acoustic Doppler Current Profiler (ADCP) Data From the Farallones Shelf and Slope Study, NPS Technical Report, NPS-OC-92-006.

Jessen, P.F., S.R. Ramp, C.A. Collins, N. Garfield, L.K. Rosenfeld, and F.B. Schwing, "Hydrographic and Acoustic Doppler Current Profiler (ADCP) Data From the Farallones Shelf and Slope Study, NPS Technical Report, NPS-OC-92-007.

Kinoshita, K., M. Noble, and S.R. Ramp, "The Farallones Moored Array Data Report," U.S. Geological Survey, Menlo Park, CA, 1992.

Manley, T.O., R.H. Bourke, and K.L. Hunkins, "Near-Surface Circulation Over the Yermak Plateau in Northern Fram Strait," *Journal of Mar. Systems*, 3, 107-125, 1992.

Miller, J.H., J.F. Lynch, C.-S. Chiu, E.L. Westreich, J.S. Gerber, R. Lappenstiel, and E. Chaulk, "Acoustic Measurements of Surface Gravity Wave Spectra in Monterey Bay Using Mode Travel Time Fluctuations," *Journal Acoustical Society of America*, accepted.

Noble, M., S.R. Ramp, and K. Kinoshita, "Current Patterns Over the Shelf and Slope Adjacent to the Gulf of the Farallones," Executive Summary, Final Report to the U.S. Environmental Protection Agency, U.S. Geological Survey, Menlo Park, CA, 1992.

Tisch, T.D., S.R. Ramp, and C.A. Collins, "Observations of the Geostrophic Current and Water Mass Characteristics off Point Sur, CA," *Journal of Geophysical Research*, 97, 12,535-12,555, 1992.

Westreich, E.L., C.-S. Chiu, J.H. Miller, J.F. Lynch, and M.D. Collins, "Modeling Pulse Transmission in the Monterey Bay using Parabolic Equation Methods," *Journal Acoustical Society of America*, submitted.

CONFERENCE PRESENTATIONS: Bourke, R.H., C.-S Chiu, J.F. Lynch, etc., "Initial Results from the Barents Sea Polar Front Experiment," American Geophysical Union Fall Meeting, San Francisco. CA, 1992.

Chu, P., S. Konstandindinis, P. Jessen, C.A. Collins, "C-vector Method Derived Three Dimensional Circulation in the Farallones National Marine Sanctuary," oral presentation, American Geophysical Union Fall Meeting, San Francisco, CA, December 1992.

Coelho, E.F. and T.P. Stanton, "Current and Stratification Time Series over Monterey Canyon," EOS Transactions, P. 318, American Geophysical Union Fall Meeting, San Francisco, CA, December 1992.

Collins, C.A., Coastal Oceanography, oral presentation, "Impact of the Environment on Coastal Warfare Symposium," Monterey, CA, June 1992.

Collins, C.A. and E. Carter, "Hydrography of the California Undercurrent," American Geophysical Union Fall Meeting, San Francisco, CA, December 1992.

Cooper, A.W., P.L. Walker, E.A. Milne, and B.J. Cook, "Evaluation of Tactical Decision Aid Predictions of FLIR Range Performance," Paper 1687-15, SPIE Symposium on EO/Aerospace Sensing, Orlando, FL, 20 April 1992.

Garfield, N., F.B. Schwing, S.R. Ramp, C.A. Collins, P.F. Jessen, T.A. Rago, and L.K. Rosenfeld, "Gulf of Farallones Hydrography: Upper Layer Water Mass Seasonal Variability," American Geophysical Union Fall Meeting, San Francisco, CA, December 1992.

Haney, R.L. and T.P. Stanton, "The Three Dimensional Current Structure Associated With A Cold Filament in the California Coastal Current," American Geophysical Union Ocean Sciences Meeting Abstracts, New Orleans, LA, 27-31 January 1992, pp. 50-51.

Noble, M. and S.R. Ramp, "Current Measurements Over the Continental Slope Near the Farallon Islands, CA," American Geophysical Union Fall Meeting, San Francisco, CA, December 1992.

Paduan, J.D. and T.C. Neal, "Evaluation of Remotely-Sensed Surface Currents in Monterey Bay from Coastal Ocean Dynamics Applications Radar (CODAR)," EOS, Transactions, American Geophysical Union Fall Meeting, 73 Supplement, p. 315, San Francisco, CA, December 1992.

Paduan, J.D. and T.C. Neal, "Evaluation of Remotely-Sensed Surface Currents in Monterey Bay from Coastal Ocean Dynamics Applications Radar (CODAR)," 39th Eastern Pacific Ocean Conference, Mt. Hood, OR, 21-23 October 1992.

Rago, T.A., N. Garfield, and C.A.Collins, "Measurements of Ocean Currents Across the Continental Margin off Point Sur, CA, American Geophysical Union Fall Meeting, San Francisco, CA, December 1992.

Ramp, S.R., C.A. Collins, P.,F. Jessen, N. Garfield, K.A.S. Hays, L.K. Rosenfeld, and F.B. Schwing, "The Effects of the 1991-1992 ENSO Event on the Shelf and Slope Waters off Central California, American Geophysical Union Fall Meeting, San Francisco, CA, December 1992.

Rosenfeld, L.K., M.A. Noble, S.R. Ramp, C.A. Collins, N. Garfield, and F.B. Schwing, "Direct Measurements of the Poleward Undercurrent Off the Gulf of the Farallones," American Geophysical Union Fall Meeting, San Francisco, CA, December 1992.

Rosenfeld, L.K., M.A. Noble, S.R. Ramp, C.A. Collins, N. Garfield, and F.B. Schwing, "Direct Measurements of the Poleward Undercurrent Off the Gulf of the Farallones," EOS Transactions, 73, 315. American Geophysical Union Fall Meeting, San Francisco, CA, December 1992.

Schwing, F.B., N. Garfield, C.A. Collins, S.R. Ramp, and L.K. Rosenfeld, "Persistence and Seasonality in Shelf and Slope

Circulation Near the Gulf of the Farallones as Deduced from ADCP and Hydrographic Surveys," American Geophysical Union Fall Meeting, San Francisco, CA, December 1992.

Stanton, T.P., "Effects of Solar Heating on the Turbulent Boundary Layer Under an Arctic Lead," EOS Transactions, p. 285, American Geophysical Union Fall Meeting, San Francisco, CA, December 1992.

THESES DIRECTED: Campbell, B., LT, USN, "Electromagnetic Propagation Effects of a Frontal Passage in a Coastal Environment," Master's Thesis, July 1992.

Hicks, M.J., LT, USCG, "Alongshore Sub-thermocline Current Variability in the Central California Current System," Master's Thesis, December 1992.

Kreitz, J.C., LT, USN, "Preliminary Evaluation of the PREOS Program for Determining Detection Ranges of Airborne FLIR Systems, Master's Thesis, December 1992.

Neal, T.C., LT, USN, "Analysis of Monterey Bay CODAR-Derived Surface Currents, March to May 1992," Master's Thesis, September 1992.

Rugg, S., CPT, USAF, "Continuous Measurements of Marine Atmospheric Boundary Layer Properties with the High Resolution Interferometer Sounder (HIS0)," Master's Thesis, December 1992.

Siletzky, S., LT, USN, "Electromagnetic Propagation Effects of a Frontal Passage in a Coastal Environment," Master's Thesis, July 1992.

Tisch, T.D., LT, USN, "Assessing the Energetic Interactions of Subtidal Flow on the Continental Slope in an Eastern Boundary Region," NOAA Cprs., Ph.D., December 1992.

CALIFORNIA UNDERCURRENT STUDIES

Curtis A. Collins, Professor and Chairman of Oceanography
N. Garfield, Adjunct Professor
Department of Oceanography
Sponsor: Department of Oceanography
Funding: Office of Naval Research

OBJECTIVE: The objective of this research project is to understand the dynamics and kinematics of the California Undercurrent off Central California. The following questions formed the basis for our investigation. What is the mean pattern of poleward and equatorward flow off Point Sur? What are the poleward transports of heat and salt? Is there a reference level that can be used for geostrophic calculations? How can various velocity measuring techniques be used in a consistent manner?

SUMMARY: The California Current and Undercurrent was observed in each of 19 research cruises between April 1988 and April 1991. The Undercurrent core location varies between 43 and 70 kilometers offshore. The depth of the core of the current is found around a depth of 200 meters. The extent of poleward flow is usually within a triangular shaped region, extending from the surface nearshore down to at

least 70 meters (often much deeper) along the slope, thence to the surface approximately 70 kilometers offshore. The computed poleward transport varies from 3 to 7 Sv. The north-south component of flow is often barotropic in character across the continental slope, but the east-west component of flow is strongly sheared, with flow in the upper 200 meter directed more strongly offshore than flow at depth. In an investigation of the continuity of the alongshore flow in May 1989, we were able to trace the dynamic signature of the Undercurrent (isopycnals sloping downward at the coast) and the water mass anomaly associated with the Undercurrent (high salt and spiciness) from Point Sur to Pigeon Point. During 1991 and 1992 we also investigated the Undercurrent between Point Reyes and Half Moon Bay.

Final processing of Pegasus and CTD data was carried out during 1992. A copy of the CTD data has been provided to Professor Haney who is investigating the depth dependence of the dynamical modes.

PUBLICATIONS: Garfield, N., T.A. Rago, K.J. Schnebele, and C.A. Collins, "Evidence of a Turbidity Current in Monterey Submarine Canyon Associated with the 1989 Loma Prieta Earthquake," *Continental Shelf Research*, in press.

Tisch, T.D., S.R. Ramp, and C.A. Collins, "Observations of the Geostrophic Currents and Water Mass Characteristics off Point Sur, California, from May 1988 through November 1989," *Journal of Geophysical Research*, 97(C8), 12535-12555, 1992.

CONFERENCE PRESENTATIONS: C. Collins and E. Carter, "Hydrography of the California Undercurrent from CTDs," American Geophysical Union Fall Meeting, San Francisco, CA, December 1992.

Rago, T.A., N. Garfield, and C.A. Collins, "Measurement of Ocean Currents Across the Continental Margin off Point Sur, California, from April 1989 through April 1991," American Geophysical Union Fall Meeting, San Francisco, CA, December 1992.

CIRCULATION ON THE CONTINENTAL SHELF AND SLOPE NEAR THE FARRALON ISLANDS, CA

Curt Collins, Professor
Steven R. Ramp, Assistant Professor
Newell Garfield, Adjunct Professor
Leslie Rosenfeld, Adjunct Professor
Department of Oceanography
Marlene Nobel, USGS, Menlo Park, CA.
Frank Schwing, PFEG, NOAA, Monterey, CA.
Sponsor: WESTDIV, Naval Facilities Engineering Command
Funding: The U.S. Environmental Protection Agency, the U.S. Army Corps of Engineers and U.S. Geological Services

OBJECTIVE: To describe the ocean circulation over the continental shelf and slope near the Farallon Islands, CA, particularly as it pertains to the dispersal of dredged material which may dumped in the area at ocean dumpsites whose exact location has not yet been designated. We will provide scientific input to managers at WESTDIV and EPA who will be making the site designation decisions.

SUMMARY: A series of 5 high-resolution shipboard hydrographic and ADCP surveys were conducted to resolve the spatial variability over the study region at different times, and six current meter moorings were deployed in the region which resolve the temporal variability. Satellite AVHRR data is being used extensively to interpret both the moored and shipboard results. A few results are briefly summarized, from high to lower frequencies. 1) Several moorings show bottom trapping of the M2 and K1 tides. These strong tides may also be rectified into energetic mean flows by submarine canyons in the area. 2) Strong mesoscale flows occurred in a coherent wedge over the continental slope. These flows were not coherent with the shelf circulation. 3) The California Undercurrent was sometimes present and sometimes not, apparently meandering or "bursting" through the area. The current was weaker than farther south off Point Sur, CA. 4) Strong seasonal and interannual variability was evident, likely in concert with the 1991-92 ENSO event.

PUBLICATIONS:

Ramp, S.R., N. Garfield, C.A. Collins, L.K. Rosenfeld, and F. Schwing, "Circulation Studies Over the Continental Shelf and Slope Near the Farallon Islands, CA, Executive Summary, Final Report to the U.S. Environmental Protection Agency, NPS Technical Report, 1992.

Noble, M., S.R. Ramp, and K. Kinoshita, "Current Patterns Over the Shelf and Slope Adjacent to the Gulf of the Farallones," Executive Summary, Final Report to the U.S. Environmental Protection Agency, U.S. Geological Survey, Menlo Park, CA, 1992.

Jessen, P.F., S.R. Ramp, C.A. Collins, N. Garfield, L.K. Rosenfeld, and F.B. Schwing, "Hydrographic and Acoustic Doppler Current Profiler (ADCP) Data From the Farallones Shelf and Slope Study," NPS Technical Report, NPS-OC-92-003, 1992.

Jessen, P.F., S.R. Ramp, C.A. Collins, N. Garfield, L.K. Rosenfeld, and F.B. Schwing, "Hydrographic and Acoustic Doppler Current Profiler

(ADCP) Data From the Farallones Shelf and Slope Study," NPS Technical Report, NPS-OC-92-004.

Jessen, P.F., S.R. Ramp, C.A. Collins, N. Garfield, L.K. Rosenfeld, and F.B. Schwing, "Hydrographic and Acoustic Doppler Current Profiler (ADCP) Data From the Farallones Shelf and Slope Study," NPS Technical Report, NPS-OC-92-005.

Jessen, P.F., S.R. Ramp, C.A. Collins, N. Garfield, L.K. Rosenfeld, and F.B. Schwing, "Hydrographic and Acoustic Doppler Current Profiler (ADCP) Data From the Farallones Shelfand Slope Study," NPS Technical Report, NPS-OC-92-006.

Jessen, P.F., S.R. Ramp, C.A. Collins, N. Garfield, L.K. Rosenfeld, and F.B. Schwing, "Hydrographic and Acoustic Doppler Current Profiler (ADCP) Data From the Farallones Shelf and Slope Study," NPS Technical Report, NPS-OC-92-007.

Kinoshita, K., M. Noble, and S.R. Ramp, "The Farallones Moored Array Data Report," U.S. Geological Survey, Menlo Park, CA, 1992.

CONFERENCE PRESENTATIONS: Ramp, S.R., C.A. Collins, P.,F. Jessen, N. Garfield, K.A.S. Hays, L.K. Rosenfeld, and F.B. Schwing, "The Effects of the 1991-1992 ENSO Event on the Shelf and Slope Waters off Central California," presented at the 39th Annual EPOC Meeting, OR, October 1992.

Ramp, S.R., C.A. Collins, P.,F. Jessen, N. Garfield, K.A.S. Hays, L.K. Rosenfeld, and F.B. Schwing, "The Effects of the 1991-1992 ENSO Event on the Shelf and Slope Waters off Central California," American Geophysical Union Fall Meeting, San Francisco, CA, December 1992.

Noble, M. and S.R. Ramp, "Current Measurements over the Continental Slope Near the Farallon Islands, CA," American Geophysical Union Fall Meeting, San Francisco, CA, December 1992.

ENHANCEMENTS TO DEEP OCEANIC CONVECTION IN THE ARCTIC SYSTEM

R.W. Garwood, Jr., Professor
P.C. Chu, Associate Professor
Department of Oceanography
Sponsor and Funding: National Science Foundation

OBJECTIVE: This is a two-year program of research to explore the roles of turbulent mixing processes that have been neglected in traditional mixed layer modeling.

SUMMARY: Results include discovery of several important and new mechanisms for deep convection in oceans (e.g., symmetric instability, pressure-augmentation of the buoyancy flux), exploration of wind effect on the flexural-gravity wave, and development of a new concept of non buoyancy-conserving oceanic chimneys.

PUBLICATIONS: Chu, P.C., "Geophysics of Deep Convection and Deep Water Formation in Oceans," Elsevier Oceanography Series, 57, 3-15, 1991.

Chu, P.C., "Vertical cells Driven by Vortices - A possible Mechanism for the preconditioning of Open-Ocean Deep Convection," Elsevier Oceanography Series, 57, 267-281,

1991.

Chu, P.C., "Wind Effect on Flexural-Gravity Waves," *Atmospheric and Oceanic Waves and Stability*, 8, American Meteorological Society, 265-268, 1991.

Chu, P.C., "Symmetric Instability of Gulf Stream - A Mechanism for Exchange Between Deep and Shelf Waters," IAPSO P & A, 43, 1991.

Chu, P.C., "Low Frequency Acoustic Turbulence Attenuation and Eddy Viscosity Measurement," TOSSSM, The Oceanography Society, 33, 1991.

Chu, P.C., "Intrinsic Time-Scales of the Atmosphere-Ocean-Cryosphere Climate System," Global Change Studies, 4, in press, 1992.

Chu, P.C., "Three Dimensional Eastern Greenland Sea Circulation Computed from a CTD Data Set," *Ocean-Atmosphere-Ice Interaction*, 1, 61-64, 1992.

Chu, P.C. and Y.H. Kuo, "South Atlantic Three Dimensional Pseudovorticity Field Computed from Hydrographic and Surface Air Data Sets," *Southern Hemisphere Meteorology and Oceanography*, 4, in press, 1992.

CONFERENCE PRESENTATIONS: Chu, P.C., "Instability of Flexural-Gravity Waves," 8th Conference on Atmospheric and Oceanic Waves and Stability, American Meteorological Society, Denver, CO, 14-18 October 1991.

Chu, P.C., "Modeling of Deep Convection and Deep Water Formation in Oceans," American Geophysical Union Ocean Science Meeting, 27-31 January 1992.

Chu, P.C., "A New Mechanism Causing Deep Convection in Polar Oceans," Deep Convection Workshop, Sponsored by Office of Naval Research, San Francisco, CA, December 1992.

THESES DIRECTED: Li, W.S., "Three Dimensional Ocean Circulation in Eastern Greenland Sea," Master's Thesis, December 1992.

OTHER: Book Publication. Chu, P.C. and J.C. Gascard (ed), Deep Convection and Deep Water Formation in Oceans, (Elsevier Publishing Company, 1991).

STUDIES OF THE OCEANIC PLANETARY BOUNDARY LAYER

R.W. Garwood, Jr., Professor
P.C. Chu, Associate Professor
Department of Oceanography
Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: The scientific objective is to understand the thermodynamic and dynamic processes that couple the oceanic and atmospheric planetary boundary layers.

SUMMARY: The results include exploration of a positive feedback mechanism among ocean mixed layer, precipitation and cumulus clouds, establishment of a new ENSO theory, and discovery of incompatible wind and buoyancy forcing in ocean numerical models.

PUBLICATIONS: Chu, P.C. and R. W.

Garwood Jr., "On the Two-phase Thermodynamics of the Coupled Cloud-Ocean Mixed Layer," Proceedings of the American Meteorological Society, 96, 3425-3426, 1992.

Chu, P.C., "An Important Ocean Feature Overlooked in Current El Nino-Southern Oscillation Theories," *Global Change Studies*, 3, 52-59, (refereed by editor), 1992.

Chu, P.C., "Generation of Low-Frequency Unstable Modes in a Coupled Equatorial Troposphere and Ocean Mixed Layer Clouds," *Journal of Atmospheric Science*, in press.

Chu, P.C. and R.W. Garwood, Jr., "Effect of Cloud-Precipitation-Ocean Mixed Layer Feedback on Drag Coefficient," *Turbulence and Diffusion*, 10, 117-120, 1992.

Chu, P.C., "Intrinsic Time-Scales of the Atmosphere-Ocean-Cryosphere Climate System," *Global Change Studies*, 4, in press, 1992.

Chu, P.C. and Y.H. Kuo, "Incompatible Wind and Buoyancy Forcing in Ocean Numerical Models," *Advanced Atmospheric Science*, 10, in press, 1992.

CONFERENCE PRESENTATION: Chu, P.C., "Wind Effect on Flexural-Gravity Waves," 8th Conference on Atmospheric and Oceanic Waves and Stability, American Meteorological Society, Denver, CO, October 1991.

Chu, P.C., "An Air-Ocean Surface Heat Exchange Model," 5th Conference on Climate, American Meteorological Society, Denver, CO, October 1991.

Chu, P.C., "An Important Ocean Feature Overlooked in Current ENSO Theories, American Union Fall Meeting, San Francisco, CA, December 1991.

Chu, P.C., "A New Switch Theory for ENSO Phenomenon," American Meteorological Society Annual Meeting, Atlanta, GA, January 1992.

Chu, P.C. and R.W. Garwood, Jr., "Cloud-Precipitation-Ocean Mixed Layer Feedback," Tenth Symposium on Turbulence and Diffusion, Portland OR, 29 September - 2 October 1992.

THESES DIRECTED: Whitney, C., "Modeling the Tropical Ocean Response to Westerly Wind Forcing," Master's Thesis, 1992.

Crabtree, G.D., "Computer Simulation of Acoustic Fluctuations Due to Finescale Temperature Perturbations Measured by Thermistor Chain," Master's Thesis, 1992.

Yin, T.C., "Tests of a Convective Cloud Model with Soundings During the TCM-90 Field Experiment," Master's Thesis, 1992.

Steadley, S. "Thermodynamic Air-Ocean Feedback Mechanisms in the Equatorial Pacific," Master's Thesis, 1992.

LARGE-SCALE MEAN CONVERGENCE IN THE MIXED LAYER OF THE CANARY BASIN AS DETERMINED FROM LAGRANGIAN DRIFTERS

J.D. Paduan, Assistant Professor
Department of Oceanography
Sponsor and Funding: Office of Naval Research

OBJECTIVE: The objective of this project is to obtain statistically-reliable estimates of the mean surface currents and temperatures in the Subduction region of the northeast Atlantic Ocean and to use this information, gathered over two years, to describe the mean large-scale horizontal convergence near the surface (~15 m). We hope to be able to expose the relative importance of this large-scale frontal convergence as compared with more localized observations and to compare observed convergence with Ekman convergence estimates in order to partition it into wind-driven and non-wind-driven components.

SUMMARY: The approach being used is to make direct measurements of surface currents and temperatures using satellite- tracked Lagrangian drifters. The deployment pattern that is being used was designed to assess the importance of the semi-permanent oceanic front, which occurs south of the Azores Islands, in the north-to-south convergence over the larger Subduction region. Over the first field year, data from 29 drifters has been returned via the satellite telemetry link. Over forty drifters are scheduled for deployment in the second year. The deployment schedule seeks to spread out observations throughout the two field years, thereby providing the most statistically-significantdescription of the current regime. The most prominent result of the early data returns has been the predominance of mesoscale eddy motions around the Azores Front. Virtually no mean flow has been detected in the first 13 months of drifter data whereas eddy-like motions with strong but variable velocities are common. In addition to the statistical deployment mode, the final group of drifters will be deployed in a cooperative effort with the rench-sponsored SEMAPHORE Experiment. This process study will cover the region around the Azores Front with a minimum of 35 surface drifters plus subsurface floats and extensive ship-based measurements.

CONFERENCE PRESENTATIONS: Paduan, J.D., "Drifter Velocity and Temperature Data in the Canary Basin," Status Report of the Subduction Experiment, 5th Meeting, SVP Planning Committee, Hamilton, Bermuda, 6-8 April 1992.

Paduan, J.D., "Drifter Observations Before and During SEMAPHORE, Status Report of the SUBDUCTION Experiment," SEMAPHORE Drifting Buoy Planning Meeting, France, 9 October 1992.

LAGRANGIAN MEASUREMENTS EDDY CHARACTERISTICS IN THE CALIFORNIA CURRENT

J.D. Paduan, Assistant Professor
Department of Oceanography
Sponsor: Office of Naval Research
Funding: Office of Naval Research and NPS

OBJECTIVE: The objectives of this program are to describe the mesoscale eddy variability in the California Current System off the west coast of the United States and to relate that variability to narrow jet-like features in the current and to the mean current. The data sets to be collected are position and surface temperature following satellite-tracked surface drifters.

SUMMARY: This program is part of a larger coordinated effort to study the eddy field in an eastern boundary current sponsored by the Office of Naval Research. This program will deploy satellite-tracked surface drifters in two modes during the two-year field program: 1) in quarterly deployments of drifters along a line at 39.5°N latitude in an effort to obtain a statistical description of the current field downstream of that location and 2) as clusters of drifters within a single eddy to track the eddy and measure its deformation field (e.g. its divergence and vorticity). Deployments in the first, incoherent, mode will begin in April, 1993 and the first cluster deployment will take place in June, 1993. Efforts are underway to schedule volunteer aircraft deploy-ment of the drifters for both the incoherent and cluster modes. Such a use of aircraft, particular in the cluster mode, would be unique. It should provide the first truly synoptic observation of eddy movement.

LAGRANGIAN MEASUREMENTS OF SURFACE CURRENTS OFF THE CALIFORNIA COAST

J.D. Paduan, Assistant Professor
Department of Oceanography
Sponsor: Research Initiation Program
Funding: Naval Postgraduate School

OBJECTIVE: The objective of this program is to expose surface circulation patterns, including potential differences between upwelling and non-upwelling regimes, in and around Monterey Bay . A primary goal is to describe the flow of the upwelling plume offshore of Monterey Bay, including whether or not the plume actually enters the Bay from the north as is hypothesized and how water subsequently circulates within the outer portions of the Bay. Additional goals include the development and testing of a higher-accuracy drifter design for nearshore observations and the calibration and incorporation of remotely-sensed surface currents from HF radar installations around Monterey Bay.

SUMMARY: Under the general goal of studying the surface circulation in

Monterey Bay, this project is seeking to develop and evaluate two new technologies for nearshore ocean current measurements. Firstly, the project is sponsoring the construction of surface drifters with positioning capabilities of higher resolution than the existing satellite tracking technology provides. The new positioning will be accomplished using Global Positioning System (GPS) receivers. GPS is also a satellite-based positioning system but it is capable of an order of magnitude improvement in position accuracy over the present-day ARGOS system. It also is capable of providing positioning on regular time intervals with frequencies up to 1 HZ. This should be contrasted to the irregular data stream from the ARGOS system, which provides position data about once every two hours at the latitude of Monterey Bay. Other programs are attempting to incorporate GPS technology into small surface drifters. The difficulty is that, unlike the present-day ARGOS system, there is no communication link back to the satellites for data telemetry. This program is seeking to solve that problem for nearshore observations by relaying GPS data back to shore via line-of-sight VHF radio equipment using standardized packet radio communication protocols. For locations such as the west coast of the United States where coastal mountain ranges provide high elevations for receiving stations, such a technology combination, GPS and packet radio, should be a useful solution to the telemetry problem. At this time, one prototype GPS drifter has been constructed and is undergoing land and sea trials to establish the useful range of this system in the Monterey Bay area. The second technology issue being addressed under this program is the verification, calibration, and analysis of CODAR-derived surface currents. The ability to measure surface currents remotely using HF radar installations on the shore has been postulated for over twenty years but relatively few field verifications of this technology have taken place. Through the sponsorship of the National Oceanic and Atmospheric Administration (NOAA), three HF radars of the CODAR design have been installed around Monterey Bay. This program has already analyzed a continuous, three-month current record from CODAR and found that the remotely-sensed currents compare favorably with traditional moored observations for motions with periods greater than a week and for higher frequency tidal and diurnal-period motions. The results of this analysis appear in the thesis work by T.C. Neal. In addition to analyzing CODAR-derived currents as produced by the radars, this program is also working to verify and improve the radar processing by deploying multiple surface drifters and by conducting at-sea verification studies of the various radar antenna patterns. Both of these efforts are designed to expose errors in the radar processing and to suggest corrections to the radar algorithms.

MESOSCALE VARIABILITY IN WEAKLY NONLINEAR SYSTEMS
AN OFFICE OF NAVAL RESEARCH ACCELERATED RESEARCH INITIATIVE

Steven R. Ramp, Assistant Professor
Department of Oceanography
Robert L. Smith and P. Michael Kosro, Oregon State University
Sponsor: Office of Naval Research
Funding: Office of Naval Research and Naval Postgraduate School

OBJECTIVE: The objective this ARI is to study the energetics of the mesoscale eddy field in the California Current System and the exchanges of energy between this eddy field and the mean flow. Three coherent moored arrays (called local dynamics arrays or LDAs) with instrumentation concentrated in the upper 600 m will be deployed off the central California coast just south of Point Arena. The primary contribution of this investigator is to obtain and analyze data from the continental slope LDA in cooperation with Drs. R. L. Smith and P. M. Kosro of Oregon State University.

SUMMARY: The slope LDA was successfully deployed on a cruise aboard the research vessel POINT SUR during 9 - 16 June 1992. All moorings were equipped with dual acoustic releases and satellite locating devices which switch on and transmit their position if the mooring should accidentally surface for any reason. The instrumentation was concentrated at the 100, 150, 300, and 600 m levels with one additional current meter at 1800 m on the central mooring. A hydrographic survey of the region was also conducted during the cruise to delineate the spatial structure of any eddies that might have been present during deployment. The slope LDA will be recovered and redeployed in late May 1993, just prior to the main shipboard field program. An upward-looking acoustic Doppler current profiler (ADCP) will be added to each of the slope LDA moorings at this time to obtain a high-resolution profile of currents in the upper 150 m of the water column. Final recovery of the array will be in late May or June 1994.

This project is still in the data collection phase. The hydrographic survey and satellite AVHRR sea surface temperature imagery obtained since the deployment show an energetic eddy field in the moored array region at a variety of spatial scales. The site chosen for the array seems to have been a good one. Significant scientific results are anticipated as the program continues and the data are analyzed.

THE POINT SUR TRANSECT (POST) PROGRAM

Steven R. Ramp, Assistant Professor
Tim Tisch, Postdoctoral Investigator
Paul Jessen, Oceanographer
Todd Anderson, Oceanographer
Marla Stone, Oceanographer
Department of Oceanography
Sponsor and 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: Moorings have now been maintained off Point Sur in various configurations since May 1989. Mooring P2 on the 800 m isobath has been maintained continuously with Aanderaa RCM8 vector averaging current meters at 100 m, 350 m, 500 m, and sometimes 225 m depth. Three Master's theses were completed during 1991 using the data along the POST. A fourth thesis that describes the low-frequency alongshore variability off central California using the Point Sur moorings, two moorings off the Monterey Bay, and six moorings off the Farallones slope (LT Mike Hicks) was completed this year. Results from this thesis and LT Tisch's PhD dissertati are summarized below. Three tim ents were identified when the mc data from the various programs along the coast overlapped (Hicks, 1992). Temporal (EOF) and cross-spectral (coherence and phase) analysis was done on these segments to identify the dominant modes of variability. Segment 1 had data from off Point Sur and Point Piedras Blancas. This was the least interesting segment, dominated by steady poleward flow. Segment two had data from Point Sur and the Monterey Bay, and showed a strong, coherent signal at 29 days, propagating poleward. The signal did not fit any of the usual dispersion relations for coastally-trapped motions, likely due to the presence of the Monterey Canyon in between. Segment three had data from Point Sur, the Monterey Bay, and the Farallones slope, and was dominated by on and off-shore excursions of a strong meander / eddy of the California Current which is often observed near the mouth of the Monterey Bay. There is some evidence that this feature "blocks" the California Undercurrent during its onshore excursions, shutting off the subsurface poleward flow farther north off the Farallon Islands. The energy transfers in and near the California Undercurrent were examined (Tisch, 1992) by calculating terms in the eddy potential energy (EPE) equation as described by Niiler and Hall (1988) and Dewar and Bane (1989). At mooring P2, baroclinic instabilities within the water column were signaled by downgradient horizontal eddy heat fluxes that converted mean potential energy to EPE at both 225 and 425 m depth. The dominant balance at 225 m was between mean flow advection (source) and upward eddy heat fluxes (EPE to EKE) with additional losses coming from downstream advection by the eddy flow. At 425 m, the dominant balance was between downgradient eddy heat

fluxes (source) and downstream advection by the eddy flow (sink). Farther offshore at mooring P3, the net balance at 225 m was dominated by vertical processes. Analysis of energetic events within the time series of terms in the EPE equations did not reveal any canonical or common pattern which would explain the temporal means, but suggests instead that the flow in the region was highly variable.

PUBLICATION: Tisch, T.D., S.R. Ramp, and C.A. Collins, "Observations of the Geostrophic Current and Water Mass Characteristics off Point Sur, California from May 1988 through November 1989," *Journal of Geophysical Research*, 97, 12,535-12,555, 1992.

THESES DIRECTED: Tisch, T.D., "Assessing the Energetic Interactions of Subtidal Flow on the Continental Slope in an Eastern Boundary Region," PH.D Dissertation, 1992.

Hicks, M.R., "Alongshore Sub-Thermocline Variability in the Central California Current System," Master's Thesis, 1992.

SCIENTIFIC DEVELOPMENT OF A MASSIVELY PARALLEL OCEAN CLIMATE MODEL

Albert J. Semtner, Jr., Professor
Department of Oceanography
Sponsor: National Science Foundation
Funding: U.S. Department of Energy
(for the CHAMMP Program on Climate Research)

OBJECTIVE: The purpose of this project is to transition global ocean prediction models onto massively parallel computers.

SUMMARY: The funded research is moving an existing global eddy-resolving ocean model onto massively parallel computers, for climate studies related to CHAMMP. To guide the proper physical development of a comprehensive model, scientific study in three areas is being undertaken: (i) investigation of the physics of ocean heat transport; (ii) inclusion of near-surface oceanic processes relevant to climate ;and (iii) examination of resolution requirements for ocean climate modeling. The most important aspect of the research will be the demonstration of feasibility and scalability of a climatically sound global ocean model for performing multi-century integrations at a grid spacing as fine as 1/8 degree on massively parallel machines.

PUBLICATIONS: Semtner, A.J. and R.M. Chervin, "Including Eddies in Global Ocean Models," *Geophysics News*, American Geophysical Union, pp. 14-15, 1992.

Semtner, A.J.and R.M. Chervin, "Ocean Circulation from a Global Eddy Resolving Model," *Journal of Geophysical Research*, 97, pp. 5493-5550, 1992.

DEVELOPMENT OF A GLOBAL EDDY RESOLVING THERMODYNAMIC OCEAN MODEL

A.J. Semtner, Professor
Department of Oceanography
Sponsor and Funding: National Science Foundation

OBJECTIVE: The purpose of this project is to develop global ocean prediction models.

SUMMARY: Research is being funded to implement and test a free-surface formulation for the global eddy-resolving ocean model, in order to improve certain physical and numerical aspects of the calculation. Since very complicated geometries can be handled, the global ocean is being configured with fully realistic geometry, including the Arctic Basin and all marginal seas, at both 1/2 and 1/4 degree gridsizes. Prognostic integrations of the improved model are included, with simulations of 20 years and 5.0 years at the two gridsizes, respectively.

PUBLICATIONS: Semtner, A.J. and R.M. Chervin, "Including Eddies in Global Ocean Models," *Geophysics News*, American Geophysical Union, pp. 14-15, Washington, D.C., 1992.

Semtner, A.J.and R.M. Chervin, "Ocean Circulation from a Global Eddy Resolving Model," *Journal of Geophysical Research*, 97, pp. 5493-5550, 1992.

THESIS DIRECTED: Gordon, L., LCDR, USN, "Analysis of Tropical Pacific Ocean Using Global Ocean Model," Master's Thesis, October 1992.

COHERENT ACOUSTIC SEDIMENT-FLUX PROBE (CASP FOR MEASURING SUSPENDED) AND BEDLOAD SEDIMENT TRANSPORT

Timothy P. Stanton, Associate Research Professor
Edward B. Thornton, Professor
Department of Oceanography
Sponsor: U.S. Army Waterways Experiment Station
Funding: U.S. Army Corps of Engineers

OBJECTIVE: Develop a sediment flux meter to measure both suspended and bedload transport.

SUMMARY: The basis of the instrument is an already field deployed coherent acoustic doppler velocity meter operating at 5 MHz in both monostatic and bistatic modes, which noninvasively measures all three components of velocity at 4mm resolution, with a 44 Hz response and a 75 db dynamic range. Sediment concentration will be inferred by range gating the 3, 5 MHz acoustic beams, plus an additional 1 MHz beam; the two acoustic frequencies will allow sediment size discrimination. The combined 3 components of velocity and sediment concentration allows calculating sediment flux. Prototype electronic and mechanical systems are being designed, built and assembled. Initial field tests are planned for September 1993.

THE TURBULENT STRUCTURE OF EVOLVING ARCTIC LEADS

T.P. Stanton, Associate Research Professor
Department of Oceanography
Sponsor: Office of Naval Research
Funding: Office of Naval Research and Naval Postgraduate School

OBJECTIVE: The goal of this research program is to define the dynamics controlling turbulent fluxes in the ocean mixed layer as arctic leads refreeze.

SUMMARY: A four week field program during March and April 1992 provided an opportunity to measure continuous profiles of microstructure-resolving temperature, salinity, velocity shear and acoustic backscatter at the down-current side of four fresh arctic leads. Simultaneous quantitive video timelapse records of the lead surface structure were recorded at each site.

Over 1000 continuous timeseries profiles were recorded with our automated profiling system providing a unique record of the mean and turbulent structure over a range of lead sizes and forcing conditions.

The large data processing task on the 80 Gigabytes of raw data has been completed, and analyses of the dissipation and very high resolution is in progress. A paper describing the unexpected reversal of mixed layer heat fluxes by solar radiation has been submitted. Two further collaborative papers describing the changes in turbulence characteristics of the ocean boundary layer and their relationship to ice formation and deformation events are being written. Several data sets are being prepared for contribution to the LEADEX database.

CONFERENCE PRESENTATION: Stanton, T.P., "Effects of Solar Heating on the Turbulent Boundary Layer Under an Arctic Lead," EOS Transactions, p. 285, American Geophysical Union Fall Meeting, San Francisco, CA, December 1992.

NEARSHORE WAVE PROCESSES

Edward B. Thornton, Professor
Department of Oceanography
Sponsor: Office of Naval Research
Funding: Office of Naval Research and Naval Postgraduate School

OBJECTIVE: The long-term goals are to predict the wave-induced three-dimensional velocity field and induced sediment transport over arbitrary bathymetry in the near shore.

SUMMARY: Using field data from the 1986 SUPERDUCK experiment (a barred beach) and the 1980 NSTS experiment (a plane beach), the model for shear instability of longshore currents by Bowen and Holman (1989) was extended to include the effects of dissipation in the form of bottom friction. Observed frequency-cyclic wavenumber (f-k) spectra were examined and compared with theoretical predictions. Good qualitative agreement between observation and theory was found at SUPERDUCK, where these motions dominate the observed

f-k spectra and where theoretical growth rates of the temporal instability tend to be large. This comparison supports the shear instability hypothesis. Results from NSTS are less conclusive. It is suggested that shear instabilities may be a more common feature on barred beaches.

Abreu, Larraza, and Thornton (1991) developed a shallow water, nonlinear spectral wave transformation model for conditions of a mild sloping bottom and small amplitude waves. Nonlinearities and combined shoaling and refraction effects act on the same time and length scales. The evolution equation of the wave action is prescribed by the wave Boltzmann equation, whereby resonant collinear triad interactions transfer energy among Fourier components. A numerical solution of the three wave collision integral is developed, and the steady state wave Boltzmann equation integrated using a piecewise ray method. Good comparisons are obtained with the high-resolution frequency-directional wave measurements by Freilich, Guza and Elgar (1990).

PUBLICATIONS: Marom, M., L. Shemer,, and E.B. Thornton, "Energy Density Directional Spectra of Nearshore Wave Field Measure by Interferometric Synthetic Aperture Radar," *Journal of Geophysical Research*, 96(C12), 22, pp.125-22, 134, 1991.

Dodd, N., J. Oltman-Shay, and E.B. Thornton, "Instabilities of Longshore Current: Comparison of Observation and Theory," *Journal of Physical Oceanography*, 22(1), pp. 62-82, 1992.

Abreu, M., A. Larraza, and E. Thronton, "Nonlinear Transformation of Directional Wave Spectra in Shallow Water," *Journal of Geophysical Research*, 97(C10), 15, pp.15,579-15,589, 1992.

Whitford, D.J. and E.B. Thornton, "Comparison of Wind and Wave Forcing of Longshore Currents," Accepted November 1992, *Journal of Continental Shelf Research*, 1992.

Church, J.C. and E.B. Thronton, "Effects of Breaking Wave Induced Turbulence Within a Longshore Current Model," Accepted November 1992, *Journal of Coastal Engineering*, 1992.

Thornton, E.B. and J.C. Church, "Modeling Strong Longshore Currents During DELILAH," Proceedings of the 23rd Coastal Engineering Conference, American Society of Civil Engineers, 1992.

Church, J.C., E.B. Thornton, and J. Oltman-Shay, "Mixing by Shear Instabilities of the Longshore Current," Proceedings of the 23rd Coastal Engineering Conference, American Society of Civil Engineers, 1992.

Kim, C.S. and E.B. Thornton, "Tidal Modulation of Longshore Currents," Proceedings of the 23rd Coastal Engineering Conference, American Society of Civil Engineers, 1992.

Dodd, N. and E.B. Thronton, "Longshore Current Instabilities: Growth to Finite Amplitude," Proceedings of the 23rd Coastal Engineering Conference, American Society of Civil Engineers, 1992.

CONFERENCE PRESENTATIONS: Thornton, E.B., ""Modeling Strong Longshore Currents During DELILAH," International Conference on Coastal Engineering, Venice, Italy, 4-10 October 1992.

Church, J.C., E.B. Thornton, and J.

Oltman-Shay, "Mixing by Shear Instabilities of the Longshore Current," International Conference on Coastal Engineering, Venice, Italy, 4-10 October 1992.

Kim, C.S. and E.B. Thornton, "Tidal Modulation of Longshore Currents," International Conference on Coastal Engineering, Venice, Italy, 4-10 October 1992.

Dodd, N. and E.B. Thornton, "Longshore Current Instabilities: Growth to Finite Amplitude," International Conference on Coastal Engineering, Venice, Italy, 4-10 October 1992.

Thornton, E.B., "Near Shore Process Studies: Past, Present, and Future," Invited talk, Portugese Hydrographic Institute, 13 October 1992.

Humiston, R. and E.B. Thornton, "Cross-shore Transport During DELILAH," American Geophysical Union Fall Meeting, San Francisco, CA, December 1992.

Thornton, E.B. and J.C. Church, "Set-up/down During DELILAH," American Geophysical Union Fall meeting, San Francisco, CA, December 1992.

Oltman-Shay, J., P.A. Howd, R.A. Holman, R.T. Guza and E.B. Thornton, "Evidence of High Mode Igragravity Edge Waves in the Nearshore," American Geophysical Union Fall Meeting, San Francisco, CA, December 1992.

Lippman, T., R.A. Holman, and E.B. Thornton, "Wave Breaking in the Trough of a Natural Sand Bar," American Geophysical Union Fall Meeting, San Francisco, CA, December 1992.

DEPARTMENT OF OCEANOGRAPHY

1992
Faculty Publications and Presentations

TECHNICAL REPORTS

Collins, C.A., Coastal Oceanography, p. F-1 in "Impact of the Environment on Coastal Warfare Symposium," NRL Technical Report, NRL/PU/7543-92-002, 1992.

Jessen, P.F., S.R. Ramp, C.A. Collins, N. Garfield, L.K. Rosenfeld, and F.B. Schwing, "Hydrographic and Acoustic Doppler Current Profiler (ADCP) Data from the Farallones Shelf and Slope Study," 13-18 February 1991. NPS Technical Report, NPS-OC-92-003, 1992.

Jessen, P.F., S.R. Ramp, C.A. Collins, N. Garfield, L.K. Rosenfeld and F.B. Schwing, "Hydrographic and Acoustic Doppler Current Profiler (ADCP) Data from the Farallones Shelf and Slope Study," 16-21 May 1991, NPS Technical Report, NPS-OC-92-004, 1992.

Jessen, P.F., S.R. Ramp, C.A. Collins, N. Garfield, L.K. Rosenfeld, and F.B. Schwing, "Hydrographic and Acoustic Doppler Current Profiler (ADCP) Data from the Farallones Shelf and Slope Study, 29 October-3 November 1991, NPS Technical Report, NPS-OC-92-007, 1992.

Jessen, P.F., S.R. Ramp, C.A. Collins, N. Garfield, L.K. Rosenfeld and F.B. Schwing, "Hydrographic and Acoustic Doppler Current Profiler (ADCP) Data from the Farallones Shelf and Slope Study, 7-17 February 1991, NPS Technical Report, NPS-OC-92-005, 1992.

Jessen, P.F., S.R. Ramp, C.A. Collins, N. Garfield, L.K. Rosenfeld and F.B. Schwing, "Hydrographic and Acoustic Doppler Current Profiler (ADCP) Data from the Farallones Shelf and Slope Study, 12-18 August 1991, NPS Technical Report, NPS-OC-92-006, 1992.

Kinoshita, K., "Current Patterns Over the Shelf and Slope Adjacent to the Gulf of the Farallones," Executive Summary, Final Report to the U.S. Environmental Protection Agency, U.S Geological Survey, Menlo Park, CA, 1992.

Kinoshita, K., and Noble, M., "The Farallones Moored Array Data Report to the U.S Geological Survey, Menlo Park, CA, 1992.

Noble, M., Ramp, S.R., "Current Patterns Over the Shelf and Slope Adjacent to the Gulf of the Farallones," Executive Summary, Final Report to the U.S. Environmental Protection Agency, U.S Geological Survey, Menlo Park, 1992.

Rago, T.A., "Hydrographic Data From the Pegasus in the Sea of Cortes Area Cruise," (PESCAR-01), NPS Technical Report, NPS-OC-92-009, 1992.

Ramp S.R., "The Farallones Moored Array Data," Final Report to the U.S Geological Survey, Menlo Park, CA, 1992.

Ramp, S.R., N. Garfield, C.A. Collins, L.K. Rosenfeld, and F. Schwing, "Circulation Studies Over the Continental Shelf and Slope Near the Farallon Islands, California," Executive Summary, Final Report to the U.S. Environmental Protection Agency, NPS Technical Report, 1992.

JOURNAL ARTICLES

Abreu, M., A. Larraza and E. B. Thornton, "Nonlinear Transformation of Directional Wave Spectra in Shallow Water, *Journal of Geophysical Research*, 97 (C10), 15,579-15589, 1992.

Batteen, M.L., C.N. Lopes da Costa, and C.S. Nelson, "A Numerical Study of Wind Stress Curl Effects on Eddies and Filaments off the Northwest Coast of the Iberian Peninsula," *Journal of Marine Systems*, Vol. 3, 249-266, 1992.

Batteen, M.L., M.J. Rutherford, and E.J. Bayler, "A Numerical Study of Wind and Thermal-Forcing Effects on the Ocean Circulation off Western Australia," *Journal of Physical Oceanography*, Vol. 22, pp. 1406-1433, 1992.

Bourke, R.H. and A.S. McLaren, "Contour Mapping of Arctic Basin Ice Draft and Roughness Parameters," *Journal of Geophysical Research*, 97(C11), 17,715-17,728, 1992.

Bourke, R.H., R.G. Paquette and R.F. Blythe, "The Jan Mayen Current of the Greenland Sea," *Journal of Geophysical Research*, 97(C5), 7241-7250, 1992.

Church, J.C. and E.B. Thornton, "Effects of Breaking Wave Induced Turbulence within a Longshore Current Model", Accepted November 1992, *Journal of Coastal Engineering*, 1992.

Collins, C.A., "A Tribute to Henry Stommel," *Oceanus 35*, (special issue), 1992.

Dodd, N., J. Oltman-Shay, and E. B. Thornton, "Instabilities of Longshore Current: Comparison of Observation and Theory," *Journal of Physical Oceanography* 22(1), 62-82, 1992.

Garwood, R.W., "Oceanic Convective Instabilities Hypothesized," *ARCSS-OAII* Newsletter, Vol. 2, Number 1, pp 4-5, 1992.

Manley, T.O., R.H. Bourke and K.L. Hunkins, "Near-Surface Circulation Over the Yermak Plateau in Northern Fram Strait," *Journal of Maritime Systems*, 3, 107-125, 1992.

Marom, M., L. Shemer and E.B. Thornton "Energy Density Directional Spectra of Nearshore Wave Field Measured by Interferometric Synthetic Aperture Radar," Journal of Geophysical Research, 96(C12), 22. pp. 125-22, 134, 1991.

Newton, J.L., R.H. Bourke and A.J. Goghan, "Modeling Acoustic Propagation Over the Ice-Covered Greenland Continental Shelf and Slope (U)," *U.S. Navy Journal of Underwater Acoustics*, 42(4), 1167-1197, 1992. (SECRET)

Tisch, T.D., "Observations of the Geostrophic Currents and Water Mass Characteristics off Point Sur, CA, from May 1988 through November 1989," *Journal of Geophysical Research*, 97 (C8): 12535-12555, 1992.

Tisch, T. D., S. R. Ramp, and C. A. Collins, "Observations of the Geostrophic Current and Water Mass Characteristics off Point Sur, California from May 1988 to November 1989," *Journal of Geophysical Research*, 97, 12,535-12,555, 1992.

Semtner, A.J., and R.M. Chervin, "Ocean General Circulation from a Global Eddy Resolving Model," *Journal of Geophysical Research*, 97, pp. 5493-5550, 1992.

Whitford, D. J. and E. B. Thornton, "Comparison of Wind and Wave Forcing of Longshore Currents", Accepted November 1992, *Journal of Continental Shelf Research*, 1992.

CONFERENCE PUBLICATIONS

Batteen, M.L., R.P. Mitchell, P.T. Tsai, and C.S. Nelson, "Process-oriented Modeling Studies of Wind Forcing Effects on West Coast Ocean Circulations," American Geophysical Union, December 1992, Abstract published in Transactions of the American Geophysical Union, Vol. 73, p. 75, October 1992.

Chu, P.C., "An Important Ocean Feature Overlooked in Current El Nino-Southern Oscillation Theories," Global Change Studies, 3, 52-59, 1992.

Chu, P.C., "Three Dimensional Pseudovorticity Field in the West Spitsbergen Current," Polar Meteorology and Oceanography, 3, 101-104, 1992.

Chu, P.C. and R.W. Garwood, Jr., "Effect of Cloud-precipitation-ocean Mixed Layer Feedback on Drag Coefficient," Turbulence & Diffusion, 10, 117-120, 1992.

Chu, P.C., "Three Dimensional Eastern Greenland Sea Circulation Computed from a CTD Data Set," Ocean-Atmosphere-Ice Interactions, 1, 61-64, 1992.

Chu, P.C., S. Konstandindinis, P. Jessen, and C.A. Collins, "C-vector Method Derived Three Dimensional Circulation in Farallone National Sanctuary," EOS Supplement, 89, 1992.

Chu, P.C., "On the Two-phase Thermodynamics of the Coupled Cloud-ocean Mixed Layer," Proceedings of the American Meteorological Society Annual Meeting, 96, 3425-3426, 1992.

Clynch, J.R., G. Thurmond, L. Rosenfeld, and R. Schramm, "Error Characteristics of GPS Differential Positions and Velocities," Proceedings ION GPS-92, Albuquerque NM, 16-18 September 1992 .

Clynch, J.R., G.Thurmond, L.K. Rosenfeld, and R. Schramm, "Error Characteristics of GPS Differential Positions and Velocities," Fifth International Technical Meeting of the Satellite Division of the Institute of Navigation, September 1992.

Garwood, R. W., "Missing Physics for Deep Convection?," Artic System Science Ocean-Atmosphere-Ice Interactions Modeling Workshop Proceedings, Pacific Grove, CA, pp.49-54, 1992.

Garwood, R.W., "On the Two-phase Thermodynamics of the Coupled Cloud-ocean Mixed Layer, Proceedings of the American Meteorological Society Annual Meeting, 96, 3425-3426, 1992.

Kwak,S.H., J.B. McKeon, J.R. Clynch, and R.B. McGhee, "Incorporation of Global Positioning System into Autonomous Underwater Vehicle Navigation", Proceedings, IEEE Autonomous Underwater Vehicle Technology Symposium, Washington DC, 2-3 June 1992

Malys, S., D. Bredhauer, B. Hermann, and J.R. Clynch, "Geodetic Point Positioning with GPS: A Comparative Evaluation of Methods and Results", Proceedings 6th International Geodetic Symposium on Satellite Positioning, Columbus OH, March 1992.

McLaren, A.S., J.E. Walsh, R.H. Bourke, R.L. Weaver and W. Wittmann, "Variability in Sea-Ice Thickness Over the North Pole from 1977 to 1990," Nature, 358, 224-226, 1992.

Mitchell, R.P., M.L. Batteen and P.T. Tsai, "Visualization of Process-oriented Modeling Studies of Wind Forcing Effects on West Coast Ocean Circulations, American Geopysical Union, December 1992, Abstract published in Transactions of the American Geophysical Union, Vol. 73, p. 75, October 1992.

Paduan, J.D., and T.C. Neal, "Evaluation of remotely-sensed surface currents in Monterey Bay from Coastal Ocean Dynamics Applications Radar (CODAR). EOS, Transactions, American Geophysical Union, 73 supp., p. 315, Presented San Francisco, CA, 7-11 December, 1992.

Rosenfeld, L.K., M.A. Noble, S.R. Ramp, C.A. Collins, N. Garfield, and F.B. Schwing, "Direct Measurements of the Poleward Undercurrrent Off the Gulf of the Farallones," EOS Trans, AGU. 73, 315, Presented at the American Geophysical Union Conference , San Francisco, CA, December 1992.

Semtner, A.J., and R.M. Chervin, "Including Eddies in Global Ocean Models," Geophysics News (1992), American Geophysical Union, Washington, DC, pp. 14-15.

Tisch, T., S. Ramp. R. Haney, C. Collins, and M. Batteen, 1992: "Assessing the Energetic Interactions of Subtidal Flow on the Continental Slope off Point Sur, California from Moored Current Meter Measurements," Eastern Pacific Ocean Conference (EPOC), Published in Abstracts from the Eastern Pacific Ocean Conference, p. 10, October 1992.

CONFERENCE PRESENTATIONS

Batteen, M.L., R.P. Mitchell, P.T. Tsai, and C.S. Nelson, "Process-oriented Modeling Studies of Wind Forcing Effects on West Coast Ocean Circulations," American Geophysical Union, December 1992, Abstract published in Transactions of the American Geophysical Union, Vol. 73, p. 75, October 1992.

Bourke, R.H., C.S. Chiu, J.F. Lynch, etc., "Initial Results From the Barents Sea Polar Front Experiment," 1992 Fall Meeting, American Geophysical Union, San Francisco, December 1992. Abstract in: EOS, Transactions of American Geophysical Union, 73(43), 389, October 1992.

Carter, E., "Hydrography of the California Undercurrent from CTDs," American Geophysical Union Fall Meeting, San Francisco, CA, December, 1992.

Chu, P.C., S. Konstantinidis, P. Jessen, C. A. Collins, "C-Vector Method Derived Three-dimensional Circulation in the Farallones National Marine Sanctuary," Fall National Meeting, American Geophysical Union, San Francisco, December 1992.

Chu, P.C., "A New Switch Theory for El Nino and Southern Oscillation," The American Meteorological Society Annual Meeting, Atlanta, GA, 5-10 January 1992.

Chu, P.C., "Modeling of Deep Convection and Deep Water Formation in Oceans," The American Geophysical Union Ocean Science Meeting, New Orlean, LA, 27-31 January 1992.

Chu, P.C. and R.W. Garwood,Jr., "Cloud-precipitation-ocean Mixed Layer Feedback," Tenth Symposium on Turbulence and Diffusion, American Meteorological Society, Portland, OR, 29 September - 2 October 1992.

Chu, P.C., "Three Dimensional Circulation in Western Spitsbergen Coast," Third Conference on Polar Meteorology & Oceanography, American Meteorological Society, Portland, OR, 29 September - 2 October 1992.

Chu, P.C., and R.W. Garwood, Jr., "Cloud-precipitation-ocean Mixed Layer and Drag Coefficient," Third Conference on Polar Meteorology & Oceanography, American Meteorological Society, Portland, OR, 29 September - 2 October 1992.

Chu, P.C., S. Konstandinidis, P. Jessen, and C.A. Collins, "C-vector Method Derived Three Dimesional Circulation in Farallone National Sanctuary," American Geophysical Union Fall Meeting, San Francisco, CA, 7-11 December 1992.

Chu, P.C., "A Thermodynamic Theory for ENSO Phenomenon," Fourth International Summer Colloquium on "Climate and Environment Studies & Geophysical Fluid Dynamics," Beijing, China, 20-29 July 1992.

Chu, P.C., "A New Mechanism Causing Deep Convection in Polar Oceans," Deep Convection Workshop, sponsored by the Office of Naval Research, San Francisco, CA, 12 December 1992.

Chu, P.C., "On the Two-phase Thermodynamics of the Coupled Cloud-ocean Mixed Layer, Proceedings of the American Meteorological Society, 96, 3425-3426, 1992.

Church,J.C., E.B. Thornton and J. Oltman-Shay, "Mixing by Shear Instabilities of the Longshore Current," International Conference on Coastal Engineering, Venice, Italy, 4-10 October 1992.

Collins, Curtis A., Newell Garfield, and Everett Carter, "California Undercurrent Investigations at the Naval Postgraduate School: New Meanders for the 90's," Joint CalCOFI and Eastern Pacific Oceanic Conference, Lake Arrowhead, CA, October 1991.

Collins, C., "Hydrography of the California Undercurrent from CTDs," American Geophysical Union Fall Meeting, San Francisco, CA, December, 1992.

Collins, C.A., "Coastal Oceanography," Impact of the Environment on Coastal Warfare Symposium, Monterey, June 1992.

Collins, C.A., and E. Carter, "Hydrography of the California Undercurrent," Fall National Meeting, American Geophysical Union, San Francisco, CA, December, 1992.

Dodd, N. and E.B. Thornton, "Longshsore Current Instabilities: Growth to Finite Amplitude," International Conference on Coastal Engineering, Venice, Italy, 4-10 October 1992.

Garfield, N., F. B. Schwing, S.R. Ramp, C. A. Collins, P.F. Jessen, T. A. Rago, L.K. Rosenfeld, "Gulf of Farallones Hydrography: Upper Layer Water Mass Seasonal Variability," Fall National Meeting, American Geophysical Union, San Francisco, CA, December 1992.

Garfield, Newell, Thomas A. Rago, and Curtis A. Collins, "Movement of Bottom Deployed Instruments in Monterey Bay Canyon During the 17 October Loma Prieta Earthquake," American Geophysical Union Fall Meeting, San Francisco, CA., December 1991.

Garwood, R.W., "On the Two-phase Thermodynamics of the Coupled Cloud-ocean Mixed Layer," Proceedings of the American Meteorological Society, 96, 3425-3426, 1992.

Humiston, R. and E.B. Thornton, "Cross-shore Transport During DELILAH", Fall Meeting, American Geophysical Union, San Francisco, CA, 7-10 December 1992.

Kim, C.S. and E.B. Thornton, "Tidal Modulation of Longshore Currents," International Conference on Coastal Engineering, Italy, 4-10 October 1992.

Lippmann, T. and R.A. Holman and E.B. Thornton, "Wave Breaking in the Trough of a Natural Sand Bar", Fall Mtg., American Geophysical Union, San Francisco, CA, 7-10 December 1992.

Mitchell, R.P., M.L. Batteen and P.T. Tsai, "Visualization of Process-oriented Modeling Studies of Wind Forcing Effects on West Coast Ocean Circulations," American Geopysical Union, December 1992, audience of 100 people. Abstract published in Transactions of the American Geophysical Union, Vol. 73, p. 75, October 1992.

Paduan, J.D., and T.C. Neal, "Evaluation of Remotely-sensed Surface Currents in Monterey Bay from Coastal Ocean Dynamics Applications Radar (CODAR)," 39th Eastern Pacific Ocean Conference, Mt. Hood, Oregon, 21-23 October, 1992.

Paduan, J.D., and T.C. Neal, "Evaluation of Remotely-sensed Surface Currents in Monterey Bay from Coastal Ocean Dynamics Applications Radar (CODAR)," EOS, Transactions, American Geophysical Union, 73 supp., p315. Presented San Francisco, CA, 7-11 December, 1992.

Paduan, J.D., "Drifter Velocity and Temperature Data in the Canary Basin, Status Report of the SUBDUCTION Experiment," 5th Meeting, SVP Planning Committee, Hamilton, Bermuda, 6-8 April 1992.

Rago, T.A., N. Garfield, C.A. Collins, "Measurements of Ocean Currents across the Continental Margin off Pt. Sur, California, from April 1989 through April 1991," Fall National Meeting, American Geophysical Union, San Francisco, CA, December 1992.

Ramp, S.R., C.A. Collins, P.F. Jessen, N.Garfield, K.A.S. Hays, L.K. Rosenfeld, F.B. Schwing, "The Effects of the 1991-1992 ENSO Event on the Shelf and Slope Waters off Central California," Fall National Meeting, American Geophysical Union, San Francisco, CA, December 1992.

Ramp, S.R., "The Effects of the 1991-92 ENSO Event on the Shelf and Slope Waters Off Central California," Presented at the 39th Annual EPOC Meeting, Mt. Hood, OR, October 1992.

Ramp, S.R., "The Effects of the 1991-92 ENSO Event on the Shelf and Slope Waters Off Central California," Presented at the Fall Meeting of the American Geophysical Union, San Francisco,CA, December 1992. About 50 people attended.

Ramp, S.R.,"Current Measurements Over the Continental Slope Near the Farallon Islands, California," by M. Noble, and S. R. Ramp, presented by S. R. Ramp, at the Annual Fall Meeting of the American Geophysical Union, San Francisco, CA, December 1992.

Rosenfeld, L.K., M.A. Noble, S.R. Ramp, C.A. Collins, N. Garfield, F.B. Schwing, "Direct Measurements of the Poleward Undercurrent off the Gulf of the Farallones," Fall National Meeting, American Geophysical Union, San Francisco, December 1992.

Rosenfeld, L.K., M.A. Noble, S.R. Ramp, C.A. Collins, N. Garfield, and F.B. Schwing, "Direct Measurements of the Poleward Undercurrrent off the Gulf of the Farallones," EOS Transactions, AGU. 73, 315, Presented at the American Geophysical Union Annual Meeting, San Francisco, CA, December 1992.

Schwing, F.B., N. Garfield, C.A. Collins, S.R. Ramp, L.K. Rosenfeld, "Persistence and Seasonality in Shelf and Slope Circulation Near the Gulf of the Farallones as Deduced from ADCP and Hydrographic Surveys," Fall National Meeting, American Geophysical Meeting, San Francisco, CA, December 1992.

Shay, J., P.A. Howd, R.A. Holman, R.T. Guza and E.B. Thornton, "Evidence of High Mode Ingragravity Edge Waves in the Nearshore," Fall Meeting American Geophysical Union, San Francisco, CA, 7-10 December 1992.

Thornton, E.B., and J.C. Church, "Modeling Strong Longshore Currents During DELILAH," International Conference on Coastal Engineering, Venice, Italy, 4-10 October 1992.

Thornton, E.B., "Near Shore Process Studies: Past, Present and Future," Portugese Hydrographic Institute, 13 October 1992.

Thornton, E.B., "Nearshore Processes: Past, Present and Future", Invited talk to the Marine Technology Society Meeting, Monterey Bay Section, 28 January 1992.

Thornton, E.B., J.C. Church, "Set-up/down During DELILAH", Fall Meeting American Geophysical Union, San Francisco, CA, 7-10 December 1992.

Tisch, T., S. Ramp. R. Haney, C. Collins, and M. Batteen, "Assessing the Energetic Interactions of Subtidal Flow on the Continental Slope off Point Sur, California from Moored Current Meter Measurements," Eastern Pacific Ocean Conference (EPOC), October 1992.

WORKSHOP PRESENTATION

Chu, P.C., "C-vector Method and its Applications," Arctic System Science Workshop (sponsored by the National Science Foundation) Pacific Grove, CA, 13-17 July 1992.

DEPARTMENT OF OPERATIONS RESEARCH

Professor P. Purdue
Chairman



DEPARTMENT OF OPERATIONS RESEARCH

Operations Research (OR) was born of military necessity during WWII, when it was realized that the processes of war were amenable to scientific study. OR involves the use of mathematical and scientific methods to guide operational decision making and planning. Our research program in OR is concerned with developing new methodologies to handle ever more complex systems, and with the application of this methodology to the study of military and related problems. We have a very active research program that covers a wide methodological spectrum with sponsorship by the U.s. Navy, U.s. Army, U.S. Air Force, JCS, NSA, ONR, and AFOSR. An important role for NPS and its research programs is to serve as a medium for communications between academic, military and civilian researchers, and the operational needs of the military services. In support of this, the OR faculty has developed strong links with research workers in academia, government, and the private sector, while maintaining and developing essential contacts at the Fleet level.

Our faculty and their students are active in a number of different areas, including large-scale optimization, modeling and simulation, statistics and data analysis, decision processes, combat models, including, in almost all cases, the application of their results to operational issues. While it is essential that our efforts be rooted in problems of interest of the military, it is equally important that we contribute to the development of new, basic results in our field and publish this work in the standard OR literature. Hence, the results of our efforts appear in the form of student theses and dissertations, technical reports and letters to sponsors, conference proceedings, and refereed journal papers.

This report contains research summaries submitted by department faculty for calendar year 1992; summaries of projects done outside the Department appear elsewhere. This report does not include summaries of any classified projects. Here is a brief review of a sampling of the research summaries, broken down by applications area (Summaries are listed by authors).

NAVAL WARFARE/SUPPORT ACTIVITIES

Professor Hughes examined the relationship between staying power and fire power as it relates to warships subjected to missile attacks, using a simple salvo model. **Professors Dell and Lawphongpanich** showed how underway replenishment of carrier groups could be improved using a dynamic programming approach. **Professors Schrady and Wadsworth** continue to develop their tactical decision aide "Battle Group Logistics Support System" to integrate it into standard Navy C2 systems. **Professors Bailey, Whitaker, and Sohn** developed a series of analytical and simulation results pertaining to reliability requirements for naval gunfire support missions. **Professors Gaver and Jacobs** developed an aircraft readiness degradation forecasting methodology, and

continued their investigation of OR applications to Navy OT and E problems. Driven by the problems of ever decreasing budgets, **Professors Lawphongpanich and Rosenthal** developed optimization models for locating Navy (and Army) recruiting stations.

ARMY AND FORCE PROBLEMS

Professors Bradley, Brown and Wood continue a longstanding and very successful program to develop theory and algorithms for solving large-scale USAF (and USN) optimization problems. Another focus area for this group was the development of optimization and game-theoretic models and algorithms to solve network interdiction problems in support of the U.S. Army's attempts to optimize the allocation of assets to the interdiction of illegal drugs and precursor chemicals in South America. **Professors Dell, Parry and Rosenthal** developed a model that generates realignment and closure recommendations for U.S. Army and maneuver and training installations. As part of a continuing effort to develop a stochastic, hierarchical model of theater combat, **Professors Gaver, Jacobs and Parry** developed a new model for ground combat that incorporates the effects of the C3I system. Environmental issues are of growing concern to all services. In support of Navy and Army environmental programs, **Professors Gaver and Jacobs** have initiated mathematical and statistical work to provide quantitative, data-based assessments of toxicological phenomena. **Professor Dell**, et. al. have begun a series of optimization and statistical studies in support of the U.S. Army Recruiting Command.

MODELING AND SIMULATION

Almost all of the Department's research projects involve modeling and simulation to some degree; **here we will a mention just a few. Professor Kemple, et. al.** have initiated a program aimed at developing a taxonomy of models and model fidelity to facilitate off-the-shelf use of simulation models. **Professor Gaver et. al.** developed probabilistic models for evaluating routing and congestion control procedures in multi-type broad-based networks. **Professor Kemple** developed a model for the fusion geological data extracted from rock strata. **Professor Sohn** showed how we can use a random effects Poisson regression model in performing a risk assessment of a electric power system.

RELIABILITY REQUIREMENTS FOR COMPONENTS OF MAJOR CALIBER AMMUNITION

Michael P. Bailey, Assistant Professor
Lyn R. Whitaker, Associate Professor
So Young Sohn, Associate Professor
Department of Operations Research
Sponsor and Funding: Naval Weapons Support Center, Crane Division

OBJECTIVE: Multiyear project dealing with the required reliability of components of major caliber ammunition, the goal being a prescribed level of mission effectiveness for naval gunfire support.

SUMMARY: Analytic and simulation based results have been obtained, and the method has been extended so that it is useful in determining whether stockpiled ammunition should be reworked. This year's objectives included resolving implementation problems as well as fostering confidence in the major caliber ammunition community in the methods used.

PUBLICATIONS: Bailey, M., K. Kang, M. Bartoli, and A. Callahan, "Reliability Goals for components of Major Caliber Ammunition," *Naval Research Reviews*, 39, (7), pp. 788-792, 1992.

Whitaker, L. and M. Bailey, "Pyrotechnic Device Reliability," NPS Technical Report, NPS-OR-92-005.

Sohn, S.Y., "An Application of Growth Curve Analysis to Ammunition Stockpile Deterioration Model," NPS Technical Report, NPS-OR-92-013, August 1992.

THESIS DIRECTED: Mazanec, W.A., "Interactive Naval Gunfire Support Training," Master's Thesis, March 1992.

VARIABLE RESOLUTION SIMULATION MODELING

William G. Kemple, Assistant Professor
Michael P. Bailey, Assistant Professor
Michael G. Sovereign, Professor
Peter Purdue, Professor
Department of Operations Research
Sponsor and Funding: Strategic Defense Initiative Office

OBJECTIVE: This Project is aimed at developing a taxonomy of models and model fidelity to facilitate off-the-shelf use of simulation to solve specific short-term study projects.

SUMMARY: Funding began in October 1992, though the group had been working in the area for over a year. Preliminary meetings were attended at SAIC in San Diego, and our role in the Analytical Tool Box group of SDIO was established.

PUBLICATIONS: Bailey, M. and W. Kemple, "The Scientific Method of Choosing Model Fidelity," Proceedings of the Winter Simulation Conference, Washington, D.C., 1992.

PRESENTATIONS: Bailey, M.P., "The Scientific Method of Choosing Model Fidelity," ORSA/TIMS, Orlando, FL, 1992.

Bailey, M., "Model Fidelity and Resolution in Combined Models," EURO-TIMS, Helsinki, Finland, 1992.

LARGE-SCALE OPTIMIZATION

G.H. Bradley, Professor
G.G. Brown, Professor
R.K. Wood, Associate Professor
Department of Operations Research
Sponsor and Funding: Office of Naval Research

OBJECTIVE: This continuing research program develops theory and algorithms for solution of large-scale optimization models.

SUMMARY: One focus has been on persistence of integer and nonlinear optimization solutions, automatic exploitation of special structure in integer and nonlinear enumeration, and communication of model structure from modeler to solver. Another focus was the development of optimization and game theoretic models and algorithms to solve network interdiction problems with emphasis on the US Army's optimal allocation of assets to the interdiction of illegal drugs and precursor chemicals in South America.

PUBLICATIONS: Brown, G., K. Wood, R. Clemence, W. Teufert, "An Optimization Model for Modernizing the Army's Helicopter Fleet", *Interfaces*, 21, No. 4, 1991, pages 39-52.

Brown, G., D. Bausch, R. Rosenthal, and S. Rapp, "Mobilizing Marine Corps Officers", *Interfaces*, 21, No. 4, 1991, pages 26-38 (1989 Koopman Award winner).

Brown, G.,K. Wood, W. Avery, and J. Rosenkranz, "Optimization of Purchase, Storage and Transmission Contracts for Natural Gas Utilities," *Operations Research*, 40 (May-June), 1992, pages 446 - 462.

Brown, G., D. Bausch, and D. Ronen, "Elastic Set Partitioning - a Powerful Tool for Scheduling Transportation of Oil and Gas," (invited paper in Advances in Operations Research in the Oil and Gas Industry, (M. Breton and G. Zaccour, eds, Additions Tecnip, Paris, 1991), pages 151 - 162.

Brown, G., D. Bausch, and D. Ronen, "Scheduling Transportation with Elastic Set Partitioning , "Towards the Integration of the Logistics Pipeline, (J. Masters, ed., Transportation and Logistics Research Fund, Ohio State University, 1991), pages 169 - 180.

CONFERENCE PRESENTATIONS: Wood, K., "New Network Interdiction Models,", TIMS/ORSA Joint National Meeting, Anaheim, CA, 3-6 November 1991.

Brown, G., D. Bausch, and D. Ronen "Scheduling Oil Transportation with Elastic Set Partitioning," TIMS/ORSA Joint National Meeting, Anaheim, CA, 3-6 November 1991.

Bradley, G. and H. Oliveira, "NETWORK ASSISTANT to Construct, Test and Analyze Graph and Network Algorithms", DIMACS Workshop on Computational Support for Discrete

Mathematics, Rutgers University, New Brunswick, NJ, 12-14 March 1992.

Bradley, G., G. Brown, D. Wallace and L. Buckingham, "New Tools for Optimizing USAF Sortie Allocation Planning", TIMS/ORSA Joint National Meeting, Orlando, FL, 26-29 April 1992.

Brown, G., T. Harrison, and B. Arntzen, "Global Manufacturing Strategy Analysis", TIMS/ORSA Joint National Meeting, Orlando, FL, 26-29 April 1992.

Bradley, G. and H. Oliveira, "NETWORK ASSISTANT to Construct, Test and Analyze Network Algorithms", TIMS/ORSA Joint National Meeting, Orlando, FL, 26-29 April 1992.

Bradley, G. and H. Oliveira, "NETWORK ASSISTANT to Construct, Test and Analyze Graph and Network Algorithms", Fourth SIAM Conference on Optimization, Chicago, IL, 11-13 May 1992.

Wood, K. and A. Washburn, "Game-Theoretic Network Interdiction Models", TIMS/ORSA Joint National Meeting, San Francisco, CA, 2-4 November 1992.

Bradley, G., "Overview of NETWORK ASSISTANT", TIMS/ORSA Joint National Meeting, San Francisco, CA, 2-4 November 1992.

Bradley, G. and H. Oliveira, "Using NETWORK ASSISTANT to Evaluate Graph and Network Algorithms", TIMS/ORSA Joint National Meeting, San Francisco, CA, 2-4 November 1992.

Brown, G., K. Wood, J. Mamer, and R. McBride, "Solving a Large-Scale Generalized Multi-Commodity Flow Problem", TIMS/ORSA Joint National Meeting, San Francisco, CA, 2-4 November 1992.

THESES DIRECTED: Wallace, David, E., "Analysis Tools for United States Air Force Sortie Optimization and Munitions Planning," Master's Thesis, March 1992.

EXPLOITING SPECIAL STRUCTURE IN LARGE-SCALE USAF OPTIMIZATION MODELS

G. H. Bradley, Professor
G.G. Brown, Professor
R.K. Wood, Associate Professor
Department of Operations Research
Sponsor and Funding: Air Force Office of Scientific Research

OBJECTIVE: This continuing research program develops theory and algorithms for solution of large-scale USAF optimization models.

SUMMARY: The research project emphasized theory, analysis and algorithms that exploit special structure in real-world optimization problems. One focus of the research has been a mathematical development of a dynamic factorization approach to large-scale linear programs. The research used the theory to reinterpret existing algorithms, discover common principles and then applied them to develop new algorithms. Another focus has been the design and prototyping of a computer workstation environment to support optimization experts as they build models and design, analyze and

test innovative algorithms. We have supported the "heavy attack" sortie optimization system for nearly fifteen years. Heavy attack is a large-scale, nonlinear optimization model of weapon, aircraft, weather, and target-constrained sortie assignment, embedded within a multi-time period simulator accounting for target reconstitution, revaluation, and logistical resupply. The Air Force uses the system in peacetime to determine annual conventional munitions purchases and prepositioning (worth over $2 billion annually).

PUBLICATIONS: "An Optimization Model for Modernizing the Army's Helicopter Fleet", (G. Brown and K. Wood with R. Clemence and W. Teufert), *Interfaces*, 21, No. 4,1991, pages 39-52.

OPTIMIZATION OF MUNITIONS MODELING

G. H. Bradley, Professor
G.G. Brown, Professor
A.R. Washburn, Professor
Department of Operations Research
Sponsor: HQ, USAF
Funding: USAF Aero Systems Division, Eglin AFB

OBJECTIVE: This continuing research program develops computational models of sorties with air-dropped conventional munitions The research seeks to provide quick response decision support for theater-level logistics planning and stockpiling.

SUMMARY: The sortie planning and munitions expenditure models developed in this research program ("HEAVY ATTACK" in particular) have enjoyed renewed interest following Desert Storm. Desert Storm provided valuable anecdotal tests of model efficiency, while stressing computational abilities to the limit of model technology. This research has accommodated larger, more challenging problems, rendered faster, more reliable model response, enhanced model interfaces, and provided alternatives to the customary techniques for solving the problems at hand. In concert with this effort, munitions planners are being re-equipped with new, customized, portable, decision support computer hardware and software suites.

PUBLICATIONS: Brown, G., D. Coulter, and A. Washburn, "Optimization of Munitions Procurement", 1991 draft, awaiting sponsor release, 18 pages.

CONFERENCE PRESENTATIONS: Bradley, G., D. Wallace, G. Brown, and L. Buckhingham, "New Tools for Optimizing USAF Sortie Allocation Planning", TIMS/ORSA Joint National Meeting, Orlando, FL, 26-29 April 1992.

OTHER: The computer codes HEAVY ATTACK in operation at HQ/USAF, Eglin AFB, and elsewhere.

SCHEDULING UNDERWAY REPLENISHMENTS FOR CARRIER BATTLE GROUPS

Robert F. Dell, Assistant Professor
Siriphong Lawphongpanich, Associate Professor
Department of Operations Research
Sponsor: None
Funding: Unfunded

OBJECTIVE: To develop an optimization based tool for scheduling underway replenishment of carrier groups.

SUMMARY: During this reporting period, three tasks were accomplished. First, we classified basic optimization models for planning underway replenishment of a battle group. This classification focused on two scenarios, routine and rearming, and considered three replenishment tactics: circuit rider, delivery boy and gas station. Second, we developed a branch and bound algorithm for scheduling underway replenishment using the delivery boy and circuit rider tactics. Finally, we developed a dynamic programming algorithm for solving scheduling underway replenishment as a generalized orienteering problem.

CONFERENCE PRESENTATION: Dell, R., Lawphongpanich, S. and Zabarouskas, M., "Scheduling Underway Replenishment,' ORSA/TIMS Meeting, Orlando, Florida, April, 1992.

THESES DIRECTED: Wu, LT, T.L., "Optimization Models for Underway Replenishment," Master's Thesis, March 1992.

Zabarouskas, LT., M.W., "Scheduling Underway Replenishment Problems with Delivery Boy and Circuit Rider Tactics," Master's Thesis, March 1992.

Dunn, LT, J.S., "Scheduling Underway Replenishment as a Generalized Orienteering Problem," Master's Thesis, June 1992.

OPTIMALLY STATIONING UNITS TO BASES (OSUB): A MODEL FOR BASE CLOSURE

Robert F. Dell, Professor
Samuel H. Parry, Professor
Richard E. Rosenthal, Professor
Department of Operations Research
Sponsor and Funding: Office Chief of Staff of the Army DACS-SM(TABS)

OBJECTIVE: The goal of this multi-year research project is to provide optimization based decision making tools for the analysis of Army base realignment and closure.

SUMMARY: The first year of this multi-year project was completed in 1992. An optimization model specifically designed to generate realignment and closure recommendations for maneuver and training installations (referred to as OSUB) has been developed and delivered to the sponsor. OSUB is a bi-criteria mixed integer programming model with the objectives of military value and force stationing cost.

OSUB has the ability to analyze tool where alternative basings of a force structure can be generated and analyzed. Realignments are restricted by a number of constraints which include the need to provide Army units with housing, facilities, maneuver land, deployment, and ranges. Constraints on contruction and movement costs are also included to ensure one-time realignment costs are kept within reasonable limits.

CONFERENCE PRESENTATIONS: Singleton, J. G., and R. F. Dell, Stationing United States Army Units to Bases: A Bi-Criteria Mixed Integer Programming Approach. National Meeting of the Operations Research society of Americal and the Institute of Management Science, 26-29 April 1992.

Tarantino, W. J., R. F. Dell, S. H. Parry, and R. E. Rosenthal, Modeling Closure of Army Materiel Command Istallations: A Bi-Criteria Mixed Integer Programming Approach. 60th symposium of MORS (the Military Operations Research Society), 23-25 June 1992.

Dell, R. F., S. H. Parry, R E. Rosenthal, and W. J. Tarantino, Modeling Army Base Closure: Considering Various Levels of Detail. *EURO XII/TIMS XXXI Joint* International Conference, 29 June -1 July 1992.

THESES DIRECTED: Tarantino, W.J., "Modeling Closure of Army Materiel Command Installations: A Bi-Criteria Mixed Interger Programming Approach," Master's Thesis, September 1992.

DAMAGE AGGREGATION MODELS FOR WEAPONS SALVOS

J. D. Esary, Professor
Department of Operations Research
Sponsor: Naval Air Warfare Center
Weapons Division, China Lake
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 conducted during the previous three years 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 initial two years concerned empirical rules for estimating the expected percentage of damage to an area target compared to a rule derived from a plausible model, and the first of an emerging family of target configuration and weapons impact scenarios which lead to the plausible model (now called a proportional effects damage aggregation mechanism). Results

documented during the third year include extensions to the family of targeting scenarios which lead to a proportional damage aggregation mechanism and the first consideration of dependencies in weapons hit distributions. Results documented during this year are about the relationship between concepts of subproportional damage aggregation (cumulative and incremental subproportionality) and a fairly general targeting scenario which leads to the stronger incremental type of damage aggregation. In addition to salvos directed against area targets, some of the targeting scenarios considered may be applicable to the defense of task forces against incoming missiles with and without target allocation.

PUBLICATIONS: Esary, J.D., "Subproportional Damage Aggregation and the CE11AI Targeting Scenario," Working Paper on Damage Aggregation, Naval Postgraduate School, June 1992.

METEOROLOGICAL DATA ANALYSIS: ESTIMATION OF PREDICTION ERROR VARIANCES

D. P. Gaver, Distinguished Professor
P. A. Jacobs, Professor
Department of Operations Research
Sponsor and Funding: Naval Research Laboratory-West

OBJECTIVE: Variance of prediction errors are required in the optimum interpolation analysis used in numerical weather prediction. The purpose of this study is to investigate the relationship of the current variances to other atmospheric parameters in order to improve estimation.

SUMMARY: Statistical models for the prediction error have been formulated which have log-linear scale parameters which include covariances. Data from February, April, and July of 1991 were used to estimate the model parameters and to study the predictive ability of the models. This preliminary investigation indicates that observational and first guess wind components can be helpful in predicting mean square prediction error for wind components. The development of a recursive updating procedure to estimate the model parameters has been initiated

PUBLICATIONS: Jacobs, P. A. and Gaver, D. P., "Preliminary Results From the Analysis of Wind Component Error-July Data, NPS Technical Report, NPSOR-93-003, November 1992.

Jacobs, P. A. and Gaver, D. P., "Bayesian Prediction of Mean Square Error with Covariates," NPS Technical Report, NPSOR-93-004, November 1992.

PERFORMANCE ANALYSIS STUDIES

D. P. Gaver, Distinguished Professor
P. A. Jacobs, Professor
P. Purdue, Professor
Department of Operations Research
Sponsor and Funding: Defense Communications Agency

OBJECTIVE: To conduct mathematical performance analysis studies and develop models to a) assess the contribution of common channel signalling in voice network routing; and b) to evaluate routing and congestion control procedures in multi-type (voice, data, video) broad-band networks.

SUMMARY: Probabilitistic models have been formulated and studied for voice traffic using a line controlled by a smart multiplexer. A heuristic procedure for calculating blocking on the line with smart multiplexers was proposed.

OTHER: Lt. L. Henson spent her experience tour at the Defense Communications Agency Engineering Center. The topic of her master's thesis, "Models for Smart Multiplexer," was suggested by center personnel.

QUANTITATIVE TOXICOLOGY AND RISK ASSESSMENT

D. P. Gaver, Distinguished Professor
Department of Operations Research
Sponsor and Funding: Naval Medical Research Institute, Toxicology Detachment

OBJECTIVE: To initiate mathematical and statistical work on the interaction between a) PBPK compartment models, b) dose-response models, and c) risk analysis with emphasis on a military population at risk.

SUMMARY: Models of organic cell response to toxicology have been proposed.

OTHER: D. P. Gaver, "Conjectural Models of Organic Cell Response to Toxicity," forthcoming.

MANAGEMENT INDICATOR

D. P. Gaver, Distinguished Professor
P. A. Jacobs, Professor
Department of Operations Research
Sponsor and Funding: NAVAIR (AIR 419)

OBJECTIVE: To develop a reliable aircraft readiness degradation forecasting methodology to assist decision making for maintaining aircraft availability at minimum cost.

SUMMARY: Development of an aircraft readiness degradation forecasting method has been initiated.

PUBLICATION: Gaver, D.P. and P. A. Jacobs, "Statistical Approaches to

Detection and Quantification of a Trend with Return-On-Investment

Application," NPS Technical Report, NPSOR-93-007, December 1992.

QUANTITATIVE TOXICOLOGY

D. P. Gaver, Distinguished Professor
P. A. Jacobs, Professor
Department of Operations Research
Sponsor and Funding: U.S. Army Biomedical Research and Development Laboratory

OBJECTIVE: To initiate an effort to provide quantitative, data-based assessments of toxicological phenomena relevant to Army goals and to advance the quantitative methodology needed for the assessments.

SUMMARY: A generalization has been proposed for a two-stage clonal expansion model for the transformation of normal somatic genes to a cancerous state. The generalization recognizes the possibly variable susceptibilities or exposures of the cells in question. A statistical analysis of data from a histopathologic examination of tissues from Japanese medaka fish has been performed.

PUBLICATIONS: Gaver, D.P. and Jacobs, P.A., "Modeling and Statistical Analysis of Medaka Bioassay Data," Naval Postgraduate School Technical Report, NPSOR-92-012, May 1992.

CONFERENCE PRESENTATIONS:
Gaver, D.P. and Jacobs, P.A., "Modeling and Statistical Analysis of Bioassay Data," Army Biomedical Research and Development Project Review, 21-22 April 1992.

PROBABILISTIC MODELS FOR SHAPES AND HIERARCHICAL BAYESIAN MODELING AND ESTIMATION

D. P. Gaver, Distinguished Professor
P. A. Jacobs, Professor
Department of Operations Research
Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: To conduct probabilistic and statistical research on a) simple characteristics of random environmental shapes, and b) non-standard data analysis techniques such as non-Gaussian time series prediction and hierarchical statistical models.

SUMMARY: A hierarchical model for a Poisson time series with covariates was introduced and its use in short-term forecasting investigated. Models for service-adaptive multi-type repair were formulated and studied. Previous research on optimal sequential replenishment of ships was awarded the Koopman prize by the Military Applications Section of the Operations Research Society of America. A study of the effect of random wind forcing on the

geostrophic vorticity equation was begun.

THESES SUPERVISED: Beel, J., "Anti-UAV defense for ground forces and hypervelocity rocket lethality models" M. S. Thesis, March 1992.

PUBLICATIONS: Gaver, D.P.(chair), "Combining Information: Statistical Issues and Opportunities for Research," National Research Council, National Academy Press, 1992

CONFERENCE PRESENTATIONS: Gaver, D.P., "Service-Adaptive Multi-Type Repairman Problems," EURO XII/TIMS XXXI Joint International Conference, Helsinki, Finland, June 1992.

Gaver, D.P. and Jacobs, P. A., "Non-Standard Service: A Partial Overview," TIMS/ORSA Joint National Meeting Orlando, Florida, April 1992.
Gaver, D. P., "Exploratory Modeling," EURO XII/TIMS XXXI Joint International Conference, Helsinki, Finland June 1992.

OTHER: Pilnick, S.E., Glazebrook, K.D., and Gaver, D.P. Gaver, "Optimal Sequential Replenishment of Ships During Combat," *Naval Research Logistics*, Vol. 38, pp. 637-668, 1991. The paper was awarded the Koopman prize by the military application section of the Operations Research Society of America. The research for this paper was partially supported by the Research Foundation. Professor Glazebrook was an NRC fellow at NPS. CAPT Pilnick was awarded a Ph.D. in Operations Research from NPS.

ANALYTICAL SUPPORT FOR NAVY OPERATIONAL TEST AND EVALUATION

D. P. Gaver, Distinguished Professor
Department of Operations Research
Sponsor and Funding: COMOPTEVFOR

OBJECTIVE: To bring operations research approaches and methodology to bear in Navy OT&E.

SUMMARY: Research has been initiated concerning the assessment of computer software quality and maturity. Initial decision- theoretic models of how much testing is enough" which incorporate the cost of testing have also been formulated.

THESES SUPERVISED: Dennison, T.E., "Fitting and Prediction for a Software Reliability Model," Master's Thesis, March 1992.

OTHER: Gaver, D.P. and Jacobs, P.A., "Economics of Testing", forthcoming. Uribe, L., "Missile Testing," Fortran software, November 1992.

STOCHASTIC HIERARCHICAL MODELING OF THEATER COMBAT

D. P. Gaver, Distinguished Professor
S. H. Parry, Professor
P. A. Jacobs, Professor
Department of Operations Research
Sponsor and Funding: Conventional Forces Analysis Division, J-8, The Joint Staff

OBJECTIVE: To initiate development of an architecture for probabilistic models of joint theater level combat.

SUMMARY: Research has been aimed towards the development of an architecture of a stochastic model of a joint theater level model. Work has concentrated on ground combat and manuever and the effects of C3/I.

THESES DIRECTED: Bonomo, J., "A Framework for Incorporating Battlefield Purpose and Intelligence," Master's Thesis, September 1992.

CONFERENCE PRESENTATIONS: Youngren, M., Gaver, D.P., and Jacobs, P.A., Future Stochastic Theater Level Modeling, Working Group 14, Military Operations Research Society, Monterey, CA, June 1992.

Gaver, D.P., Jacobs, P.A., and Youngren, M., "A New Theater-level Modeling Approach," ORSA/TIMS Joint National Meeting San Francisco, CA., November 1992.

Gaver, D.P., Jacobs, P.A., and Parry, S., "Stochastic Theater-level Modeling," Theater Level Combat Modeling Workshop, George Mason University, January 1992.

OTHER: Uribe, L., "Stochwars," Fortran software, September 1992.

THE VALUE OF WARSHIP ATTRIBUTES IN MISSILE COMBAT

Wayne P. Hughes, Jr., Senior Lecturer
Department of Operations Research
Sponsor and Funding: Naval Ship Warfare Center, Carderock Division, Bethesda, Maryland

OBJECTIVE: To describe the relationship between key attributes of warships in missile combat: offensive and defensive firepower, staying power, scouting effectiveness, personnel readiness, and numbers engaged on both sides.

SUMMARY: A methodology is introduced with which to compare the military worth of basic warship combat capabilities, individually and in a force. It is based on two principles. First, a simple salvo model is necessary for exploratory analysis of modern warship characteristics. Second, the "fractional exchange ratio" is a robust way to compare equal-cost configurations of naval forces, even though we cannot know in advance how and where the warships will be fought. The methodology is justified three ways: (1) By tracing the evolution of elemental naval force-on-force models since 1902. (2) By a summary of studies covering model exposition, verification and application, and the collection of

battle data. (3) By illustration with important conclusions from parametric analysis.

PUBLICATION: Hughes, W.P. Jr., "The Value of Warship Attributes in Missile Combat," NPS Technical Report NPS-OR-93-001.

DEVELOPMENT OF A THEORY OF COMBAT

Wayne P. Hughes, Jr., Senior Lecturer,
Department of Operations Research
Sponsor: Director Test, Evaluation and Technical Requirements
Office of the Chief of Naval Operations (OP-091)
Funding: Naval Postgraduate School

OBJECTIVE: To specify a comprehensive theoretical structure for the study of combat. The structure will form the foundation of combat science for both operators (combat leaders) and military operations analysts.

SUMMARY: The research paper establishes the basic premises and structure for the study of all 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 processes. The exposition is organized under six fundamental axioms.

PUBLICATION: The NPS technical report, "Combat Science: An Organizing Study," comprising 120 pages, is in final editing.

A CONSTRAINED OPTIMIZATION ENVIRONMENT FOR STRATIGRAPHIC CORRELATION

William G. Kemple, Assistant Professor
Department of Operations Research
Sponsor: Research Initiation Program
Funding: Naval Postgraduate School

OBJECTIVE: This research is part of a continuing project. To develop a formalism for the fusion of geological data (primarily fossil data) extracted from rock strata that will produce a usable time scale for these strata. To develop useable tools for paleontologists within this framework, providing both computer programs and decision aids to help them tailor the programs for the analysis or reanalysis at hand. The programs should be optimized to reduce the time required to achieve a solution, and by the output should be tailored to the needs of the paleontologist. To extend the research into the C^3 information systems area.

SUMMARY: In the paleontological arena, I was notified that I will receive an NSF grant, and we were invited to present our work to the paleontologists at AMOCO Research, but the main advances were in operations research. We proved that the constrained stratigraphic

correlation problem is strongly NP complete. We also devised a new neighborhood structure and developed extremely fast C code that can solve the problem with any of three well-known heuristics: *simulated annealing*, *tabu search*, and *steepest descent with random restarts*. We then conducted a large, statistical experiment to compare the performance of, and results obtained by, these heuristics. In the early phases, two data bases from the geological literature were used to eliminate the steepest descent algorithm from further consideration and to develop a method for determining parameter settings when the remaining heuristics were applied to new data bases. In the final phase, three other data bases from the geological literature were used to compare simulated annealing and tabu search. Coupled with previous results, this information provides the foundation needed to develop a *pseudo* AI routine to choose the best heuristic and tailor it to the database being analyzed and the CPU time available. In addition, this is an example of the proper application of statistical techniques to experiments that compare computer algorithms. Also, based on the discussion that followed presentation of our results at the 1992 ORSA/TIMS meeting, Glover (tabu search) has developed a new method for determining parameter settings when tabu search is used in a new problem domain.

PUBLICATIONS: Kemple, W.G., Dell, R., and Tovey, C., "Heuristically Solving the Stratigraphic Correlation Problem," First Industrial Engineering Research Conference Proceedings, pp. 293-297, 1992.

CONFERENCE PRESENTATIONS: Kemple, W.G., Dell, R., and Tovey, C., " On Solving the Stratigraphic Correlation Problem with Tabu Search and with Simulated Annealing - a Comparative Study," The Operations Research Society of America/Institute of Mathematical Sciences Joint National Meeting, 4-6 November 1991.

Kemple, W.G, Dell,R., and Tovey, C., "Heuristically Solving the Stratigraphic Correlation Problem," National Meeting of the Institute of Industrial Engineers, Research Conference, 20-21 May 1992.

Kemple, W.G., Dell, R., and Tovey, C., "Applying Tabu Search and Simulated Annealing to the Stratigraphic Correlation Problem," The Operations Research Society of America/Institute of Mathematical Sciences Joint National Meeting, 1-4 November 1992.

Kemple, W.G., Sadfler, P. and Strauss, D., "Simultaneous Graphical Correlation of Multiple Sections," Annual Paleontology Seminar of the Paleontology Group, AMOCO Research, 3-4 December 1992.

OTHER: I have received notification from the National Science Foundation that my proposal to continue this research will be funded for two years.

BATTLE ENHANCED ANALYSIS METHODOLOGIES

Harold Larson, Professor,
William Kemple, Assistant Professor
Department of Operations Research
Sponsor and Funding: US Army Training and Analysis Command, Monterey

OBJECTIVES: Explore possible ways of objectively assessing performance of Army battalion-sized groups at the National Training Center, relative to published Army battlefield tenets.

SUMMARY: Several displays have been described and implemented. These include simple line of sight displays, indicating how many weapons can bring fire against a given point on the battlefield, as well as displays of combat potential (how much destructive power can be brought against certain targets in areas of interest). In addition, simplified procedures for indicating the progress of company-size (or larger) units on the battlefield have been prototyped. These make it much easier to observe the flow of the battle, including both the synchronization and the agility of the forces displayed. It is intended that these displays will provide a useful training tool giving objective indications of how well visiting units performed at the National Training Center. Possible user interfaces have been explored and suggestions made for software employed in creating these displays. These are currently being used in this effort.

PUBLICATIONS: Larson, H., Dryer, D., and Kemple, W., "Enhancing Tactical Direct Fire Synchronization Measures, Proceedings of the Symposium on the Interface: Computing Science and Statistics, Accepted May 1992.

CONFERENCE PRESENTATIONS: Larson, H., Dryer, D., and Kemple, W., "Enhancing Tactical Direct Fire Synchronization Measures," Interface '92, College Station, Texas, March 20, 1992.

Larson, H., Kemple, W., Lamont, R., Nelson, M., and Dryer, D., "Battle Enhanced Analysis Methodologies," 60th MORS Symposium, Working Groups 29 and 31, Monterey, Ca, 23 June 1992.

Larson, H., Kemple, W., Lawphongpanich, Lamont, R., Nelso, M., Dryer, D., and Fernana, J., "Toward Battlefield Visualization," American Statistical Association Annual Meeting, Boston, Massuchusetts, August 1992.

THESES DIRECTED: Lamont, Major R.W., USMC, "Direct Fire Synchronization," Master's Thesis, September 1992.

Nelson, Captain M.S., USA, "Graphical Methods for Depicting Combat Units," Master's Thesis, September 1992, co-advisor with W. Kemple.

OPTIMAL RECRUITING STRUCTURE

Siriphong Lawphongpanich, Associate Profesor
Richard E. Rosenthal, Professor
Department of Operations Research
Sponsor: Naval Recruiting Command
Funding: Naval Personnel Research and Development Center

OBJECTIVE: To develop an optimization based tool for realigning the Naval Recruiting Structure.

SUMMARY: Constrained by a decreasing Department of Defense budget, Naval Recruiting Command (NRC) must use its resources efficiently to meet its recruiting goals. The recruiting structure plays a pivotal role in the utilization of these resources. Excess or insufficient levels and units in the hierarchical recruiting structure (e.g., areas, districts, zones, and stations) leads to inefficient use of resources. The goal of this proposal is therefore to develop an optimization based tool which will enable NRC to evaluate recruiting structures. This will allow NRC to identify the most efficient recruiting structure under varied scenarios. During this reporting period, we developed two optimization models for locating recruiting stations, one based on the concept of coverage radius and the other based on a statistical model provided by the Naval Recruiting Command. Both models have been implemented using a commercially available software and tested using actual data provided by the command.

OPTIMAL REALIGNMENT OF THE U.S. ARMY RECRUITING STATIONS

Siriphong Lawphongpanich, Associate Professor
So Young Sohn, Assistant Professor
Department of Operations Research
Sponsor and Funding: U.S. Army Recruiting Command

OBJECTIVE: To develop an optimization based tool for realigning the United States Army recruiting stations to maximize effectiveness.

SUMMARY: The decision to close, consolidate and relocate recruiting stations has a profound impact on the Army's recruiting efforts. In particular, the number and locations of stations that are 'optimally' determined can provide Army recruiters with competitive advantages over recruiters from the other services. This research proposes to examine the problems of determining the 'optimal' number and locations of stations to be placed within the boundary of a recruiting company. In particular, these problems can be formulated as integer programming problems with input data determined in part by statistical analyses. This project was started in December 1992.

PUBLISHED PAPERS: Hearn, D.W. and Lawphongpanich, S., "Decomposition Topics for Large-Scale Optimizations," Proceedings of the 1992 NSF Design and Manufacturing Systems Conference, Atlanta, Georgia, January, 1992. (NR)

Kachitvichyanukul, V. and Lawphongpanich, S., "Industrial

Engineering and Operations Research Applications for Newly Industrialized Countries," Proceeding of the Second International Workshop on Advanced Science and Technology Transfer to Thailand, Bangkok, Thailand, August, 1992.

CONFERENCE PRESENTATIONS:

Hearn, D.W. and Lawphongpanich, S., "Decomposition Topics for Large-Scale Optimizations," NSF Design and Manufacturing Systems Conference, Atlanta, Georgia, January, 1992.

Dell, R., Lawphongpanich, S. and Zabarouskas, M., "Scheduling Underway Replenishment," Operations Research Society of America/TIMS Meeting, Orlando, Florida, April, 1992.

Kemple, W., Larson, H., Lawphongpanich, S., Lamont, R., Nelson, M., and Dryer, D., "Battle Enhanced Analysis Methodologies," 60th Military Operations Research Society Symposium, Monterey, California, June 1992.

Kachitvichyanukul, V. and Lawphongpanich, S., "Industrial Engineering and Operations Research Applications for Newly Industrialized Countries," the Second International Workshop on Advanced Science and Technology Transfer to Thailand, Bangkok, Thailand, August, 1992.

CNO CHAIR OF EMERGING TECHNOLOGIES

K. T. Marshall, Professor
Department of Operations Research
Sponsor: Office of the Chief of Naval Operations (OP-091)

OBJECTIVE: This Chair was established in 1990 to provide a direct relationship between the Director, Office of Navy Requirements for Research and Development, Test and Evaluation (OP-091) and the Superintendent of the Naval Postgraduate School (NPS) in order to establish a focused research program that examines the military implications of emerging technologies, and foster interactions NPS and the Navy R&D community.

SUMMARY: Approximately one half year was devoted to the Chair in 1991. Principal activities included 1) a seminar involving NPS faculty and navy lab personnel on target identification and classification problems, 2) visits with navy labs, including a brief to lab CO's and TD's on potential NPS interactions, 3) attracting Dr Alex Becker of UC Berkeley to visit NPS to work in electo-magnetics in ASW, 4) a seminar involving NPS students recently assigned from Desert Shielk/Desert Storm on lessons learned, 5) member of U.S. delegation to international meeting on military OR in space, 6) participation in the Surface Warfare 2030 Symposium and Wargame.

ATTRITION RATE GENERATION FOR MANPOWER MODELS

Robert R. Read, Professor,
Department of Operations Research
Sponsor and Funding: HQ USMC, Code MI

OBJECTIVE: This is a continuing project. The goal is to build a general purpose system that will convert officer personnel data into attrition probabilities that are valid for time intervals of several lengths, and sensitive to other important classifying parameters. Rank, years commissioned service, occupation specialty are major discriminators but others, such as commissioning source, gender, etc can be required as well. These requirements have the effect of inducing a large number of cells which have low personnel inventory and the building of a rate generator under these circumstances poses the major problem. Modern multi-parameter estimation schemes have been tested.

SUMMARY: Previous work has supplied a validated method for the one year lead time window. This method has been implemented into the Marine Corps manpower models by a commercial organization. This year's work dealt with a performance review of that implementation. A copy of the attrition rate generator has been supplied by the sponsor, installed on our local PC's and tested. The initial testing uncovered some gross errors of implementation and these have been corrected. Other aspects tested include the speed of the processing and the convenience of use in the various manpower models that draw upon it. Firstly it was found to be very slow. The organization of the attrition rate generator interface with the various manpower model end uses was extremely inefficient. Recommendations based upon the efficiencies of scale and parallel processing have been made. Their implementation will require that the end use user interfaces be redesigned. The redesign recommendations also include items to enhance convenience and to expand the capabilities. Groundwork for the extension of the work to other communities (reserves, limited duty officers, warrant officers) has been laid.

REPORTS: Read, R.R., "Performance Review of The Officer Rate Generator, Version 1.0," NPS Technical Report, NPS-OR-93-002, October 1992.

RANGE CALIBRATION STUDIES

R.R. Read, Professor
Department of Operations Research
Sponsor and Funding: Naval Undersea Warfare and Engineering Center, Keyport, WA

OBJECTIVE: This is a continuing project. NUWES operates several underwater vehicle tracking ranges of the short baseline type. That is, path segments are developed from a network of bottom based three dimensional tracking arrays, and it is necessary to splice together the path segments contributed by individual arrays in order to study the overall behavior of the vehicle. Unfortunately there exist serious

mismatches, oftentimes fifty feet or more, in the attempt to make ends meet. This problem has been present since the opening of the ranges over thirty years ago, and all previous error budgets and interpretations have failed to account for errors of this magnitude. In previous work we have identified important error sources in the ray tracing algorithm which account for about one third of the total separation error. A number of our suggestions have been made operational by the sponsor and a the calibration of the range has improved.

SUMMARY: In the present period we have sought to exploit an algorithm developed last year by the P.I. It utilizes the raw data that input the several versions of track that are present in the "triple overlap" regions, i.e. those regions in the range whose acoustic signals can be heard by three arrays (roughly positioned to form an equilateral triangle). For data in these regions we can use long baseline methods to convert acoustic signals into vehicular track. Each interior array of the range will share a triple overlap region with each of six other arrays (in six directions separated by about 60 degrees each) and the idea is to compare the three versions of vehicle path in each of the six triple overlap regions with those versions produced using the long baseline methods. Such comparisons can provide relative information about the quality of track produced by the contributing arrays.
An idealized version of the method was tested by my student, Lt. Gembarski, who focused on a single interior array, used simulated tracking data and the assumption that the calibration errors associated with the satellite arrays are smaller those of the interior array. He was able to properly correct the calibration of the interior array under these circumstances. More recently we have been working with operational data and attempting to develop decision rules for closing distance between the several versions of track. The idiosyncrasies of real data include the facts that seldom do we get a vehicle traversing through all six triple overlap regions and occasionally the depth- velocity sound speed information is not current. Some success has been experienced and some new problems have been uncovered. A report is in preparation.

THESIS DIRECTED: Gembarski, J.A.,"Use of Multiple Tracking Data in the Calibration of Short Baseline Arrays," Master's Thesis, March 1992.

BATTLE GROUP LOGISTICS SUPPORT SYSTEM

D.A. Schrady, Professor
D.B. Wadsworth, CDR, SC, USN,
Department of Operations Research
C.T. Wu, Professor
Bernadette Brooks, LT, USN
Department of Computer Science
Sponsor and Funding: Office of the Deputy Chief of Naval Operations

OBJECTIVE: The goal of this research was to restructure the stand-alone, microprocessor version of the Battle Group Logistics Coordinator Support System, BGLCSS, into the standard Navy command and control systems NTCS-A and OSS and to do so with the "2.1 Unified Build" of these systems.

SUMMARY: The stand-alone, PC BGLCSS prototype had been demonstrated and used in a number of fleet exercises and a requirement to incorporate BGLCSS in NTCS-A was adopted by the N6 Fleet Requirements Working Group in October 1991. The original BGLCSS was written in Turbo Pascal for a DOS operating system. NTCS-A programs are written in the C language for a UNIX workstation. Further changes were that certain inputs made manually in the PC version would be acquired automatically from the track database in NTCS-A. Finally, a number of features of the PC version would be changed based on experience with that system. The Sun 4 workstation and software was obtained from PMW 162 and installed at NPS. High-level BGLCSS 2.0 design was accomplished during the Spring Quarter, along with redesign of the event handling code. GOTS development tools were discarded in favor of TAE for interface development. In October, the "Unified Build" software update from NRaD was assimilated with numerous difficulties. Graphical user interface design and construction have been completed. Library construction and integration of the libraries to the interface and NTCS-A software is ongoing.

PUBLICATIONS: Schrady, D.A.,"NPS-Developed Logistics Support System Evaluated," research note, *Naval Research Reviews*, Office of Naval Research, No. 1, 1992.

Schrady, D.A., "Analysis of Carrier Air Wing Sortie Rates and Fuel Use," NPS Technical Report, NPS-OR-93-005, December, 1992 (CONFIDENTIAL).

CONFERENCE PRESENTATIONS: Schrady, D.A., "Tactical Logistics," N6 NTCS-A Fleet Requirements Working Group meeting, NRaD, San Diego, 24 February, 1992.

Cali, S.M. and Schrady, D.A., "Battle Group Tactical Rearming," TIMS/ORSA Joint National meeting, Orlando, 29 April, 1992.

Schrady, D.A., "Naval Combat Logistics Support System," 60th Military Operations Research Society Symposium, Monterey, 23 June 1992.

OTHER: A technical report bringing together the classified database for BGLCSS is in preparation.

VARIABLE SELECTION IN A LINEAR GROWTH CURVE MODEL WITH AUTOREGRESSIVE ERRORS

So Young Sohn, Assistant Professor
Department of Operations Research
Sponsor: Research Initiation Program
Funding: Naval Postgraduate School

OBJECTIVE: The goal of this project was to compare estimation methods for variable selection schemes in a linear random coefficient growth curve model. The following summary contains the application of the extended version of the theoretical development made during the first year ('91) of this project.

SUMMARY: The key information required for risk assessment of the electric power system includes the prediction of transmission line outage rates. In this paper, a random effect Poisson regression model is used to formulate the outage rate as a function of line characteristics. A two-stage procedure is used to estimate the transmission outage rate. The method suggested is applied to analyze the outage data recorded over a 12-year period on 112 345-kV transmission lines of the Commonwealth Edison Company. Results indicate that variations of log outage rates can be explained in part by the log line length and the line elasticity of annual outage rate is 0.49927.

PUBLICATIONS: Sohn, S. Y., "A Two-Stage Estimation of Transmission Outage Rate," IASTED Reliability, Quality Control International Conference Proceedings, November 1992.

Sohn, S. Y., "A Two-Stage Estimation of Transmission Outage Rates: A Case Study," Quality and Reliability Engineering International, forthcoming.

CONFERENCE PRESENTATIONS: Sohn, S. Y., "A Two-Stage Estimation for Extra-Poisson Variation," TIMS/ORSA Joint National Meeting, Orlando, FL, April, 1992.

Sohn, S.Y., "A Two-Stage Estimation of Transmission Outage Rate: A Case Study," IASTED Reliability, Quality Control International Conference, Washington, DC, November 1992.

DEPARTMENT OF OPERATIONS RESEARCH

1992 Faculty Publications and Presentations

TECHNICAL REPORTS

Gaver, D.P., and P. A. Jacobs, "Statistical Approaches to Detection and Quantification of a Trend with Return-On-Investment Application," NPS Technical Report, NPSOR-93-007, December 1992.

Gaver, D.P., and Jacobs, P.A., "Modeling and Statistical Analysis of Medaka Bioassay Data," NPS Technical Report, NPSOR-92-012, May 1992.

Hughes, W.P., Jr., "The Value of Warship Attributes," NPS TEchnical Report, NPS-OR-93-001, October 1992.

Jacobs P.A. and Gaver, D.P., "Bayesian Prediction of Mean Square Error with Covariates," NPS Technical Report, NPSOR-93-004, November 1992.

Jacobs, P.A., and Gaver, D.P., "Preliminary Results from the Analysis of Wind Component Errors-July Data," NPS Technical Report, NPSOR-93-003, November 1992.

Read, R.R., "Performance Review of the Officer Rate Generator, Version 1.0" NPS Technical Report, NPR-OR-93-002, October 1992.

Schrady, D.A., "Analysis of Carrier Air Wing Sortie Rates and uel Use," NPS Technical Report, NPS-OR-93-005, December 1992. (CONFIDENTIAL)

Sohn, S.Y., "An Application of Growth Curve Analysis to Ammunition Deterioration Stock Pile Model," NPS Technical report, NPS-OR-92-013, August 1992.

Woods, M.W., "Baseline System Effectiveness Models for NSSMS and SDSMS," 17 July 1992. Sponsored by the Naval Warfare Assessment Center, Corona, California. Work order: N6070192WP00064.

JOURNAL ARTICLES

Avery, W., Brown, G., Rosenkranz, J., and Wood, K., "Optimization of Purchase, Storage and Transmission contracts for Natural Gas Utlities" *Operations Research*, Vol. 40, No. 3, May-June 1992 pp. 446-462.

Larson, H.J., "Least squares estimation of linear splines with unknown knot location," *Computational Statistics & Data Anlysis*, pp. 1-8, Vol. 13, January 1992.

Schrady, D.A., "NPS-Developed Logistics Support System Evaluated", Research note, Naval Research Reviews, Office of Naval Research, No. 1, 1992.

Sohn, S.Y., "Variable Selection in a Linear Growth Curve Model with Autoregressive Within-individual Errors," *Journal of Statistical Computation and Simulation*, Vol. 40, pp. 247-255, 1992.

Washburn, A.R., "Present Values with Renewals," *Management Science*, Vol. 38, no 6, June 1992, pp. 846-850.

CONFERENCE PROCEEDINGS

Bailey, M. and Sovereign, M., "Object-Oriented Modeling of the MAGTF Communications Architecture," Proceeding of the Joint Directors of Laboratories 1992 Symposium on Command and Control Research, pp. 211-217, 1992.

Dell, R. and Tovey, C., "Heuristically Solving the Stratigraphic Correlation Problem," First Industrial Engineering Research Conference Proceedings, pp. 293-297, 1992.

Gaver, D.P. (chair), "Combining information: statistical Issues and Opportunities for Research," National Research Council, Academy Press, 1992.

Hearn, D.W. and Lawphongpanich, S., "Decomposition Topics for Large-Scale Optimizations," Proceedings of the 1992 NSF Design and Manufacturing Systems Conference, Atlanta, Georgia, January 1992.

Hughes, W.P., Jr., "Command and Control Within a Theory of Combat," in Proceeding of the AAIA Command, Control and Communications Symposium, December, 1992.

Kachitvichyanukul, V. and Lawphongpanich, S., "Industrial Engineering and Operations Research Applications for Newly Industrialized countries," Proceeding of the Second Internaional Workshop on Advanced Science and Technology Transfer to Thailand, Bangkok, Thailand, August 1992.

Wood, K., and Washburn, A.R., "Game Theoretic Network Interdiction Models", San Francisco ORSA/TIMS, November 1992.

CONFERENCE PRESENTATIONS

Barnes, P., and Larson, B., "Reusable ADA Software for Command and control Workstation Map Manipulation," Joint Directors of Laboratories 9th Annual conference on Command and Control Decision Aids, 8-9 June 1992.

Bailey, M., and Sovereign, M., "Marine Corps Communication Architecture Analysis Model," 60th Military Operations Research Society Symposium, 23-25 June 1992.

Bailey, M., "What's so Great about Object-Oriented Simulation?," 60th Military Operations Research Society Symposium, 23-25 June 1992.

Bailey, M., "The Scientific Method of Choosing Model Fidelity," 1992 Winter Computer Simulation Conference, December 1992.

Bailey, M., Kemple, W., and Sohn, S.Y., "Data Analysis," Naval Air Test Center, Pax River, MD, 8-9 December 1992.

Bailey, M. and Sovereign, M., "Object-Oriented Modeling of the MAGTF Communications Architecture," Joint Directors of Laboratories 1992 Symposium on Command and Control Research, 10-11 June 1992.

Bradley, G., Brown, G., Wallace, D., and Buckingham, L., "New Tools for Optimizing USAF Sortie Allocation Planning," TIMS/ORSA Joint National Meeting, Orlando, FL, 26-29 April 1992.

Bradley, G., Oliveira, H.F., "NETWORK ASSISTANT to Construct, Test and Analyze Network Algorithms," TIMS/ORSA Joint National Meeting, Orlando, FL, 26-29 April 1992.

Bradley, G., Oliveira, H.F., "NETWORK ASSISTANT to Construct, Test and Analyze Graph and Network Algorithms," Fourth SIAM Conference on Optimization, Chicago, IL, 11-13 May 1992.

Bradley, G., "Overview of NETWORK ASSISTANT," TIMS/ORSA Joint National Meeting, San Francisco, CA, 2-4 November 1992.

Bradley, G. and Oliveira, H.F., "Using NETWORK ASSISTANT to Evaluate Graph and Network Algorithms," TIMS/ORSA joint National Meeting, San Fracisco, CA, 2-4 November 1992.

Dell R., and Tovey, C., "Heuristically Solving the Statigraphic Correlation Problem," National Meeting of the Institute of Industrial Engineers, Research Conference, 20-21 May 1992.

Dell, R., and Tovey, C., "Applying Tabu Search and Simulated Annealing to the Stratigraphic Correlation Problem," National Meeting of the Operations Research Society of America and the Institute of Management Science, 1-4 November 1992.

Dell, R.F., Parry, S.H., Rosenthal, R.E., and Tarantino, W.J., "Modeling Army Base Closure: Considering Various Levels of Detail," EURO XII/TIMS XXXI Joint International Conference, 29 June - 1 July 1992.

Dell, R.F. and Farmer, R.A., "Developing Coast Guard District Cutter Schedules," Symposium on Decision Making, sponsored by the Defense Resources Management Institute, 20 November 1992.

Dryer, D., Larson, H., and Lamont, R., "Enhancing Tactical Direct Fire Synchronization Measures," 24th Symposium on the Interface: Computing Science and Statistics, 18-21 March 1992.

Gaver, D.P. and Jacobs, P.A., "Non-standard Service: A Partial Overview," TIMS/ORSA Joint National Meeting, Orlando, Florida, April 1992.

Gaver, D.P., Jacobs, P.A., and Youngren, M., "A New Theater-Level Modeling Approach," ORSA/TIMS Joint National Meeting, San Francisco, CA, November 1992.

Gaver, D.P., "Service-adaptive Multi-type Repairman Problems," EURO XII/TIMS XXXI Joint International Conference Helsinki, Finland, June 1992.

Gaver D.P., "Exploratory Modeling," EURO XII/TIMS XXXL Joint International Conference, Helsinki, Finland, June 1992.

Ghosh, M. and Sohn, S.Y., "Hierarchical and Empirical Bayes Estimation of All Employee Links," ASA Joint Statistical Meetings, Boston, MA, August 1992.

Kemple, W.G., Dell, R.F., and Tovey, C.A., "Applying Tabu Search and Simulated Annealing to the Stratigraphic Correlation Problem," National Meeting of the Operations Research Society of America and The Institute of Management Science, 1-4 November 1992.

Larson, H., Lawphongpanich, S., Lamont, R., Nelson, M., Dryer, D., and Fernan, J., "Toward Battlefield Visualization," American Statistical Association Annual Meeting, 9-13 August 1992.

Larson, H., Lawphongpanich, S., Lamont, R., Nelson, M., and Dryer, D., "Battle Enhanced Analysis Methodologies," 60th Military Operations Research Society Symposium, Working Groups 29 and 31, 23-25 June 1992.

Larson, H.J., "Enhancing Tactical Direct Fire Synchronization Measures," presented by Dryer, D. with Kemple, W., Interface '92, 20 March 1992.

Larson, H.J., Kemple, W., Lawphongpanich, S, Lamont, R., Nelson, M., and Dryer, D.,"Battle Enhance Analysis Methodologies," 60th MORS Symposium, Working Groups 29 and 31 Monterey, CA, June 23, 1992, 35 and 25 Persons.

Larson, H.J., Lawphongpanich, S., Lamont, R., Nelson, M., Dryer, D., and Fernan, J., "Toward Battlefield Visualization," American Statistical Association Annual Meeting, Boston, Massuchusetts, 11 August 1992.

Lawphongpanich, S., Dell, R.F., and Zabarouskas, M., "Scheduling Underway Replenishment Using the Circuit Rider Tactic," National Meeting of the Operations Research Society of America and the Insitiute of Management Science, 26-29 April 1992.

Maskos, W., McCullers, W., and Rosenthal, R.E., "Optimization Models for Assigning Marines to Training Schools," Operations Research Society of America and The Institute of Management Science, Joint National meeting, Orlando, FL, April 1992.

Porter, G., Sovereign, M., and Norris, L., "Tactical Tic-Tac-Toe (T4) a Game for C3 Experiments," 60th Military Operations Research Society Symposium, 23-25 June 1992.

Rosenthal, R.E. and Walsh, W.J., "Optimizing Flight Operations for an Aircraft Carrier in Transit," Operations Research Society of America and The Institute of Management Science, Joint National Meeting, Orlando, FL, April 1992.

Rosenthal, R.E., "Intergerizing' Real-world Integer Programs" Graduate School of Business University of California, Irvine, CA, 19 June 1992.

Rosenthal, R.E., Dell, R.F., Wunderle, D., Bullock, M.T., and Lott, J.N., "An Integrated Optimizer/DBMS for Injection Molding Press Operations," Operations Research Society of America and The Institute of Management Science, Joint National Meeting, San Francisco, CA, November 1992.

Sadler, P. and Strauss, D., "Simultaneous Graphical Correlation of Multiple Sections," Annual Paleontology Seminar of the Paleontology Group, AMOCO Research, 3-4 December 1992.

Schrady, D., "Tactical Logistics," presentation made to the N6 sponsored NTCS-A Fleet Requirements Working Group meeting at NRaD, San Diego, 24 February 1992.

Schrady, D., "Battle Group Tactical Rearming," Invited paper at the TIMS/ORSA Joint National Meeting, Orlando, 29 April 1992.

Schrady, D., "Naval Combat Logistics Support System," Presentation made at the 60th Military Operations Research Society Symposium, Monterey, 23 June 1992.

Schrady, D., "Naval Battle Group Tactical Rearming," presentation made at the 9th International Symposium on Military Operational Resarch, Royal Military College of Science, Shrivenham, UK, 11 September 1992.

Singleton, J.G., and Dell, R.F., "Stationing United States Army Units to Bases: A Bi-Criteria Mixed Integer Programming Approach," National Meeting of the Operations Research Society of America and The Institute of Management Science, Joint Nationa Meeting, 26-29 April 1992.

Sohn, S.Y., "A Two-Stage Estimation of Transmission Outage Rate: A Case Study," IASTED Reliability, Quality Control International Conference, November 1992.

Sohn, S.Y., "A Two-Stage Estimation for Extra-Poisson Variation," TIMS/ORSA Joint National Meeting, Orlando, FL, April 1992.

Sohn, S.Y., "An Application of Growth Curve Analysis to Ammunition Deterioration Stock Pile Model," ORSA/TIMS Joint National Meeting, San Francisco, CA, November 1992.

Sohn, S. Y., "A Two-Stage Estimation of Transmission Outage Rate: A Case Study," IASTED Reliability, Quality Control International Conference, Washington, DC, November 1992.

Sovereign, M., Serfaty, D., Entin, E., and Deckert, J., "Adaptation to Stress in Team Decision Making and Coordination," Joint Directors of Laboratories 1992 Symposum on Command and Control Research, 10-11 June 1992.

Sovereign, M., Serfaty, D., Entin, E., Deckert, J., "Adaptation to Stress in Team Decision-Making and Coordination, 60th Military Operations Research Society Symposium, 23-25 June 1992.

Tarantino, W.J., Dell, R.F., Parry, S.H., and Rosenthal, R.E., "Modeling Closure of Army Materiel Command Istallations: A Bi-Criteria Mixed Integer Programming Approach," 60th symposium of the Military Operations Research Society), 23-25 June 1992.

Wing, V.F., Rice, R.E., Sherwood, R.W., Rosenthal, R.E., "Determining the Optimal Mobiblity Mix," Barchi Prize Presentation, Military Operations Research Society Symposium, Monterey, June 1992.

Youngren, M., Gaver, D.P., and Jacobs, P.A., "Future Stochastic Theater Level Modeling," Working Group 14, Military Operations Research Society Symposium, Monterey, CA, June 1992.

BOOKS

Hughes, W. P. Jr., U.S. Naval War College, Sound Military Decision, (Annapolis, Md., Naval Institute Press, 1992).

BOOK CONTRIBUTION

Hughes, W. P. Jr., "Mahan, Tactics and Principles of Strategy," Comprising Chapter 3 of The Influence of History on Mahan, J. B. Hattendorf, Ed., (Newport, RI, Naval War College Press, 1992).

WORKSHOP PRESENTATIONS

Bradley, G. and Oliveira, H.F., "NETWORK ASSISTANT to Construct, Test and Analyze Graph and Network Algorithms" DIMACS Workshop on Computational support for Discrete Mathematics, Rutgers Universitiy, New Brunswick, NJ, 12-14 March 1992.

Gaver, D.P., Jacobs, P.A., "Stochastic Theater Level Modeling" Theater Level Combat Modeling Workshop, George Mason University, January 1992.

Gaver, D.P., Jacobs, P.A., "Modeling and Statistical Analysis of Bioassay Data," Workshop 1992.

DEPARTMENT OF PHYSICS

Professor K. Woehler
Chairman



DEPARTMENT OF PHYSICS

In FY92, the research activities in the Physics Department consisted of 31 individually identified projects. Funding for these projects came from the Navy direct funding mechanism and from reimbursable funding. Nine of the 31 projects (30%) were funded by direct funding. The others were funded reimbursably at a total of $1.7M. Sponsors of the reimbursable funded projects were SPAWAR; NAVSEA-PMS421; NAVSEA; NRL'NCCOSCO-NRAD; NSWC; NSSC; ONR as Navy sponsors and AF; DNA; NASA; SDIO; OSD; CEBAF as non Navy sponsors.

The projects fall into four groups which are the areas of concentration of research in the physics department:

Center for Advanced Target Acquisition and Surveillance
Center for Space Applications
Center for Conventional and non-Conventional Weapons and Weapons Effects
Center for Applied Acoustics

The department has a broad research program which has evolved over more than twenty years in response to perceived needs of the Department of the Navy, Department of Defense and other sponsors. The programs include areas of specialization which are likely to be relevant in future Combat Systems Science and Technology. A common thread that connects all the projects in the department is the exploration of the physics in areas where Naval weapon systems technologies interface and are limited by our understanding of the natural environment and where an increase of that understanding may possibly lead to technical advances in future combat systems. This research program is very closely matched to the concentration options which the department offers for the students of the Combat System Science and Technology curriculum (Applied Electromagnetics/Optics; Weapons and Weapon Effects; Applied Acoustics), and is well suited to support the students' thesis research in their concentration area.

This research program also matches well with many aspects of the new mission areas "Joint Strike Warfare", "Joint Littoral Warfare", "Joint Surveillance", "Joint Space and Electronic Warfare", and "Strategic Deterrence". In some cases the projects have potential for increasing operational capabilities directly. Many of the projects contribute to new technologies that will affects the mission areas in the future.

The Combat System Science and Technology Curriculum which leads to a degree in Applied Physics and this research program which supports the ability of the faculty to stay at the forefront of modern weapon technology in important mission areas is totally unique and cannot be conducted at civilian universities. Following is an overview of the nature and significance of the Department of Physics' research program.

PROJECTS IN THE CENTER FOR TARGET ACQUISITION AND SURVEILLANCE TECHNOLOGIES

Laser Propagation In Turbulent Atmosphere

Professor D. L. Walters has developed over many years methods of measurement and analysis to characterize atmospheric laser propagation properties for various applications in target acquisition and surveillance systems. Recently, he has provided the characterization of the mountain turbulent layer for the siting of the new Air Force 4m surveillance telescope, and developed a scaling experiment to characterize the stratospheric turbulence for the Air Force Theater Missile Defense Program.

Novel IR Imaging System

Professor D. S. Davis is in the process of developing and evaluating the performance characteristics of a new generation of fully multiplexed and multispectral imaging devices which will allow detection and imaging of targets in the far-infrared to millimeter wavelength where no other technologies are available.

IR Search And Target Designation

Professor A. W. Cooper has conducted a comprehensive research program in Infrared Search and Target Designation Technologies for many years. Recently, he and a team of co-workers and students have conducted a series of field measurements to determine the effects of sun glint on the ability to discriminate targets in the glint corridor. A strike warfare support program is seeking to validate and improve tactical decision aid codes for field prediction of performance of operational FLIR devices by comparison with experimental observations during flight experiments with FLIR carrying aircraft and ships with known ship signatures.

PROJECTS IN THE CENTER FOR SPACE SYSTEMS APPLICATIONS

Remote Ionospheric Sensing

Professor D. D. Cleary is investigating the possibilities of remote global surveillance of the properties of the ionosphere and its variability on time scales of hours which influences HR communication and over-the-horizon detection. The goal is the development of instrumentation to measure global ionospheric electron densities continuously from a space based platform. Recently a second sounding rocket experiment was flown to test the principle and was highly successful. Development of an instrument to be flown on a satellite in 1995 is underway.

Spacecraft Charging

Professor R. C. Olsen is conducting experiments and analysis for control of the phenomenon of spacecraft charging that affects the performance of high earth orbit satellites. This involves the need for understanding the behavior of charged particle populations in the magnetosphere at the altitude where communication satellites must operate. Preparations for a space experiment have been ongoing which is expected to be launched in early 1993.

C31 Assessment

Professor J. Sternberg has under sponsorship from OSD developed a new methodology for supporting C31 requirements. In particular, the assessment of the contribution of non-organic sensor information on the effectiveness of battle forces was investigated. The method has been adapted to offensive operations against land targets and air warfare options in littoral warfare.

Whistler Waves

Professor W. B. Colson is investigating the amplification mechanisms of VLF electromagnetic waves in the magnetosphere by energetic electrons. There waves are important to the Navy for the design and use of communication and navigation systems and for their potential in monitoring and controlling magnetosphere and ionosphere and their influence on communication systems.

PROJECTS IN THE CENTER FOR WEAPONS AND WEAPON EFFECTS

Free Electron Laser

Professor W. B. Colson and his students are engaged in a project that explores the technology requirements for the design of a shipboard free electron laser (FEL) weapon system. This project has many aspects and has led to collaborations with a Stanford optical wavelength FEL experiment and the Continuous Electron Beam Accelerator Facility (CEBAF) funded by the Department of Energy. The CEBAF facility will have an IR and a UV FEL and simulation studies are done in order to establish baseline design for future weapon system development.

Phalanx Gun System

Professor W.B. Colson is investigating the performance of the Phalanx Gun System with the goal to develop change of design options that can improve the performance.

Laser Target Interaction

Professor F. Schwirzke is investigating the mechanism of target damage under high energy laser irradiation. Unipolar arcing appears as a basic damage mechanism for the vulnerability of target surfaces to laser directed energy

weapon systems. These phenomena are of equal importance in plasma opening switches which are considered for application in high power short pulse directed energy systems.

Novel Sources of X-Ray Radiation

Professor X. K. Maruyama has conducted experimentation with the NPS 100 MeV Linear Electron Accelerator for the generation of coherent and quasi coherent X-ray radiation in a novel way. There experiments are the first after some earlier experiments in the former Soviet Union. A new technique was employed giving an enhanced production of higher order parametric xradiation which holds promise for the generation of monochromatic higher energy x-rays with modest electron beam energies.

PROJECTS IN THE CENTER FOR APPLIED ACOUSTICS

Low Frequency Active Sonar Array Performance

Professors S. R. Baker, D. R. Canright and C. L. Scandrett are developing a method to give an economical yet complete description of sonar array performance which is applicable to dense low frequency active arrays. Recently a model for a ring-shell flextensional transducer was developed which will serve in a future acoustic scattering model.

Automated In-Service Sonar Transducer Performance Monitoring

Professors O. B. Wilson and S. R. Baker have continued project to develop and apply such a monitoring system. In service testing of the DT-605 and TR-317 sensors was done and evaluated.

Fiber Optic Hydrophone Development

The objective of this multiyear project under Professor D. A. Brown is to develop high sensitivity low cost fiber optic interferometric hydrophones and demodulation systems for use in hull mounted planar arrays. Use of lightweight high strength composite materials for flexural disks hydrophones increased the depth tolerance of the sensors by a factor of three compared to earlier versions.

Applications of Thermoacoustic Heat Transport

Professor A. A. Atchley is conducting a program of basic investigation of the thermoacoustic sound generator and its inverse the thermoacoustic heat pump and refrigerator. New laser Doppler anemometry was used to study details of the underlying mechanisms.

Sonoluminescence

Professors A. A. Atchley and X. K. Maruyama are investigating the recently rediscovered phenomenon of sonoluminescence; the light flashes from sound driven oscillations of gas bubbles in fluids. This phenomenon is of fundamental interest because of its enormously high energy concentration. Duration of the light pulses are of the order of tens pico of seconds. The spectrum indicates very high temperature of the source. The phenomenon is of interest because of the highly non-linear character of the dynamics which may help to elucidate the nature of such rapid dynamic processes.

Thermoacoustic Refrigerator

Professors S. L. Garrett and T. J. Hofler are continuing their program of the development of practical refrigerators for special applications based on the thermoacoustic refrigeration principle. A small Space ThermoAcoustic Refrigerator (STAR) was flown this year in a space shuttle experiment to prove the utility of such a device. A high capacity thermoacoustic refrigerator for Life Science Space Shuttle experiments is under development for NASA under a 1994. Also under development is the third generation thermoAcoustic Refrigerator (TARIII) or cryocooler prototype which is designed to reach low temperature of 80K for applications to the cooling of detectors and super conducting electronics in space with high reliability.

Professors Larraza and Denardo are investigating localized oscillatory structures with amplitude and carrier wave number modulation. Such phenomena have application in fiber optic communications and all-optical switching technology. Kink like structures in optical fibers might play a role in high repetition rate communications.

Aerosol Source Function of the Ocean

Professor D. E. Spiel is investigating how many aerosols of given size per unit time per unit area are generated by oceanic white caps. The aerosol source function is an important ingredient in heat transport models for the air-ocean interface. The aerosol is created by determine a number of important parameters that ultimately determine the source function.

BASIC RESEARCH IN THERMOACOUSTIC HEAT TRANSPORT

A. A. Atchley, Associate Professor
Department of Physics
Sponsor and Funding: Office of Naval Research

OBJECTIVE: The long term goal of this research is to develop a thorough understanding of thermoacoustic phenomena. The investigations involve both heat pumps and prime movers.

SUMMARY: Our major research efforts in thermoacoustic heat transport were concentrated in two areas during FY 1992: 1)a standing wave analysis of the low amplitude performance of thermoacoustic prime movers both below and above the onset of self-oscillation and 2)a study of finite amplitude standing waves in both harmonic and inharmonic tubes. In addition to these areas, FY 1992 research efforts also included the investigation of heat driven refrigerators and preliminary work on investigations of thermoacoustic engines with laser Doppler anemonmetry.

PUBLICATIONS: Atchley, Anthony A. , "Standing Wave Analysis of a Thermoacoustic Prime Mover Below Onset of Self-Oscillation," *Journal Acoustical Society of America* 92 2907-2914 (1992).

Atchley, A., Bass, H.E., Hofler, T., and Lin, H.T., "Study of a ThermoAcoustic Prime Mover Below Onset of Self-Oscillation," *Journal Acoustical Society of America*, 91, 734-743 (1992).

CONFERENCE PRESENTATIONS: Atchley, A., "Standing wave analysis of the low amplitude performance of a thermoacoustic prime mover," 123rd Meeting of the Acoustical Society of America, Salt Lake City, UT, May 1992, Journal Acoustical Society of America, 91, No. 4, Pt.2, 2396(A) (1992).

Gaitan, D. and Atchley, A., "Finite Amplitude Standing Waves in Harmonic and Inharmonic Closed Tubes," 123rd Meeting of the Acoustical Society of America, Salt Lake City, UT, May 1992, Journal Acoustical Society of America, 91, No. 4, Pt. 2,2330(A) (1992).

THESES DIRECTED: Che, C., CDR, Taiwan Navy, "Investigation of a Thermoacoustic Muffler," Master's Thesis, December 1992.

BASIC RESEARCH IN PHYSICAL ACOUSTICS

A. A. Atchley, Associate Professor
Department of Physics
Sponsor : Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: The purpose of this project is to allow investigation of various applications of physical acoustics of current Navy and scientific interest. The majority of the effort on FY 1992 was devoted to investigating sonoluminescence. Sonoluminescence is a process through which light is emitted from a single, localized, oscillating bubble. The effort was so devoted because NPS was in a position of making fundamental

advances in this new area of basic research.

SUMMARY: We concentrated on measuring the spectrum of the light emission. A Collaboration was established with Lawrence Livermore National Laboratory to accomplish part of this research. Although sonoluminescence has been studied for several decades, only recently has it become apparent that a single bubble, levitated in a standing wave field, can emit pulses of light with durations of a few tens of picoseconds. We measured the spectrum of this picosecond sonoluminescence with two separate instruments (a spectrometer/CCD detector systems and a scanning monochrometer/PMT detector system) for bubbles levitated in water and in glycerin/water mixtures. Results indicate that the spectrum resembles that of a blackbody and continually changes with time, independent of input parameters.

CONFERENCE PRESENTATIONS: Felipe, D., Holt, G., and Atchley, A., "Investigation of periodicity of sonoluminescing from a single bubble," 124th Meeting of the Acoustical Society of America, New Orleans, LA. October 1992, Journal Acoustical Society of America, 92, No. 4, Pt. 2,2452(A) (1992).

Gaitan, F., Lentz, J., and Atchley, A., "Further Investigation of a Single, Stable, Sonoluminescing Bubble Using Mie Scattering," 123rd Meeting of the Acoustical Society of America, Salt Lake City, UT, May 1992, Journal Acoustical Society of America, 91, No. 4, Pt. 2,2331(A) (1992).

THESES DIRECTED: Carlson, L., LT, USN, "Visible Spectrum of Stabel Sonoluminescence," Master's Thesis, December 1992.

Lewis, S., LCDR, USN, "Spectra of Stable Sonoluminescence," Master's Thesis, December 1992.

DEVELOPMENT OF AUTOMATED METHODS FOR IN-SERVICE SONAR TRANSDUCER PERFORMANCE MONITORING

S. R. Baker, Associate Professor
O. B. Wilson, Professor
Department of Physics
Sponsor and Funding: Naval Sea Systems Command

OBJECTIVE: The objective of this research program is to develop and apply automated methods for in-service sonar transducer testing. This is a continuing project.

SUMMARY: Software for conducting in service testing of DT-605 and TR-317 sensors was developed for use by the Complex Immittance Measurement (CIM) System. Field testing of the DT-605 software was conducted. It was found that some changes in the hardware of the CIM test unit are needed. Tests using conventional test instruments worked satisfactorily. The algorithms for an equivalent-circuit model from an impedance surve-fitting procedure were further refined and now give excellent results. From measurements on a limited number of nominally "Failed" hydrophones, some of which appeared to be normal, it was found that the values of some of

these parameters are associated with degradation of receiving sensitivity. The new portable laptop PC running the CIM software under High-Tech (HT) Basic was used as the controller in there field-tests. Work is continuing.

PUBLICATION: Wilson, O.B. and S.R. Baker, NPS-PH-93-001PR, "Sonar Transducer Performance Monitoring and Prediction, October 1992.

THESES DIRECTED: Wiulson, D.E., "Field Measurements on the DT-605 Hydrophone Using the Complex Immittance Measurement System," Master's Thesis, March, 1992.

Flipse, J.R., "Study of the Relationship Between the Acoustic Sensitivity and the Electrical Equivalent Circuit Parameters of the DT-605 Hydrophone," Master's Thesis, September, 1992.

APPLICATON OF THE T-MATRIX METHOD TO LOW FREQUENCY ACTIVE ARRAY PERFORMANCE PREDICTION

S. R. Baker, Associate Professor
Department of Physics
D. R. Canright, Assistant Professor
C. L. Scandrett, Associate Professor
Department of Mathematics
Sponsor: Naval Undersea Warfare Center
Funding: Naval Postgraduate School and Naval Undersea Warfare Center

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 continuing project.

SUMMARY: The method employed is an extension of the T-matrix, which has been previously applied to scattering problems, but has not heretofore been applied to the problem of coupled electroacoustic transducers. 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 finite-element model.

In FY90 Professors Canright and Scandrett developed a numerical model of an array of closely-spaced, identical spherical shell radiators.

Two major accomplishments occurred in CY92. First, a three-dimensional finite-element model of a class V (ring-shell) flextensional transducer was developed for use with the ATILA code. To our knowledge this is the first such model ever produced. In-air modal and in-water harmonic radiation calculations using this model were performed. Second, the authors of the ATILA code were funded by us in CY92 to upgrade the code to provide the capability to calculate the scattered acoustic field for an arbitrary field incident upon a transducer. The upgrade was received at the end of CY92. Scattering calculations for the ring-shell transducer will be performed in CY93.

CONFERENCE PRESENTATION: Baker,

S.R., Canright, D.R., and Scandrett, C.L., "Application of the T-matrix method to low-frequency active sonar array performance modeling" presented at the Third International Workshop on Transducers for Sonics and Ultrasonics, Orlando, FL, 6-8 May 1992.

THESIS DIRECTED: Pinto, R., LCDR, Brazilian Navy, "Three-dimensional finite element model of a high power, low frequency ring-shell flextensional sonar transducer," Master's Thesis, December 1992.

FIBER OPTIC HYDROPHONE DEVELOPMENT

David A. Brown, Research Assistant Professor
Department of Physics
Sponsor: Naval Sea Systems Command
Funding: Hull Array Improvement Plan 06UR

OBJECTIVE: This research project is a multi-year project in its fifth year. The objective of this research is to develop high sensitivity low cost fiber optic interferometric hydrophones and demodulation systems for use in hull mounted planar arrays.

SUMMARY: We tested four different light weight high strength composite materials for flexural disks in fiber optic interferometric hydrophones. We constructed three acceleration cancelling flexural disk hydrophones using the best two of these materials. The main result of this research is that we were able to increase the depth tolerance of the sensors by greater than a factor of three while maintaining their size and acoustic sensitivity. Using these and other new materials, we fabricated four additional planar array style sensors suitable for testing on the Wide Aperture Array (WAA) Engineering Development Model (EDM). We tested one of our multi-element polycarbonate acoustic sensors on the KAMLOOPS submarine in "pop-up" tests ant Lake Pend Oreille in Bayview, Idaho in support of the Light Weight Planar Array (LWPA) Program. The sixteen sides of the eight disk were wired in series with optical fiber and configured as a Mach-Zehnder interferometer and terminated with a fiber optic 3X3 coupler. We also improved the noise floor of our low cost 3x3 coupler-based demodulator reducing it by a factor of 11 at 600 hz, to approximately 18 urad/Hz. In software, we demonstrated a new digital demodulator with dynamic range of 200 dB.

PUBLICATIONS: Brown, D.A., Gardner, D.L., and Garrett, S.L., "Fiber-Optic Interferometric Push-Pull Hydrophones," *Naval Research Reviews*, Office of Naval Research, Vol. XLIV, pp. 17-22, 1992.

Brown,D.A., "Parallel-Wrapped Ellipsoidal Shell Acoustic Sensors," 8th Optical Fiber Sensors Conference - Interferometry II, *OFS* '92, January 1992.

Gardner, D.L., Brown, D.A., and Garrett, S.L., "Fiber-optic Push-Pull Hydrophone Systems," The Third International Workshop on Transducers for Sonics and Ultrasonics, Naval Research Laboratory, *USRD*, May 1992.

Brown, D.A. and garrett, S.L., "Resonant Acoustic Determination of Complex Elastic Moduli," Technology

2001, the Second National Technology Transfer Conference and Exposition, NASA, pp. 32-40, December 1991.

CONFERENCE PRESENTATIONS: Kaploka, D., Brown, A., Gardner, D.L., and Garrett, S.L., "Composite Fiber Optic Flexural Disk Hydrophones" Journal of Acoustical Society of America, 91, Suppl. 4, p. S2324, May 1991.

THESIS DIRECTED: Chipkovich, LT, M.B.,"A Fiber Optic Accelerometer System," Master's Thesis, March 1992.

Kapolka, LT, D., "Fiber Optic Composite Flexural Disk Hydrophones," Master's Thesis, June 1992.

FIBER OPTIC SENSORS

David A. Brown, Research Assistant Professor
Steven L. Garrett, Professor
Department of Physics
Sponsor: Research Initiation Program
Funding: Naval Postgraduate School

OBJECTIVE: The Objective of this research effort was to establish a cost sharing direct funded program to complement fiber optic sensor development which was sponsored by NAVSEA.

SUMMARY: There was no labor spent on this account. Equipment was purchased to fabricate fiber optic sensors. See the previous project summary for additional information.

A SOUNDING ROCKET EXPERIMENT FOR REMOTE SENSING OF THE IONOSPHERE

David D. Cleary, Assistant Professor
S. Gnanalingam, Adjunct Professor
Deaprtment of Physics
Sponsor: Naval Research Laboratory
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 first 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 calibrated in the NPS Physics laboratory, and launched on a NASA sounding rocket on March 19, 1992, at the White Sands Missile Range, NM. The rocket experiment yielded approximately 8000 spectra between the altitudes 100 km and 320 km. Analysis of these spectra has produced the density profile of nitric iode, and the emission profiles of the OI 2972-A and OII2470-A multiplets. Further analysis of these and other emission

features will be used to infer the electron density profile of the ionosphere.

PUBLICATIONS: Cleary, D.D., Nichols, J.W., and Davis, D.S., "A new Design for an All-Reflection Michelson Interferometer," *Applied Optics*, 31, 433, 1992.

CONFERENCE PRESENTATIONS: Humm, D. C., Asfaw, A., Seyoum, H., Morgan, H., Fortna, J., and Cleary, D.D., "High-Resolution VUV Absolute Photo-Absorption Cross Sections of N2 and Rare Gases," Optical Society of America, Annual Meeting, 1992.

THESES DIRECTED: David, T., "Use of an Optical Multichannel Analyzer for Reflectivity Measurements," Master's Thesis, March 1992.

Rivers, T., "Development of an Automated Scanning Monochromator for Sensitivity Calibration of the MUSTANG Instrument," Master's Thesis, June 1992.

Chase, B., "A Calibration of the NPS Middle Ultraviolet Spectrograph (MUSTANG) Instrument," Master's Thesis, September 1992.

McElroy, K., "Comparison of Calculated N2 Emission Profiles with Rocket Observations," Master's Thesis, September 1992.

Wallace, K., "Design of a High Resolution Spatial Heterodyne Interferomenter," Master's Thesis, December 1992.

SIMULATIONS OF WHISTLER WAVES IN THE MAGNETOSPHERE

W. B. Colson, Professor
Department of Physics
Sponsor and Funding: Naval Postgraduate School

OBJECTIVE: Develop basic theory for describing whistler wave amplification in the Earth's magnetosphere.

SUMMARY: Very low frequency (VLF) electromagnetic waves propagating in the magnetosphere, called "Whistler Waves," can be amplified by energetic electrons spiraling along magnetic field lines near the geomagnetic equator. The Navy has long been interested in whistlers for the design and use of communication and navigation systems, and as a method of monitoring and controlling the magnetosphere and ionosphere.

We have developed a set of nonlinear equations that describe the propagation and amplification of whistler waves. The equations handle the electron phase-space dynamics in the combined dipole field of the Earth, the cold plasma in the magnetosphere, and the transverse electromagnetic whistler wave. The equations are analogous to the equations describing laser beam amplification in free electron lasers.

CONFERENCE PRESENTATIONS: Colson, W.B., "Analogies Between the Free Electron Laser and Whistler Mode Amplification in the Magnetosphere," presented at the Fourteenth International Free Electron Laser Conference, Kobe, Japan, August 1992.

THESES DIRECTED: Cauldle, LT, D.L.,

USN, "Very Low Frequency Signals and Whistler Mode Amplification in the Magnetosphere and Limit-Cycle Behavior in the CEBAF Infrared Free Electron Laser," Master's Thesis, September 1992.

SIMULATIONS OF THE NONLINEAR, INHOMOGENEOUS WHISTLER INTERACTION

W. B. Colson, Professor
Department of Physics
Sponsor and Funding: Office of Naval Research

OBJECTIVE: Develop a new simulation for the study of the amplification of whistler waves in the Earth's magnetospher.

SUMMARY: Whistler waves can be amplified by energetic electrons spiraling along magnetic field lines near the geomagnetic equator. The whistler waves propagate along the magnetic field lines from the equator to points of mid-latitude in the Norther and Southern hemisphere. Natural whistlers often dominate the VLF noise spectrum in the polar regions and limit communications.

We have developed and studied new simulations used to characterize and understand whistlers. The basis for the methods has been the nature simulations techniques developed for the free electron laser. The similarities between free electron lasers and whistlers has already resulted in the formulation of several scaling relationships that were not previously known for whistler waves.

CONFERENCE PRESENTATIONS: Colson, W.B., "Whistler Simulations at the Naval Postgraduate School," Presentation at the Office of Naval Research Space Plasma Workshop, Washington, DC, April 1992.

THESES DIRECTED: Gately, LT, B.,USN, "A Theory for Whistler Wave Amplification and Wave Particle Interactions in the Magnetosphere," Master's Thesis, March 1992.

CEBAF IR/IV FREE ELECTRON LASER RESEARCH

W. B. Colson, Professor
Department of Physics
Sponsor and Funding: Naval Postgraduate School

OBJECTIVE: Simulations of the CEBAF IR and UV free electron laser in order to establish baseline design for future weapons development.

SUMMARY: The Continuous Electron Beam Accelerator Facility (CEBAF) is being built by the Department of Energy (DOE) for nuclear physics experiments, but well soon include two free electron lasers. The active collaboration with the CEBAF experiment is particularly relevant because the superconducting accelerator technology provides the possibility for high-average power, tunable wavelengths, and high wall-plug efficiency.

PUBLICATIONS: Blau, J. and Colson, W.B., "Four Dimensional Simulations of the CEBAF Infrared Free Electron

Laser," *Nuclear Instruments and Methods in Physics Research*, A318, 717-720 (1992).

CONFERENCE PRESENTATIONS: Colson, W.B., "1992 Free Electron Laser Prize Winners," Presentation of the 1992 FEL Prize at the Fourteenth International Free Electron Laser Conference, Kobe, Japan, August 1992.

THESES DIRECTED: Caudle, D.L., LT, USN, "Very Low Frequency Signals and Whistler Mode Amplification in the Magnetosphere and Limit-Cycle Behavior in the CEBAF Infrared Free Electron Laser," Master's Thesis, September 1992.

CEBAF IR AND UV FREE ELECTRON LASER RESEARCH

W. B. Colson, Professor
Department of Physics
Sponsor: Continuous Electron Beam Accelerator Facility
Funding: Southeastern University Research Association

OBJECTIVE: Research is directed toward the superconducting technology required for a shipboard free electron laser weapon system.

SUMMARY: The Continuous Electron Beam Accelerator Facility (CEBAF), Newport News, VA is proposing two new free electron lasers that operate in the infrared and ultraviolet wavelengths. We provided the primary research that evaluates the performance of their proposed lasers, and suggested several design changes that have been adopted. The collaboration with the CEBAF experiment is particularly relevant because the superconducting accelerator technology provides the possibility for high-average power, tunable wavelengths, and high wall-plug efficiency.

PUBLICATIONS: Clark, D. and Colson, W.B., "The CEBAF Infrared Free Electron Laser," *Nuclear Instruments and Methods in Physics Research*, A318, 612-616 (1992).

Bice, C.A. and Colson, W.B., "The CEBAF Ultraviolet FEL Experiment," *Nuclear Instruments and Methods in Physics Research*, A318, 606-611, (1992).

CONFERENCE PRESENTATIONS: Wallace, S.M., LT, USN, and Colson, W.B., "Magnetic Field Error Measurements of the CEBAF (NIST) Wiggler Using the Pulsed Wire Method."

THESES DIRECTED: Clark, D.L., LT, USN, "Theory for the CEBAF Infrared and Shipboard FELs," Master's Thesis, December 1992.

Wallace, S.M., LT, USN, "Magnetic Field Measurements of the CEBAF (NIST) Wiggler Using the Pulse Wire Method," Master's Thesis, June 1992.

SHIPBOARD FREE ELECTRON LASER RESEARCH

W. B. Colson, Professor
Department of Physics
Sponsor: Naval Ocean Systems Center
Funding: Strategic Defense Initiative Organization

OBJECTIVE: Research is directed toward the technology required for a shipboard free electron laser weapon system.

SUMMARY: The collaboration with the Stanford University experiment is relevant because optical wavelength control is needed for future weapons designs.

PUBLICATIONS: Sturgess, K.A. and Colson, W.B., "An Analytic Description of Longitudinal Modes in Free Electron Lasers," *Nuclear Instruments and Methods in Physics Research*, A318, 576-581 (1992).

CONFERENCE PRESENTATIONS: Blau, J. and Colson, W.B., "Amplification of Short Optical Pulses in the Boeing APLE Amplifier," Fourteenth International Free Electron Laser Conference, Kobe, Japan, August 1992.

Sturgess, K., CAPT, and Colson, W.B., "Short Pulse Evaluation in the Boeing APLE Oscillator," Fourteenth International Free Electron Laser Conference, Kobe, Japan, August 1992.

THESES DIRECTED: Frost, D., LCDR, USN, "Theory for a High-Power Free Electron Laser and Tactical Applications," Master's Thesis, March 1992.

Wallace, S.M., LT, USN, "Magnetic Field Measurements of the CEBAF (NIST Wiggler Using the Pulse Wire Method," Master's Thesis, June 1992.

SHIPBOARD FREE ELECTRON LASERS

W. B. Colson, Professor
Department of Physics
Sponsor and Funding: Naval Postgraduate School

OBJECTIVE: Research is directed toward the technology required for a shipboard free electron laser weapon system.

SUMMARY: Working on the Boeing experiment is relevant because the accelerator technology provides the possibility for high-average power, and high wall-plug efficiency.

PUBLICATIONS: Colson, W.B., J. Blau, G. Cord, D. Craun, D. Gillingham, D. Kiel, J. H. Park, and R. Souza, "Free Electron Lasers for Inertial Confinement Fusion," Chapter 16, pages 421-436, in Nuclear Fusion by Inertial Confinement, editors: G. Velarde, Y. Ronen, and J. M. Martinez-Val, CRC Press, Florida (1992).

CONFERENCE PRESENTATIONS: Caudle, D.L., LT, and W. B. Colson, "Limit-Cycle Behavior in the CEBAF IR Free Electron Laser," Fourteenth International Free Electron Laser Conference, Kobe, Japan, August 1992.

THESES DIRECTED: Frost, D., LCDR, USN, "Theory for a High-Power Free Electron Laser and Tactical

Applications," Master's Thesis, March 1992.

Clar, D.L., LT, "Theory for the CEBAF Infrared and Shipboard FELs" Master's Thesis, Decemeber 1992.

NACIT INFRARED SEARCH AND TARGET DESIGNATION RESEARCH

A. W. Cooper, Professor
W. J. Lentz, Research Associate
E. C. Crittenden, Jr., Distinguished professor
E. A. Milne, Associate Professor
Department of Physics
Sponsor: Naval Sea Systems command PMS-421
Funding: NAVSEA PMS-421 and Naval Postgraduate School

OBJECTIVE: To record and analyze background scenes and target signatures for evaluation of target detection and background suppression and for evaluation of IRST technology. This is a continuing multi-year project, supported by the Naval Surface Electro-Optics Project Office.

SUMMARY: The NPS IRST (modified Advanced Demonstration Model Of the AN/SAR-8 IRSTD), has been modified to record display and analyze background scene information in near real time using a commercial frame grabber board in a desktop computer. Image and data processing operations have been applied to 512 by 512 pixel images representing a six degree azimuth scene. Comparative recordings have been made of background scenes using the AGA Thermovission (radiometric raster-scan) imager collocated with the IRST. Equipment has been modified for two-color target ranging measurements using custom narrow-band filters.

Three series of field measurements were made of sun glint effects in target discrimination in both the 3-5 and 8-12 micrometer bands, using the AGA-780 radiometric imager with an external wire grid polarizer. Glint channel profile and degree of polarization have been analyzed. Degree of horizontal polarization from 1% to 30% was found in the glint corridor depending on solar angle and look-down angle. Significant sea surface emission polarization wa also observed outside the glint region. A Gallium Arsenide diode lidar system was built for cloud and target ranging and atmospheric transmission analysis in conjunction with he IRST. An Amber 128 x 128 pixel InSb array famera with 12 bit dynamic range and variable frame rate has been received for comparative measurements with the scanning systems.

PUBLICATIONS: Gregoris, D.J., S. Yu, A. W. Cooper and E. A. Milne, "Dual-Band Infrared Measurements of Sun Glint from the Sea Surface": Characterization, Propagation and Simulation of Sources and Backgrounds II, Dieter Clement and Wendell Watkins, Editors, Proceedings, SPIE 1687, 381-393, (1992).

Cooper, A.W., E. C. Crittenden Jr., E. A. Milne, P. L. Walker, E. Moss and D. J. Gregoris, "Mid and Far Infrared Measurements of Sun Glint From the Sea Surface." Proceedings, SPIE, Vol. 1749,1992.

CONFERENCE PRESENTATIONS: Gregoris,

D.J., S. Yu, Cooper, A. W. and Milne, E. A., "Dual-Band infrared Measurements of Sun Glint from the Sea Surface," paper 1687-53, SPIE Symposium on EO/Aerospace Sensing, Orlando, Florida, 21 April 1992.

Cooper, A. W., Crittenden, E. C., Milne, E. A., Walker, P. L., and Gregoris, D. J., "Mid-and Far-IR Measurements and Analysis of Sea Surface Sunlight," APIE Symposium on Optical Science and Engineering, paper 1749-19, San Diego, CA, 1992.

Lentz, W.J., "High Background Photon Counting LIDAR," Sixteenth International Laser Radar Conference, Boston, MA, July 23 1992, Summary published in NASA Conference Publication 3158 Pt. II, pp 601-604.

THESES DIRECTED: Heiss, John C., LT, USN, "Signal Processing and Displayed Image Improvement for the NPS-IRST," Master's Thesis, June 1992.

Moss, Eric, LT, USN, "Evaluation of the Sun Glint Clutter Channel," Master's Thesis, June 1992.

STRIKE WARFARE SUPPORT

A. W. Cooper, Professor
E. A. Milne, Associate Professor
P. L. Walker, Research Physicist
Department of Physics
Sponsor and Funding: Naval Research Laboratory, Monterey Detachment

OBJECTIVE: To validate and improve current Tactical Decision Aid (TDA) codes for field prediction of performance of operational FLIR devices by comparison of experimental observations with predictions of operational codes. To develop and evaluate improvements to existing codes.

SUMMARY: This is a continuation of a program of evaluation of FLIR Tactical Decision Aid codes by comparison of code predictions of detection range with observations from operational naval aircraft. The naval range prediction models TESS-UFLR and EOTDA MKIII have been compared and evaluated using data from nine series of aircraft overflights by FLIR-carrying aircraft using the R/V POINT SUR instrumented with a meteorological suite land array of skin temperature sensors as target. Aircrew recordings of maximum range for ship detection or recognition have been compared with predictions of the UFLR code (used in the Tactical Environmental Support Systems and also by Fleet Numerical Oceanographic Center) and the EOTDA MKII, and EOTDA MKIII codes recently adapted for navy use. Additional data were gathered during a meteorological research cruise of the R/V POINT SUR in May 1992. Radiometric images of the R/V POINT SUR were taken using an AGA Thermovission system from shore comparison with the ship signature model included in MKIII. Comparisons of measurements with the predictions of both codes using standard and locally developed input parameters have shown serious discrepancies for all codes. An evaluation of the detection criteria for inclusion in the codes was carried out with some

improvement in the prediction accuracy obtained by inclusion in the UFLER code of an adaptation of the NVEOL (Johnson) criterion in place of the Moser/Hepfer pixel condition.

PUBLICATIONS: Cooper, A.W., Walker, P.L., Milne, E. A., and Cook, B.J., "Evaluation of Tactical Decision Aid Predictions of FLIR Range Performance," Characterization, Propagation and Simulation of Sources and Backgrounds II, Dieter Clement and Wendell Watkins, Editors, Proceedings, SPIE 1687, pp. 147-157, (1992).

CONFERENCE PRESENTATIONS: Cooper, A. W., Walker, P. L., Milne, E. A., and Cook, B. J., "Evaluation of Tactical Decision Aid Code Predictions of FLIR Range Performance," paper 1687-15, SPIE Symposium on EO/Aerospace Sensing, Orlando, Florida, 20 April 1992.

FLIR PERFORMANCE PREDICTION CODE VALIDATION SUPPORT

A. W. Cooper, Professor
E. C. Crittenden, Distinguished Professor
E. A. Milne, Associate Professor
P. L. Walker, Research Physicist
W. J. Lentz, Research Associate
Department of Physics

Sponsor: Naval Command Control and Ocean Surveillance Center
R&D Division, (NRaD)
Funding: NCCOSC-NRaD

OBJECTIVE: To validate the improved PREOS T^tactical Decision Aid computer code for prediction of operational FLIR range performance including the SHIPSIG Ship Signature model by comparison with observation from operational naval aircraft; to evaluate SHIPSIG by comparison with AGA thermal image data. This is a cooperative program with NRaD and Naval Surface Warfare Center.

SUMMARY: This is a new program centered around a combined experiment, organized by NACIT at NPS, utilizing the R/V POINT SUR as an instrumented target during a one week cruise in July 1992. The ship was fitted by NPS with an array of surface temperature sensors and a meteorological instrumentation suite. Meteorological, skin temperature distribution, and ship operational data were recorded throughout the cruise. The skin temperature data were supplemented and checked with hand-held radiometer measurements, for input into and comparison with the SHIPSIG code which predicts ship average temperature based on meteorological conditions. Atmospheric profiles were measured periodically with Rawinsonde balloons. A Piper Navajo aircraft operated by NRaD carried an AGA Thermovission infrared imager and atmospheric profiling equipment. NPS arranged and coordinated eight flight periods of dedicated marine patrol aircraft from NAS Moffett Field, during which observations were made of FLIR detection range bow, port and starboard aspects and various altitudes of flight path. Thermal image information from NRaD aircraft will be coordinated with thermal

sensor data to develop ship average temperatures with SHIPSIG ship temperature predictions. During the entire period of the experiment with the exception of one day, extreme overcast conditions were encountered, giving conditions unsuitable for application of the PREOS and SHIPSIG programs. Preliminary evaluation of the "clear day" range data indicates good agreement (within about 17%) of PREOS prediction with flight crew observations. Detailed comparisons and reporting will be carried out during 1993.

THESES DIRECTED: Kreitz, J.C., LT, USN, "Preliminary Evaluation of the PREOS Program for Determining Detection Ranges of Airborne FLIR Systems," Master's Thesis, December 1992.

RESEARCH MULTIPLEXED INFRARED MULTISPECTRAL IMAGING

D. S. Davis, Associate professor
Department of Physics
Sponsor: Office of Naval Research
Funding: Naval Postgraduate School

OBJECTIVE: The objectives of this research are to develop and to evaluate the performance characteristics of a new generation of full multiplex imaging and multispectral imaging devices.

SUMMARY: The new generation of devices will work at long (far infrared-millimeter) wavelengths, where efficient focal plane array detector technology is either not available or cannot be developed for practical reasons. The new instruments are based upon a novel scheme in which multiplexing is achieved by means of optically generated Kronocker products, rather than by traditional (Hadamard, cyclic, redundancy, etc.) mask encoding approaches. This scheme is inherently less complex than traditional approaches, and it requires only a pair of discrete (as oppose to focal plane array) detectors for its implementation.

PUBLICATIONS: Cleary, D.D., J. W. Nichols, and D. S. Davis, "Design for an All-reflection Michelson Interferometer," *Applied Optics*, 34, pp. 433-435, 1992.

CONFERENCE PRESENTATION: Davis, D. S. and D. L. Walters, "Polarization-encoded Two Beam Interferometer for Optical Turbulence Measurements along Low-elevation Atmospheric Pats," Optical Society of America Technical Digest, Series 23, pp. 221, 1992. Annual Meeting of Optical Society of America, Albuquerque, NM, 25 September 1992.

THESES DIRECTED: Huguenim, B.D., LT, USN, "Design, Development and Testing of a Prototype Optical System for a Next Generation Multiplexed Imager," Master's Thesis, June 1992.

Metzer, F.J., LT, USN, "Investigation and Development of a Background Compensated Transipendance Photovoltaic Detector System", Master's Thesis, December 1992.

Barbour, C.S., LCDR, USN, "A Prototype Two-Beam Interferometer for Optical Turbulence Measurements", Master's Thesis, December 1992.

PATENT: Davis, D.S., "An Efficient and Versatile Method and Apparatus for Multiplexed Imaging using Optically Generated Kronocker Products", Navy Case 74667; PTO Serial No. 07/973099.

OTHER: The investigator is preparing additional publications on multiplexed imaging and multiplexed multispectral imaging, to appear in the refereed archival literature.

ELECTRO-OPTIC WIDE ARE SURVEILLANCE

David L. Fried, Research Professor
Department of Physics
Sponsor and Funding: United States Air Force - Rome Laboratory

OBJECTIVE: The goal of this project is the definition of and the development of supporting analysis concerning the performance of electro-optic sensors for wide area surveillance from a high altitude aircraft. Emphasis is being placed on the evaluation of expected noise level and its strength, with particular emphasis to be placed on the study of background clutter-pattern induced noise. Electro-optic system design parameters will be studied in terms of their relationship to search rate and sensitivity.

SUMMARY: A sensor concept has been formulated that appears suitable for use on an AWACS type aircraft for very long range detection of theater ballistic missiles during their boost phase. Initial analysis suggests adequate sensitivity out to a range of about 750 km, where the horizon (the need to keep the line of sight above cloud tops) is the limiting factor. Sensor details are being refined and a document supporting the analysis is being prepared.

The definition of the sensor is being formulated in such a way that it will be able to serve as a basis for defining a data collection undertaken by the sponsor. It will also serve to provide a basis for the start of an analysis, to be conducted under this program, of background clutter leakage applicable to this type of sensor.

Work on this project was started in October 1992. It is funded for one year with plans for its continuation for a total of three years.

ATMOSPHERIC TURBULENCE RELATED EFFECTS

David L. Fried, Research Professor
Department of Physics
Sponsor and Funding: Naval Research Laboratory

OBJECTIVE: The goal of this project is provide analytic support for the development of BOA (Big Optical Array) being conducted by the Naval Research Laboratory. Analysis will be conducted related to both astronomical imaging or artificial satellites.

SUMMARY: Work has been conducted related to the matter of the extent to which atmospheric turbulence

limits the achievable precession in astronomy. The objective here has been to establish the precession with which the separation between two stars can be determined when a very long baseline interferometer is used and a long measurement is employed, and in particular to access the implications of using a shared (or alternating) mode of observation of the two stars rather than providing the necessary hardware to allow use of a mode in which both stars are observed simultaneously.

We have obtained results that confirm earlier predictions (but with about a factor of two pejorative correction) that a measurement precession of the order of ten micro arcseconds ca be achieved, but only if the simultaneous mode of observation is used. (This is expected to be good enough to allow detection of the perturbing effect of large planets orbiting near by stars.) The results of this analysis have been put into a report.

Work is now starting to analyze the effects of photo detection event shot noise. The objective of this work will be to determine the limiting magnitude of stars which can be interferometrically observed, and to determine how the details of the interferometer signal processing system impact the value of this limiting magnitude. Work of this project was started in october 1992.

OTHER: A report titled "Comparison of Turbulence Effects in Dual Simultaneous-Measurement and in Dual Alternating-Measurement Interferometry for Stellar Separation Astronometry," documenting the results of the work on turbulence limits to astronometry has been prepared and submitted to the sponsor.

THERMOACOUSTIC LIFE SCIENCES REFRIGERATOR (TALSR)

S. L. Garrett, Professor of Physics and Space Systems Engineering
Space Systems Academic Group
Sponsor: NASA Life Sciences Division and General Electric Government Services
Funding: General Electric and Naval Postgraduate School

OBJECTIVE: To design, fabricate, and space-qualify, a thermoacoustic refrigerator which would be suitable for storage of biological samples on the Space Shuttle.

SUMMARY: The ThermoAcoustic Life Sciences Refrigerator is designed to be a complete refrigeration system which can be used on-board the Space Shuttle to provide cooling for biological samples. It is required to provide 700 Btu/hr of cooling at 4 °C in the "refrigerator mode" and 400 Btu/hr of cooling at -22 °C in the "freezer mode" within an insulated enclosure with a volume of approximately 2 cubic feet. Due to the similarity of TALSR to a home refrigerator/freezer, it is being developed for NASA under a Co-operative Research and Development Agreement with General Electric Government Services.

PUBLICATIONS: Garrett, S. L.,

"ThermoAcoustic Life Sciences Refrigerator: Preliminary Design Study", NASA Technical Report No. LS-10114, October 1991.

OTHER: Garrett, S.L., "ThermoAcoustic Life Sciences Refrigerator: Heat Exchanger Design and Performance Prediction", 14 June 1992. 65 pages, 11 figures, and 17 tables, 22 references.

Garrett, S.L., "SPACEHAB ThermoAcoustic Refrigerator: Task Descriptions and Development Plan", 18 February 1992. 30 pages, 7 figures, 4 tables, and 17 references.

SPACE THERMO-ACOUSTIC REFRIGERATOR

S. L. Garrett, Professor of Physics
Space Systems Academic Group
Sponsor: Naval Research Laboratory-Spacecraft Engineering
Funding: U. S. Air Force Space Test Program, Naval Research Laboratory and NPS

OBJECTIVE: To design, fabricate, and space-qualify, a thermoacoustic cryocooler suitable for flight as a Get Away Special on the Space Shuttle.

SUMMARY: The Space ThermoAcoustic Refrigerator (STAR) was an experiment that was launched on the Space Shuttle Discovery (STS-42) as a Get Away Special (NASA G-337) on january 22, 1992. 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 (microprocessor, 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).

PUBLICATIONS: Garrett, S.L., J.A. Adeff, and T.J. Hofler, "ThermoAcoustic Refrigeration for Space Application," *Naval Research Review*, 44 (2), 17-25 (1992).

Garrett, S.L., "ThermoAcoustic Refrigerators," *Journal Acoustical Society of America*, 91(1), pp. 517-518 (1992).

Garrett, S.L., and T.J. Hofler, "ThermoAcoustic Refrigeration," *American Society of Heating, Refrigeration, and Air Conditioning Engineers Journal*, (ASHRE), 34(12), pp. 28-36 (1992).

CONFERENCE PRESENTATIONS: Garrett, S.L., "ThermoAcoustic Refrigeration for Space Applications," American Institute of Aeronautics and Astronautics, Hunsville, Alabama, 25 March, 1992, paper No. 92-1712, 10 pages.

Garrett, S.L., T.J. Hofler, and D.L. Gardner, "TermoAcoustic Refrigeration Research at NPS," proceedings XIV International Congress on Acoustics, Beijing, China, 3-10 September 1992, Acoustica 76(4), 3 (1992); Vol I, paper A4-1.

THIRD GENERATION THERMOACOUSTIC REFRIGERATOR (FY 1992)

Thomas, J, Hofler, Assistant Professor
Department of Physics
Sponsor: Naval Research Laboratory
Naval Space Technology Program (Code: SPAWAR 004-4)
Funding: Naval Research laboratory

OBJECTIVE: The primary long term objective is to develop the third generation TermoAcoustic Refrigerator (TARIII), or cryocooler, prototype. The performance goal is to obtain much colder temperatures, hopefully approaching 80º K. The intended application is to cool detectors and superconducting electronics in space, with high reliability and low vibration. The secondary short term goal is to study numerical solutions of the thermoacoustic theory i order to better understand the general concepts, and to optimize solutions for prototype development. This is a continuing project.

SUMMARY: Two experimental third generation TAR engines are pursued. The first design sacrifices some thermal performance in exchange for simplicity, and the second adds the complexity of a mass element component in order to enhance the thermal performance.

The first experimental TAR III engine was almost completed. A numerical model indicates that it should achieve 125 deg.Kelvin with a cooling power of 1.5-3 watts, and an efficiency of 12%-16% of Carnot.

The mass element is a critical component in the second experimental engine. The characteristics of two different mass element designs were measured in non-refrigerating experiments. The first validated the basic concept at low amplitudes, but exhibited instabilities at high amplitudes, and the second eliminated the instability problem. A detailed numerical model for arbitrary thermoacoustic heat engines was largely completed and the design for the first engine was analyzed. The software consists of 2,000 lines of documented C code, that has been extensively tested.

Various improvements to the experimental system have been built and tested. The NRL contract to an external vendor to provide acoustic drivers did not work out, and this work was recently undertaken at NPS.

CONFERENCE PRESENTATIONS: Hofler, Thomas J., "Theoretical Study of Heat Transport in ThermoAcoustic Stacks Having Arbitrary Plate Separation," Journal Acoustic Society of America 91(4) Pt. 2, 2396, 1992.

THESES DIRECTED: Stokermans, Ron J., CAPT, Canadian Forces, "Comparison Calibration Piezoresistive Microphones for Acoustic Power Measurements," Master's Thesis, December 1992.

Grant, Larry, A., LT, USN, "An Investigation of the Physical Characteristics of a Mass Element Resonator," Master's Thesis, March 1992.

DEVELOPMENT AND EVALUATION OF COLD-SPILL DISPERSION DATA AND MODELS FOR USE AT VANDERBERG AIR FORCE BASE

R. F. Kamada, Adjunct Research Professor
Department of Physics
Sponsor: Air Force Space Systems Division
Funding: Naval Postgraduate School

OBJECTIVE: To obtain and assess available relevant data and atmospheric dispersion models for use in defining toxic hazard corridors from rocket propellent spills and exhausts at Vandenberg Air Force Base.

SUMMARY: a) The NPS Lompoc Valley Diffusion Experiment was evaluated to determine causes of plume dispersion patterns from propellent storage sites at Vandenberg AFB.

b) LINCOM/RIMPUFF, a dispersion model was tested against data from Vandenberg Mountain Iron tracer study.

c) A K-ϵ turbulence closure was developed for the RAMS mesoscale windflow model and tested against the Wangara experiment, and other models.

d) Six diagnostic windflow and diffusion modeling systems were assessed for speed, range of suitability, physics, and use in emergency response at Vandenberg.

e) Kinearized, thermally inclusive, Boussiness equations were solved to extend the LINCOM mesoscale windflow model to non-neutrally stable atmospheric conditions.

f) RAMS was modified to predict explosive fireball and cloud rise in space shuttle, Titan, Atlas, and other large rocket launch aborts.

PUBLICATIONS: Kamada, R.F., "Evaluation of Diagnostic Atmospheric Dispersion Models for Cold-Spill Applications at Vandenberg AFB, California," NPS Technical Report, NPS-PH-93-05, December 1992.
Kamada, R,F., S.A. Drake, T. Mikkelsen, and S. Thykier-Nielsen, "A Comparison of Eight Cases Selected from the Vandenberg AFB Mt. Iron Tracer Study with Results form the LINCOM/RIMPUFF Dispersion Model," NPS Technical Report, NPS-PH-92-06, January 1992.

Skupniewicz, C.E., R.F. Kamada, and S.A. Drake, "Lompoc Valley Diffusion Experiment, Final Report," NPS Technical Report, NPS-PH-92-04, January 1992.

CONFERENCE PRESENTATIONS: Kamada, R. F., T. Mikkelsen, and S. Thykier-Nielsen, "LINCOM/RIMPUFF vs Mt. Iron, a Data/Modeling Comparison," 7th JANNAF Safety and Environmental Protection Subcommittee Meeting, Naval Postgraduate School, Monterey, CA, 10-14 August 1992.

Kamada, R.F. and S.A. Drake, "An e-ϵ Turbulence Closure Scheme for Mesoscale Windflow Models with Large Horizontal/vertical Grid Aspect Ratios," 10th Symposium on Turbulence and Diffusion, Portland, OR, 29 Oct - 2 Nov 1992.

EXTENDING THEORY AND ANALYSIS OF TURBULENT BOUNDARY LAYERS

R. F. Kamada, Adjunct Research Professor
Department of Physics
Sponsor: None
Funding: Unfunded

OBJECTIVE: Extend theory and analysis of turbulent boundary layers to solve operational problems in atmospheric windflow and diffusion.

SUMMARY: a) Convective scaling theory for horizontally homogenous turbulent boundary layers was extended to include baroclinic, surface layer, and entrainment zone effects resulting from shear. The theory agrees with data from the BLX 1983 experiments.

b) An algorithm based on a type of self-affine fractal was developed to distinguish gravity waves form intermittent turbulence and background flow in a nocturnal atmospheric boundary layer. Using data from Boulder Atmospheric Observatory's 300 meter tower, this algorithm appeared to be the only one viable for operational use among eight tested, including Fourier transforms, Richardson number, self-similar Fractals, and various phase relations.

c) Chaos metrics such as self-affine fractals, Lyapunov exponents, and Shannon information entropy were used to analyze the behavior of the logistics difference equation and Henon attractor and compare them with two Lagrangian Monte Carlo particle models and expected results from real turbulent fluids. Distinctions were made between diffusion and dispersion versus wave behavior.

PUBLICATIONS: Kamada, R.F., "Amending the w* Velocity Scale for Surface Layer, Entrainment Zone, and Baroclinic Shear in Mixed Forced/Free Turbulent Convection," NPS Technical Report, NPS-PH-92-07, March 1992.

Kamada, R.F., "A Self-Affine Multi-fractal Wave/Turbulence Discrimination Method Using Data from Single Point Fast Response Sensors in a Nocturnal Atmospheric Boundary Layer," NPS Technical Report, NPS-PH-92-08, April 1992.

CONFERENCE PRESENTATIONS: Kamada, R.F., "Generalizing w* to Mixed Forced/Free Convection in Dispersion and Boundary Layer Analysis," 10th Symposium on Turbulence and Diffusion, Portland, OR, Oct. 29-Nov. 2, 1992.

Kamada, R.F., "Multi-fractal Analysis of Coherent Structures in Fluid Dynamic Time Series," 10th Symposium on Turbulence and Diffusion, Portland, OR, Oct. 29- Nov. 2, 1992.

THESES DIRECTED: DeCaria, A.J., LT, USN, "Multi-fractal Analysis of Nocturnal Boundary Layer Time Series from the Boulder Atmospheric Observatory," Master's Thesis, March 1992.

Jackson, K.V., MAJ, "The Use of Chaos Metrics to Analyze Lagrangian Particle Diffusion Models," Master's Thesis, June 1992.

NONLINEAR DYNAMICS OF WAVES AND OSCILLATORS

Robert Keolian, Assistant Professor of Physics
Department of Physics
Sponsor and Funding: Naval Postgraduate School

OBJECTIVE: There were three main goals for this last year of this Research Initiation Project: 1) Test for a new propagating "sea state mode" on the surface of water excited by many random interacting waves, 2) Advance our symmetric demodulation method for fiber optic hydrophones, 3) Finish off our work in Magnetic Resonance Imaging (MRI) of oscillatory motion in the cochlea.

SUMMARY: The primary results for this past year in the tasks above were: 1) A depletion in the background surface wave spectrum has been found to propagate, apparently on its own, in our wind-wave tank. We believe this to be the collective mode of sea state that have been looking for (our theoretical and physical understanding of which has also progressed), but this has not yet been conclusively proven. 2) A digital version of our symmetric demodulation technique has been simulated on the computer, the results look promising and informative, and a real time implementation using a Digital Signal Processor has commenced. A digital version of the symmetric algorithm promises a larger dynamic range and low noise floor than the analog version assembled in 1991. 3) The dissemination of our cochlear motion MRI results is nearly complete. We were able to image oscillatory motion from 200-2000 Hz with 50 nm rms noise levels in water and in the cochlea of a living anesthetized rat.

PUBLICATIONS: Denk, W., R. M. Keolian, and W. W. Webb, "Mechanical Response of Frog Saccular Hair Bundles to the Aminoglycoside Block of Mechano-Electrical Transduction," *Journal of Neurophysiology*, 68, 927-932 (1992).

CONFERENCE PRESENTATIONS: Keolian, R.M., W. Denk, S. Ogawa, and L.W. Jelinski, "Imaging Oscillatory Motion: an 'NMR Lock-in Amplifier'," The 33rd. ENC Experimental Nuclear Magnetic Resonance Conference, 29 Mar - 2 Apr 1992.

Keolian, R.M., W. Denk, S. Ogawa, L.W. Jelinski, "Cochlear Fluid Motion Visualized With Magnetic Resonance Imaging," 123rd. Meeting of the Acoustical Society of America, Journal of the Acoustical society of America, 91, Pt. 2, 2398, April 1992.

Atchley, Anthony, et. al., "Lecture Demonstrations in Acoustics," 124th Meeting of the Acoustical Society of America, Journal of Acoustical Society of America, 92, Pt. 2, October 1992.

WAVE TURBULENCE AND SOLITON DYNAMICS

R. M. Keolian, Assistant Professor
A. Larraza, Adjunct Professor
Department of Physics
Sponsor and Funding: Office of Naval Research, Physics Division

OBJECTIVE: This continuing project deals with experimental and theoretical studies of nonlinear random surface wave driven far off equilibrium. Investigations of the self focusing mechanisms of localized nonlinear structures like, kinks, and domain walls are also considered.

SUMMARY: Theoretical investigations of nonlinear interacting random waves driven far off equilibrium have led to the prediction of new propagating collective modes. In the frequency regime where the mean free path of interaction of waves is large compared to the wavelength of the mode, a theory analogous to the theory of Fermi liquids where the role of quasiparticles is played by the surface waves predicts the existence of a longitudinal and a transverse mode. An experiment is being conducted in a large wave tank with fans to create a wind driven background sea state. A computer controlled mechanical paddle modulates the background sea state, with the modulation length smaller than the mean free path. Preliminary results seem to indicate the first observation of the longitudinal collective mode as nondispersive decrease in the background spectral energy density. The propagation speed was determined to be a function of the spectral peak frequency, in qualitative agreement with the theory.

Experimental and numerical investigations of localized structures in parametrically driven nonlinear lattices were also conducted. These structures correspond to breathers, links, and domain walls between modes of a lattice.

PUBLICATIONS: Abreu M., A. Larraza, and E. Thornton, "Nonlinear Transformation of Directional Spectra in Shallow water," *Journal of Geophysical Research*, 97(C10), 15579-15590 (1992).

Denardo, B., B. Galvin, A. Greenfield, A. Larraza, S. Putterman, and W. Wright, "Observation of Localized Structures in Nonlinear Vibratory Lattices: Domain Walls and Kinks," *Physical Review Letters*, 68, 1739-0-1733 (1992).

Denardo, B., A. Larraza, R. M. Keolian, and S. Garrett, "Wave Turbulence and Soliton Dynamics, Final Report for Period April 1992 to December 1991," NPS Technical Report, NPS-PH-92-09, April 1992.

CONFERENCE PRESENTATIONS: Keolian, R., A. Larraza, and B. Denardo, "Dynamics of a Gas of Random Nonlinear waves," 3rd Annual R&D Information Exchange Conference, Naval Surface Warfare Center, Silver Spring, MD, April 1992.

Larraza, A., "Physical Applications of Wave Turbulence: Wind Waves and Classical Collective Modes," in Nonlinear Waves and Weak Turbulence Conference, Cleveland, Ohio, May 1992.

Denardo, B. and A. Larraza, "Far Off Equilibrium Phenomena in Acoustics:

Localized States, Wave Turbulence, and Absorption of Sound by Ansiotropic Noise," Physical Acoustic Summer School, Asilomar, CA, June 1992.

Larraza, A., and R. Keolian, "Collective Modes in Nonlinsear Random Gravity Waves," ONR Nonlinear Ocean Waves Workshop, Washington, D. C., October 1992.

Lawrence, R. T., R. K. Yarber, and R. M. Keolian, "Search for Second Sound in Deep Water Gravity Waves," *Journal of the Acoustical Society of America*, 92, Pt. 2, 2454 (1992).

THESES DIRECTED: Yarber, R.K., "Development and Calibration of Two and Four Wire Water Surface Wave Height Measurement Systems," Master's Thesis, September 1992.

Lawrence, R.T., LT, USN, "Experimental Inquiries Into Collective Sea State Modes in Deep Water Surface Gravity Waves," Master's Thesis, December 1992.

MODULATIONAL SOLITONS IN OPTICAL FIBERS

Andrés Larraza, Adjunct Professor
Bruce Denardo, Adjunct Professor
Steven Garrett, Professor
Department of Physics
Sponsor: Office of Naval Research, Physics Division
Funding: Naval Postgraduate School

OBJECTIVE: This project was intended for analytical and numerical investigations of localized oscillatory structures where both the amplitude and carrier's wave number are modulated. Mechanical equivalents and applications to fiber optic communications and al-optical switching were considered.

SUMMARY: Numerical and analytical investigations of the nonlinear dispersive equations for a lattice and for the continuum mechanics reveal localized standing solutions where both the amplitude and wavenumber are spatially modulated. These structures correspond to domain walls between regions of different wave numbers, and also to kinks between two extended standing wave wavenumber. The domain wall can appear even when the dispersion law is a single-valued function of the wave number, and except for lattices, their existence seems to be highly restricted to very special class of systems. The existence of kinks, on the other hand, is less restrictive, and it is expected for systems such as optical fibers and surface gravity waves. It is expected that kink structures in optical fibers might play a fundamental role on high repetition rate communications, but further research is required.

Self-localized kink structures have been observed in standing surface gravity waves in a parametrically driven annular channel of liquid. The kink regions have substantially greater amplitude and smaller wavelength than the extended mode region, and can exist indefinitely only for sufficiently large drive amplitude.

For lower drive levels, the structures exist as transients that

spontaneously participate in the transition from one mode to a mode with either one less or one more wavelength. in this mode hopping process, the destruction or creation of the wavelength occurs in the kink region. It is very suggestive that a kink assisted mode hoping also takes place in semiconductor diode lasers, where as the temperature or current (which are analogous to the drive frequency or amplitude, respectively) is changed, the frequency can hysterically jump to a different value. An understanding of the dynamics of mode hopping may thus lead to the manufacture of diode lasers with reduced noise characteristics.

PUBLICATIONS: Denardo, B., A. Larraza, S. Putterman, and P. Roberts, "Nonlinear Theory of Localized Standing Waves," *Physical Review Letters*, 69, 597-600 (1992).

CONFERENCE PRESENTATION: Denardo, B., A. Larraza, and C. McClelland, "Kink-Assisted Mode Hopping in a Resonator," Journal of the Acoustical Society of America, 91, Pt.2, 2PA2 (1992).

THESES DIRECTED: McClelland, C.B. McClelland, CAPT, USMC, "Kink Assisted Mode Hopping in a Surface Wave Resonator, Master's Thesis, June 1992.

FACILITIES SUPPORT FOR THE NAVAL POSTGRADUATE SCHOOL LINAC AND FLASH X-RAY MACHINE

X. K. Maruyama, Professor
Department of Physics
Sponsor: Naval Surface Warfare Laboratory
Funding: Naval Postgraduate School

OBJECTIVE: The radiation sources at NPS, the 100 MeV RF electron linear accelerator and the 1.7 MV pulsed flash x-ray machine are required for a number of projects at NPS, including the study of unipolar arcing plasma physics, investigation of novel sources of coherent radiation and radiation effects in materials and electronic devices. These radiation sources are maintained by the Physics department, but are available to a variety of investigators from the Naval Postgraduate School and their associated external collaborators. These radiation source facilities are also used for classroom course instruction.

SUMMARY: The flash x-ray (FXR) machine has been productive this past year of explosive plasma formation electrodes. This investigation revealed that the electron beam from a cathode of a high voltage diode occurs within time scales of nanoseconds and the mechanisms are due to unipolar arcing. In addition to the capability to do basic physics and we maintain the resources to study transient radiation effects. In addition, this program also provides the Naval Postgraduate School the ability to measure rf signatures arising form charge particle beams and related radiators. The FXR resources were also used to study plasma interactions in a plasma opening switch. The linac again proved to its usefulness and uniqueness by with the completion of several theses related to parametric x-radiation and radiation safety.

Because the radiation sources are maintained, we have the capability to make rf pulse measurements such as for EMP effects and to make radiation dose calculations and analyses. Previous year experiments done with the linac on high temperature superconductors have reached publication this past year.

The results of the use of the radiation sources are listed separately under individual project summaries where appropriate. Those listed below are significantly listed under current sponsored projects.

PUBLICATIONS: Bechtold, J., Y.Y. Xue, Z.J. Huanf, E.V. Hungerford, P.H. Hor, C.W. Chu, X.K. Maruyama, H. Backe, F.R. Buskirk, S.M. Connors, D. D. Snyder, Y.C. Jean, and J.W. Farmer, "Defect Size Dependence of Critical Current Density Enhancement for Irradiated YBa2Cu3O7-d," *Physica*, C 191, (1992) 199-204.

Schwirzke, F., M.P. Hallal Jr., X. K. Maruyama, "Ion Formation on the Surfaces of Electrodes," *Nuclear Instruments and Methods in Physics Research*, B67 (1992) 554-559.

Hor, P.H., J. Bechtol, Y.Y. Xue, C.W. Chu, E.V. Hungerford, X.K. Maruyama, H. Backe, F.R. Buskirk, S.M. Connors, Y.C. Jean, and J.W. Farmer, "Irradiation Effects on Flux Pinning and Jc in High Temperature Superconductors," *Physica*, C 185-189 (1991) 2311-2312.

Neighbours, J.R., X.K. Maruyama, A. Gala, D.D. Snyder, D. Galarowicz, "Measurement and Analysis of the Project Evergreen Experiment," Naval Postgraduate School Technical Report, NPS-PH-92-011, August 1992.

PRESENTATIONS: Maruyama, X.K., "Activities at the NPS Linac," contribution to the Photonuclear Gordon Conference, Tilton, NH, 10 August 1992.

PROCEEDINGS: Hor, P.H., J. Bechtol, Y.Y. Xue, C.W. Chu, E.V. Hungerford, X.K. Maruyama, H. Backe, F.R. Buskirk, S.M. Connors, Y.C. Jean, and J.W. Farmer, "Irradiation Effects on Flux Pinning and Jc in High Temperature Superconductors," Proceedings of the Third International Conference on Materials and Mechanics of Superconductivity: High-Temperature Superconductors, 1991.

Bechtol, J., Y. Y. Xue, E. V. Hungerford, R. L. Meng, P. H. Hor, C. W. Chu, X. K. Maruyama, H. Backe, F. R. Buskirk, S. M. Connors, D. D. Snyder, Y. C. Jean, J. W. Farmer, "Radiation Damage Effects in YBa_2CuO_7," Proceedings of the 1992 TCSUH Workshop on HTS Materials, Bulk Processing, and Bulk Applications, Houston, TX, February 27-28, 1992.

CONFERENCE PRESENTATIONS: Schwirzke, F., M. P. Hallal Jr., X. K. Maruyama, "The Physics of 'Vacuum' Breakdown," 1992 High Voltage Workshop, Wright Laboratory, Wright Patterson AFB, Ohio, 20-21 October 1992. (Classified Conference).

Schwirzke, F., M.P. Hallal Jr., X.K. Maruyama, "Onset Breakdown and Formation of Cathode Spots," XV International Symposium of Discharges and Electrical Insulation in Vacuum, Darmstadt, 6-10 September 1992.

OTHER: Current external 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, x-ray transition radiation and x-ray

optics, parametric x-rays.

THESES DIRECTED: Yaw, R.N., "Monte Carlo Analysis of Energy Deposition in Solid State Materials by 400 and 200 MeV Electrons," Master's Thesis, June 1992.

Davison, D.F., "Radiation Survey of the Naval Postgraduate School LINAC," Master's Thesis, June 1992.

Frazier, F.J., "Evaluating Aircraft EMP Survivability Using the Concept of Electromagnetic Stress Envelope," Master's Thesis, December 1992.

NOVEL SOURCES OF COHERENT AND QUASI-COHERENT RADIATION

X. K. Maruyama, Professor
Department of Physics
Sponsor: Naval Surface Warfare Center
Funding: Naval Postgraduate School

OBJECTIVE: There are many interactions between a charge particle and materials which generate coherent and quasi-coherent radiation. These mechanisms have only recently been brought to the attention of experimentalists who can measure them. The sources may show surprisingly unique properties such as spectral brightness, coherence and polarization. In addition, new phenomena do not easily fit into previously established categories. Sonolominescence is one such phenomenon which was partially supported by this project. This project studies novel sources of radiation.

SUMMARY: The latest unique novel source to be studied at the Naval Postgraduate School is parametric x-radiation, which may be characterized as the Bragg scattering of the Coulomb field associated with the electron to produce monochromatic x-radiation. This phenomenon had been observed previously only in the Soviet Union. At the Naval Postgraduate School, we have been able to enhance the production of higher order parametric x-radiation by exploiting the energy dependence of the production and attenuation lengths of x-rays. This discovery shows promise to generate monochromatic higher energy x-rays with a modest electron beam energy. The spectral brightness has potential application for uses such as digital subtraction angiography.

Optical transition radiation studies conducted under this program has produced a value for the normalized emittance of the Naval Postgraduate School linac. Our development of measurement techniques has resulted in a knowledge of a fundamental machine parameter which had not been available for 26 years. This same effort has also allowed us to develop a new beam position monitor in a diffuse screen optical transition radiator.

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. These x-rays have also allowed us to investigate the possibilities to create an x-ray focussing optic.

Our experimental work this past year has concentrated on measurement of the properties of parametric x-radiation. X-ray and optical transition radiation and x-ray optics works have achieved maturity by publication of results. Measurements of the spectrum of sonolominescence was begun and completed this year using facilities both at the Naval Postgraduate School and at Lawrence Livermore National Laboratory.

PUBLICATIONS: Piestrup, M A., D.G. Boyers, C.I. Pincus, Qaintg Li, G.D. Hallewell, M.J. Moran, D.M. Skopik, R.M. Silzer, X.K. Maruyama, D.D. Snyder, G.B. Rothbart, "Observation of Soft X-ray Spatial Coherence from Resonance Transition Radiation," *Physical Review*, A45, 1183-1196, 1992.

Piestrup, M.A., D.G. Boyers, C.I. Pincus, Qiang Li, X.K. Maruyama, D. M. Skopik, R.M. Silzer, M.J. Moran, and G.B. Rothbart, "Observation of Focusing of X-ray Transition Radiation Using Cylindrical Optics," *Applied Physical Letters*, No. 9, 61, pp. 1019, 1992.

Pincus, C.I., M.A. Piestrup, D.G. Boyers, Qiant Li, J.L. Harris, X.K. Maruyama, D.M. Skopik, R.M. Silzer, H.S. Caplan, G.B. Rothbart, "Measurements of X-Ray Emission from Photoabsorption-Edge Transition Radiation," *Applied Physical Letters*, 72, pp. 4300, 1992.

PRESENTATIONS: Maruyama, X.K., M. J. Osborne, S. Evertson, R.B. Fiorito, D.W. Rule, M.A. Piestrup, A. Ho, Q. Li, "First Observation of Enhanced Higher Order Parametric X-radiation," Bulletin American Physical Society, No. 37,pp. 951, 1992, Washington, D. C., April 1992.

Maruyama, X.K., "Optical Transition Radiation Interferometry and Beam Emittance Measurements," Twelfth International Conference on the Applications of Accelerators in Research and Industry, Denton, TX, November 1992.

THESES DIRECTED: Evertson, S.R., "Experimental Considerations of Gigher Orders Parametric X-Rays from Silicon Crystals of Varying Thicknesses," Master's Thesis, June 1992.

Lewia, S.D., "Spectra of Stable Sonolumiscence," Master's Thesis, December 1992.

Carlson, J.T., "Visible Spectrum of Stable Sonoloumінescence," Master's Thesis, December 1992.

Fasanello, T.J., Jr., "Solid State X-Ray Detector Calibration Techniques and Linac Beam Intensity Measurements," Master's Thesis, December 1992.

Dinova, K.L., "Enhanced Higher Order Parametric X-Radiation Production," Master's Thesis, December 1992.

OTHER: Ten invited colloquia at Universities and Laboratories nationwide were presented as a consequence of this project.

UNSPONSORED RESEARCH

X. K. Maruyama, Professor of Physics
Department of Physics
Sponsor: None
Funding: Naval Postgraduate School

OBJECTIVE: The goal of any innovative scientist is to use whatever resources are available to create research results wherever the opportunity presents itself. Some of these results are continuations of research which in the past has had a funded research project, while other arise because the instructional requirements for thesis supervision produce results. Some are investigations initiated with a view towards a future funded project proposal. Not all results fit neatly into the bureaucratic niches.

SUMMARY: The mean free path of protons within nuclei have been measured by (e,e'p) coincidence measurements. The work reported here is the analysis of data taken nearly 6 years ago at MIT Bates Linear Electron Accelerator.

Invited talks were presented to general physics audiences at four institutions with the title: "Confusion Concerning Cold Fusion." In these presentations, the social and scientific background surrounding the cold fusion controversy was discussed.

PUBLICATIONS: Garrino, G., M. Saber, R.E. Segel, D.F. Geesaman, R. Gilman, M.C. Green, R.J. Holt, J.P. Schiffer, B. Zeidman, E.J. Beise, G.W. Dodson, S. Hoibraten, L.D. Pham, R.P. Redwine, W.. Sapp, C.F. Williamson, S.A. Wood, N.S. Chant, P.G. Toos, J.D. Silk, M. Deady, and X.K. Maruyama, "Proton Propagation in Nuclei," *Physical Review*, C45, 780-790, 1992.

SPACE POWER EXPERIMENT ABOARD ROCKET (SPEAR)

R. C. Olsen, Associate Professor
Department of Physics
Sponsor: Defense Nuclear Agency
Funding: Naval Postgraduate School

OBJECTIVE: Support design phase for the SPEAR III project. In particular advise on the charging behavior experienced in SPEAR I, and on instrumentation to be flown in the new mission.

SUMMARY: Work under this project has been preliminary, in attending design meetings. As a result of this work, the SPEAR III payload includes an electrostatic analyzer which will monitor vehicle charging. This launch is now set for February 1993, at which point more meaningful results will be obtained.

PLASMA HEATING AT THE PLASMAPAUSE

R. C. Olsen, Associate Professor
Department of Physics
Sponsor: National Aeronautics and Space Administration
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 ongoing study has concluded. One paper was published, and two papers have been submitted based on work supported by this grant.

PUBLICATIONS: Olsen, R.C., "The Density Minimum at the Earth's Magnetic Equator." *Journal of Geophysical Research*, 97, 1135-1150, 1992.

CONFERENCE PRESENTATIONS: Olsen, R. C., and L.J. Scott, "Equatorially Trapped Plasmas and Parallel Electric Fields," EOS, 72, pp. 401, 1991, Presented at fall meeting of the American Geophysical Union, San Francisco, CA, 9-13 December 1991.

THESES DIRECTED: Braccio, P.G.,"Survey of Trapped Plasmas at the Earth's Magnetic Equator," Master's Thesis, December 1991.

Scoot, L.J., "On the consequences of bi-maxwellian distributions on Parallel Electric Fields," Master's Thesis, December 1991.

SATELLITE CHARGE CONTROL

R. C. Olsen, Associate Professor
Department 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: The flight unit for the POLAR satellite has been completed, and has been delivered for integration. Launch has slipped to 1994. Laboratory work towards a solid state ion source was conducted. A compact, lightweight, and electromagnetically quiet source appears practical. Work in a possible flight design was started. Analysis of electrostatic charging dielectric materials on satellites indicates that it may have a catalytic effect on the development of satellite charging. Analysis of the charging on 1989-046 was conducted.

PUBLICATIONS: Olsen, R.C., R.R. Anderson, and F.S. Mozer, "Plasma Wave Observations During Electron Gun Experiments on ISEE-1," *Journal Advances in Space Research*, 12, (12)29, 1992.

THESES DIRECTED: Melvin, M.E., "Design and Evaluation of Ion Source for Satellite Charge Control." Master's Thesis, June 1992.

Fiely, D.P., "Survey of Spacecraft Charging Behavior for the Geosynchronous Satellite 1989-046." Master's Thesis, March 1992.

DISCHARGE PHYSICS AND UNIPOLAR ARCING

Schwirzke, F. Professor
X. K. Maruyama, Professor
Department 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 from within nanoseconds. Unipolar arcing represents a discharge form which can explain the explosive like formation of cathode spots. Power dissipation for a 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 power discharges. Despite their fundamental importance, the details 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 flash X-ray facility.

PUBLICATIONS: Schwirzke, F., M.P. Hallal Jr., and X.K. Maruyama, "Ion Formation on the Surfaces of Electrodes." *Nuclear Instruments and Methods in Physics Research*, B67, 554-559, 1992.

Schwirzke, F., M.P. Hallal Jr., and X.K. Maruyama, "The Physics of Vacuum Breakdown." 9th. International Conference on High Power Particle Beams, Washington, D. C., 25-29 May 1992.

Schirzke, F., M.P. Hallal Jr., and X.K. Maruyama, "Onset of Breakdown and Formation of Cathode Spots," XV International Symposium on Discharges and Electrical Insulation in Vacuum, Darmstadt, Germany, 6-10 September 1992. IEEE Catalog Number 92CH3192-2, ISBN 3-8007-1856-1, pp. 149-153. (Invited Paper).

CONFERENCE PRESENTATIONS: Schwirzke, F., M.P. Hallal Jr., and X.K.

Marruyama, "Onset of Breakdown and Formation of Cathode Spots." Conference Record, IEEE Catalog No. 9THO460-6, 1992 IEEE International Conference on Plasma Science, 1-3 June 1992, Tampa, Florida, p.116.

Schwirzke, F., M.P. Hallal Jr., and X.K. Maruyama, "The Physics of Vacuum Breakdown," 9th. International Conference on High Power Particle Beams, Washington, D. C., 25-29 May 1992.

Schwirzke, F., "Cathode Spots, Hot Spots for Impurities Release." 10th. International Conference on Plasma Surface Interactions in Controlled Fusion Devices, Monterey, CA, 30 March - 3 April 3, 1992.

Schwirzke, F., "Onset of Breakdown and Formation of Cathode Spots." Invited Paper, XV International Symposium on Discharges and Electrical Insulation in Vacuum." Darmstadt, Germany, 6-1- September 1992.

Schwirzke, F., "Breakdown and Formation of Cathode Spots." Seminar presentation at Kernforschungsinstitut, Karlsruhe, Germany, 16 September 1992.

Shwirzke, F., "The Physics of Vacuum Breakdown." DoD 1992 High Voltage Workshop, Wright Patterson Air Force Base, Ohio, 20-21 October 1992.

Schwirzke, F., "Onset of Breakdown and Plasma Formation on Electrodes." IX Symposium on High Current Electronics, Russia, 21-30 July 1992.

Schwirzke, F., "Breakdown and Formation of Cathode Spots." 1992 Annual Meeting of the Division of Plasma Physics of the American Physical Society, Seattle, WA., 16-20 November 1992, Abstract published in Bulletin Am. Phys. Society, 1563, 1992.

THESIS DIRECTED: Welsh, David S. "Current Density Limitations in a Fast-Pulsed High-Voltage Diode," Master's Thesis, June 1992.

THE AEROSOL SOURCE FUNCTION OF THE OCEAN

Donald E. Spiel, Research Associate Professor
Department of Physics
Sponsor and Funding: Office of Naval Research

OBJECTIVE: The purpose of this research is to determine the ocean's aerosol source function. That is, to determine how many aerosols of a given size per unit time per unit area are generated by oceanic whitecaps.

SUMMARY: A collapsing bubble can, depending on its size, create aerosols by two distinct mechanisms. The first aerosols to emerge are so-called film droplets which originate form the disruption of the bubble cap by rapid acceleration of the torn cap edges and the escaping bubble gas. The second mechanism for droplet generation arises as a result of the surface tension accelerating the surface in a boundary layer shear flow down the cavity wall. As the water converges at the bottom of the cavity opposing jets are created. The upward jet is unstable and usually breaks up into a number of droplets which are thrust upwards into the air at varying velocities. These are called jet drops.

During the past year a measurement of the number and size and ejection velocities of the jet drops generated by bursting bubbles with sizes ranging from 300 to 3000 micrometers radius has been made. This is a significant milestone. in the past only the size of the top drop and an inferred ejection speed for that drop have been determined.

In the course of this work during the past year, two unexpected and significant discoveries were made. First, it was found that a bursting bubble acts as a Helmholtz resonator. This is important because it permits the determination of bubble size by listening to the signal it generates in the air above the surface. This will allow the determination of the spectrum of bursting bubbles in, say, a whitecap, which heretofore has not been possible. In the end, it will also permit the inference of the aerosol source function by spectral analysis of the sounds of busting bubbles. The second significant discovery is that a bursting bubble emits a strong underwater signal. This is a hitherto undiscovered major source of ambient noise in the ocean. The underwater signals are such that one can infer the size of the bubble generating the sound by listening to the burst. Hence it has been discovered that one can determine the size of a bubble by listening to its burst from either above or below the surface.

PUBLICATIONS: Spiel, Donald E., "Acoustical Measurements of Air Bubbles Bursting at a Water Surface: Bursting Bubbles as Helmholtz Resonators." *Journal of Geophysical Research*, 97, 11443-11454, 1992.

A NEW METHODOLOGY FOR SUPPORTING C3I REQUIREMENTS

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Department of Physics
R. Thackeray, Adjunct Professor
Department of Operations Research
Command and Control Academic Group
Sponsor and Funding: Director Net Assessment, OSD

OBJECTIVE: The goal of this project was to develop and exercise a new methodology for assessing the contribution of non-organic sensor information on the effectiveness of a battle force.

SUMMARY: A new three element methodology is being developed to achieve the program objective. The key element of the methodology is a uniquely designed wargame where the non-organic information can be treated as the experimental variable affecting the tactical choices and decisions made by the commanders. The initial phase of the current program has been concerned with adapting this methodology to Contingency type operations against land targets as well as air warfare options of importance in littoral warfare. The game support package is being modified to make this possible and with cooperation from SPAWAR realistic non-organic information flow is being generated. AAW tactics for use in littoral warfare have not yet been fully developed, but we are making use of the latest results from exercises and analyses.

OTHER: Progress during this period has been documented in working papers and reports covering the Gaming Research and Analysis Support System, a critical review of the Strike Campaign model to be used, Pre-Game Orientation and Basic Background, etc.

ACOUSTIC SOUNDER CHARACTERIZATION FOR THE AIR FORCE 4m TELESCOPE AT AMOS

D. L. Walters, Associate Professor
Department of Physics
Sponsor: Phillips Laboratory
Funding: US Air Force

OBJECTIVE: To provide Winter-Spring measurements of the mountain turbulent surface layer in order to assess the benefit on a pedestal for 4m telescope.

SUMMARY: The performance of the 4m telescope under construction at Mt. Haleakala, HI, depends on the thickness of the turbulent surface layer. If this were typical, then the performance of the telescope could be doubled by placing it on a 4m tower. Since a pedestal involves a significant cost, measurements in other seasons were needed to determine id the June-July results were typical and representative of other seasons. Measurements collected during March 1992 showed a similar 20m layer, but with more complex patterns produced by the winter storm frontal movements.

THESES DIRECTED: Gast, V.J., LT, USN, "Characterization of Atmospheric Turbulence for High Resolution Imaging and Laser Propagation Objectives," Master's Thesis, December 1992.

OTHER: Results Presented at the first Adaptive Optics Conference, Lahaina, HI.

ACOUSTIC SOUNDER CHARACTERIZATION FOR THE AIR FORCE THEATER MISSILE DEFENSE PROGRAM

D. L. Walters, Associate Professor
Department of Physics
Sponsor: Phillips Laboratory
Funding: US Air Force

OBJECTIVE: To use the NPS high resolution acoustic sounder to perform optical turbulence measurements for a 3 km, horizontal path, Theater Missile Defense Intelligence.

SUMMARY: The US Air Force Airborne Laser Technology Insertion Program included a horizontal path adaptive optics experiment. This experiment needed precise measurements of optical turbulence in the middle of a 3 km path, 70m above the ground to insure accurate simulation of atmospheric propagation conditions found in the stratosphere. After considering many alternatives, this was accomplished using NPS acoustic sounder in two phases. The first

phase involved calibration of the sounder results during 28-30 April 1992, against thermal probes mounted on a 40m tower near the test range. The second phase involved the measurements from a small hill located at mid-path. After a second calibration in August 1992, the instrument provided optical measurements during 13 adaptive optical experiments conducted during September-October 1992 at the Starfire Optical Range, New Mexico.

THESES DIRECTED: Gast, V.J., LT, USN, "Characterization of Atmospheric Turbulence for High Resolution Imaging and Laser Propagation," Master's Thesis, December 1992.

ATMOSPHERIC OPTICAL TURBULENCE DEVELOPMENTS

D. L. Walters, Associate Professor
Department of Physics
Sponsor: Phillips Laboratory
Funding: US Air Force

OBJECTIVE: To assist the Starfire Optical Range in the development of atmospheric optical equipment, collection of optical data, systems calibrations and software support.

SUMMARY: During 1992 the Airborne Laser Program became a high priority task in the US Air Force Phillips Laboratory. Reflecting these changes, starting in June 1992, we devoted nearly all of our effort to the development of a four probe balloon sensor to determine the magnitude land spatial distribution of stratospheric turbulence. A key goal was to determine if stratospheric turbulence had a Kolmogorov distribution or not. If so, existing theoretical procedures would be applicable for systems analyses. By making measurements between four probe pairs with different separations we could measure the atmospheric structure function directly, verifying the Kolomogorov dependence. During July we developed a four probe sensor design, electronic package, telemetry and calibration procedures. After fabrication the circuit components had our first launch on 1 August 1992 with probe pair separations of 12, 25, 50 and 100 cm. A series of eight launches occurred during August and December. Each launch resolved problems and answered questions found during previous launches. These efforts culminated in the successful joint Air Force NPS experiments conducted in November 1992 between de ARGUS KC-135 aircraft and the Geophysics Directorate balloon sensor package. These experiments verified the consistency of the three different approaches used to perform stratospheric measurements. We found that turbulence in the stratosphere was Kolmogorov over the 25-100 cm range but that it appeared in very thin layers perhaps 10 m or thinner.

THESES DIRECTED: Rahl, W., LT, USCG, "Investigation of a CCD Camera for Measurement of Optical Atmospheric Turbulence," Master's Thesis, March 1992.

Gast, V.J., LT, USN, "Characterization of Atmospheric Turbulence for High Resolution Imaging and Laser Propagation Objectives," Master's Thesis, December 1992.

Roper, D., CAPT, USA, "Investigation of Systematic Effects in Atmospheric Microthermal Probe Data," Master's Thesis, December 1992.

DEPARTMENT OF PHYSICS

1992 Faculty Publications and Presentations

TECHNICAL REPORTS

Denardo, B., Larraza, A., Keolian, R.M., and Garrett, S.,"Wave Turbulence and Soliton Dynamics," NPS Technical Report, NPS-PH-92-09, April 1992.

Garrett, S.L., "ThermoAcoustic Life Sciences Refrigerator: Preliminary Design Study", NASA Technical Report No. LS-10114, 31 October 1991.

Kamada, R.F., "Evaluation of Diagnostic Atmospheric Dispersion Models for Cold-Spill Applications at Vandenberg AFB, California," NPS Technical Report, NPS-PH-93-05, December 1992.

Kamada, R.F., Drake, S.A., Mikkelsen, T., and Thykier-Nielsen, S., "A Comparison of Eight Cases Selected from the Vandenberg AFB Mt. Iron Tracer Study with Results form the LINCOM/RIMPUFF Dispersion Model," NPS Technical Report, NPS-PH-92-06, January 1992.

Kamada, R.F., "Amending the w* Velocity Scale for Surface Layer, Entrainment Zone, and Baroclinic Shear in Mixed Forced/Free Turbulent Convection," NPS Technical Report, NPS-PH-92-07, March 1992.

Kamada, R.F., "A Self-Affine Multi-fractal Wave/Turbulence Discrimination Method Using Data from Single Point Fast Response Sensors in a Nocturnal Atmospheric Boundary Layer," NPS Technical Report, NPS-PH-92-08, April 1992.

Neighbours, J.R., Maruyama, X.K., Gala, A., Snyder, D.D., Galarowicz, D., "Measurement and Analysis of the Project Evergreen Experiment," NPS Technical Report, NPS-PH-92-011, August 1992.

Skupniewicz, C.E., Kamada, R.F., and Drake, S.A., "Lompoc Valley Diffusion Experiment," NPS Technical Report, NPS-PH-92-04, January 1992.

Wilson, O.B. and Baker, S.R., "Sonar Transducer Perfromance Monitoring and Prediction," NPS Technical Report NPS-PH-93-002, October 1992.

JOURNAL ARTICLES

Abreu, M., Larraza, A., and Thornton, E., "Nonlinear Transformation of Directional Spectra in Shallow Water," *Journal of Geophysical Research*, 97(C10), 15579-15590 (1992).

Atchley, A.A., "Standing Wave Analysis of a Thermoacoustic Prime Mover Below Onset of Self-Oscillation," *Journal of Acoustical Society of America*, 92, 2907-2914 (1992).

Atchley, A.A., Bass, H.E., Hofler, T.J., and Lin, H.T., "Study of a Thermoacoustic Prime Mover Below Onset of Self-Oscillation," *Journal Acoustical Society of America*, **91, pp. 734-743 (1992).**

Bechtold, J., Xue, Y.Y., Huanf, Z.J., Hungerford, E.V., Hor, P.H., Chu, C.W., Maruyama, X.K., Backe, H., Buskirk, F.R., Connors, S.M., Snyder, D.D., Jean, Y.C., and Farmer, J.W., "Defect Size Dependence of Critical Current Density Enhancement for Irradiated YBa2Cu3O7-d," *Physica*, C 191, (1992), pp. 199-204.

Bice, C.A. and Colson, W.B., "The CEBAF Ultraviolet FEL Experiment," *Nuclear Instruments and Methods in Physics Research*, A318, pp. 606-611, (1992).

Blau, J. and Colson, W.B., "Four Dimensional Simulations of the CEBAF Infrared Free Electron Laser," *Nuclear Instruments and Methods in Physics Research*, A318, pp. 717-720 (1992).

Brown, D.A., Gardner, D.L., and Garrett, S.L., "Fiber-Optic Interferometric Push-Pull Hydrophones," *Naval Research Review*, Office of Naval Research, Vol. XLIV, pp. 17-22, 1992.

Brown, D.A., "Parallel-Wrapped Ellipsoidal Shell Acoustic Sensors," 8th. Optical Fiber Sensors Conference - Interferometry II, *OFS '92*, January 1992.

Clark, D. and Colson, W.B., "The CEBAF Infrared Free Electron Laser," *Nuclear Instruments and Methods in Physics Research*, A318, pp. 612-616 (1992).

Cleary, D.D., Nichols, J.W., and Davis, D.S., "A New Design for an All-Reflection Michelson Interferometer," *Applied Optics*, 31, pp. 433, 1992.

Davis, D.S. and Walters, D.L., "Polarization-Encoded Two Beam Interferometer for Optical Turbulence Measurements Along Low-Elevation Atmospheric Paths," *Optical Society of America Technical Digest*, Series 23, p. 221, 1992.

Denardo, B., Galvin, B., Greenfield, A., Larraza, A., Putterman, S., and Wright, W., "Observation of Localized Structures in Nonlinear Vibratory Lattices: Domain Walls and Kinks," *Physical Review Letters*, 68, 1739-0-1733 (1992).

Denardo, B., Larraza, A., Putterman, S., and Roberts, P., "Nonlinear Theory of Localized Standing Waves," *Physical Review Letters*, 69, 597-600 (1992).

Denk, W., Keolian, R.M., and Webb, W.W., "Mechanical Response of Frog Saccular Hair Bundles to the Aminoglycoside Block of Mechano-Electrical Transduction," *Journal of Neurophysiology*, 68, pp. 927-932 (1992).

Fried, D.L. and Vaughn, J.L., "Branch Cuts in the Phase Function," *Journal of Applied Optics*, 31, pp. 2865-2882, 1992.

Gaitan, D.F., Crum, L.A., Church, C.C., and Roy, R.A., "Sonoloumines cence and Bubble Dynamics for a Single, Stable Cavitation Bubble," *Journal Acoustical Society of America*. Vol.91, pp. 3166-3183, 1992.

Gardner, D.L., Brown, D.A., and Garrett, S.L., "Fiber-Optic Push-Pull Sensor Systems Research at NPS," *Acoustica*, 76(4), 106, 1992; Vol IV, Paper M1-1, 2 pages.

Garrett, S.L., Adeff, J.A., and Hofler, T.J., "ThermoAcoustic Refrigeration for Space Application," *Naval Research Review*, 44 (2), pp. 17-25 (1992).

Garrett, S.L., "ThermoAccustic Refrigerators," *Journal Acoustical Society of America*, 91(1), 517-518 (1992).

Garrett, S.L., and Hofler, T.J., "ThermoAcoustic Refrigeration," *Journal American Society of Heating, Refrigeration and Air Conditioning Engineers.* (ASHRE Journal), 34(12), pp. 28-36 (1992).

Garrino, G., Saber, M., Segel, R.E., Geesaman, D.F., Gilman, R., Green, C., Holt, R.J., Schiffer, J.P., Zeidman, B., Beise, E.J., Dodson, W., Hoibraten, S., Phma, L.D., Redwine, R.P., Sapp, W.W., Williamson, C.F., Wood, S.A., Chant, N.S., Toos, P.G., Silk, J.D., Deady, M., and Maruyama, X.K., "Proton Propagation in Nuclei," *Physical Review*, C45, 780-790, 1992.

Hor, P.H., Bechtol, J., Xue, Y., Chu, C.W., Hungerford, E.V., Maruyama, X.K., Backe, H., Buskirk, F.R., Connors, S.M., Jean, Y.C., and Farmer, J.W., "Irradiation Effects on Flux Pinning and Jc in High Temperature Superconductors," *Physica*, C 185-189 (1991) 2311-2312, 1992.

Lawrence, R.T., Yarber, R.K., and Keolian, R.M., "Search for Second Sound in Deep Water Gravity Waves," *Journal of the Acoustical Society of America*, 92, Pt. 2, 2454 (1992).

Kapolka, D., Brown, D.A., Gardner, D.L., and Garrett, S.L., "Composite Fiber Optic Flexural Disk Hydrophones," *Journal of Acoustical Society of America*, 91, Suppl.4, pp S2324, May 1991.

Piestrup, M.A., Boyers, D.G., Pincus, C.I., Li, Q., Hallewell, G.D., Moran, M.J., Skopik, D.M., Silzer, R.M., Maruyama, X.K., Snyder, D.D., Rothbart, G.B., "Observation of Soft X-ray Spatial Coherence From Resonance Transition Radiation," *Physical Review*, A45, 1183-1196, 1992.

Piestrup, M.A., Boyers, D.G., Pincus, C.I., Li, Q., Maruyama, X.K., Skopik, D.M., Silzer, R.M., Moran, M.J., and Rothbart, G.B., "Observation of Focusing of X-Ray Transition Radiation Using Cylindrical Optics," *Applied Physics Letters*, 61, 1992, 1019.

Pincus, C.I., Piestrup, M.A., Boyers, D.G., Li, Q., Harris, J.L., Maruyama, X.K., Skopik, D.M., Silzer, R.M., Caplan, H.S., Rothbart, G.B., "Measurements of X-Ray Emission from Photoabsorption-Edge Transition Radiation," *Applied Physics*, 72, 4300, 1992.

Olsen, R.C., "The Density Minimum at the Earth's Magnetic Equator." *Journal of Geophysical Research*, 97, 1135-1150, 1992.

Olsen, R.C., Anderson, R.R., and Mozer, F.S., "Plasma Wave Observations During Electron Gun Experiments on ISEE-1," *Journal Advances of Space Research*, 12, (12)29, 1992.

Schwirzke, F., Hallal, M.P., Jr., and Maruyama, X.K., "Ion Formation on the Surfaces of Electrodes." *Nuclear Instruments and Methods in Physics Research*, B67, 554-559, 1992.

Schwirzke, F., Hallal, M.P., Jr., and Maruyama, X.K., "Onset of Breakdown and Formation of Cathode Spots," *IEEE Catalog* Number 92CH3192-2, ISBN 3-8007-1856-1, pp. 149-153.

Spiel, D.E., "Acoustical Measurements of Air Bubbles Bursting at a Water Surface: Bursting Bubbles as Helmholtz Resonators." *Journal of Geophysical Research*, 97, 11443-11454, 1992.

Sturgess, K.A. and Colson, W.B., "An Analytic Description of Longitudinal Modes in Free Electron Lasers," *Nuclear Instruments and Methods in Physics Research*, A318, 576-581 (1992).

Sternberg, J., Isbell, W.M., Anderson, E.E., Asay, J.R., Bless, S.J., and Grady, D.E., "Penetration Mechanics Research in the Former Soviet Union," Foreign Applied Sciences Assessment Center, *Technical Assessment Report*, September 1992.

CONFERENCE PROCEEDINGS

Bechtol, J., Xue, Y.Y., Hungerford, E.V., Meng, R.L., Hor, P.H., Chu, C.W., Maruyama, X.K., Backe, H., Buskirk, F.R., Connors, S.M., Snyder, D.D., Jean, Y.C., and Farmer, J.W., "Radiation Damage Effects in YBa2CuO7," Proceedings of the 1992 TCSUH Workshop on HTS Materials, Bulk Processing, and Bulk Applications, Houston, TX, 27-28 February 1992.

Brown, D.A. and Garrett, S.L., "Resonant Acoustic Determination of Complex Elastic Moduli," *Technology 2001,* **the Second National Technology transfer Conference and Exposition, NASA, pp. 32-40, December 1991.**

Cameron, C.B., Keolian, R.M., and Garrett, S.L., "A Simetric Analog Demodulator for Optical Fiber Interferometric Sensors," Proceedings 34th Midwest Symposium on Circuits and Systems of IEEE, Vol 2, 666-671, 1992.

Cooper, A.W., Crittenden E.C., Jr., Milne, E.A., Walker, P.L., Moss, E., Moss, E., and Gregoris, D.J., "Mid and Far Infrared Measurements of Sun Glint From the Sea Surface." Proceedings SPIE Vol. 1749, 1992.

Brown, D.A., Gardner, D.L., and Garrett, S.L., "Fiber Optic Interferometric Push-Pull Hidrophones," Naval Research Review, 44(1), 17-22, 1992.

Cooper, A. W., Walker, P.L., Milne, E. A., and Cook, B. J., "Evaluation of Tactical Decision Aid Predictions of FLIR Range Performance," Characterization, Propagation and Simulation of Sources and Backgrounds II, Dieter Clement and Wendell Watkins, Editors, Proc. SPIE 1687, pp. 147-157, (1992).

Gardner, D.L., Garrett, S.L., and Brown, D.A., "Fiber-Optic Push-Pull Hydrophone Systems," Procceedings Third International Workshop on Transducers for sonics and Ultrasonics, 6-8 May 1992, Orlando, Florida.

Garrett, S.L., "ThermoAcoustic Refrigerators," Journal Acoustic Society of America, 91(1), 517-518, 1992.

Garrett, S.L. and Hofler, T.J., "ThermoAcoustic Refrigeration," American Society Heating, Refrigeration, Air Conditioning Engineers. (ASHRE Journal). 34(12), 28-36, 1992.

Garrett, S.L., Adeff, J.A., and Hofler, T.J., "ThermoAcoustic Refrigeration for Space Application," Naval Research Review, 44(2),17-25, 1992.

Garrett, S.L., "TermoAcoustic Rifrigeration for Space Applications," American Institute of Aeronautics and Austronautics, Huntsville, AL, 25 March 1992. Paper Number 92-1712.

Garret, S.L., Hofler, T.J., and Gardner, D.L., "ThermoAcosutic Refrigeration Rsearch at NPS," Proceedings XIV International Congress on Acoustics, Beijing, China, 3-10 September 1992, Acoustica, 76(4), 3(1992); Vol. I, Paper a4-1.

Gregoris, D.J., Yu, S., Cooper, A.W. and Milne, E.A., "Dual-Band Infrared Measurements of Sun Glint from the Sea Surface": Characterization, Propagation and Simulation of Sources and Backgrounds II, Dieter Clement and Wendell Watkins, Editors, Proc. SPIE 1687, 381-393, (1992).

CONFERENCE PRESENTATIONS

Atchley, A., Keolian, R., Bolen, L., Crum, L., Korman, M., Kuhl, P., West, J., Blassengame, R., Campbell, N., Dunn, B., Gordon, S., Thomas, T., and Walker, K., "Lecture Demonstrations in Acoustics," 124th Meeting of the Acoustical Society of America, Journal of Acoustical Society of America, 92 Pt. 2, October 1992.

Atchley, A.A., "Standing Wave Analysis of the Low Amplitude Performance of a Thermoacoustic Prime Mover," 123rd Meeting of the Acoustical Society of America, Salt Lake City, UT, May 1992, Journal Acoustical Society America 91 No. 4, Pt.2, 2396(A) (1992).

Baker, S.R., Canright, D.R., and Scandrett, C.L., "Application of the T-Matrix Method to Low-Frequency Active Sonar Array Performance Modeling" presented at the Third International Workshop on Transducers for Sonics and Ultrasonics, Orlando, FL, 6-8 May 1992.

Bechtold, J., Sue, Y.Y., Hungerford, E.V., Meng, R.L., Hor, P.H., Chu, C.W., Maruyama, X.K., Backe, H., Buskirk, F.R., Connors, S.M., Snyder, D.D., Jean, Y.C., and Farmer, J.W., "Radiation Damage Effects in YBa_2CuO_7," 1992 TCSUH Workshop on HTS Materials, Bulk Processing, and Bulk Applications, Houston, TX, February 27-28, 1992.

Blau, J. and Colson, W.B., "Amplification of Short Optical Pulses in the Boeing APLE Amplifier," Fourteenth International Free Electron Laser Conference, Kobe, Japan, August 1992.

Blau, J., Frost, D.J., and Colson, W.B., "Micropulse Slippage and Optical Mode Distortion in the Boeing APLE Amplifier," 14th. Annual Free Electron Laser Conference, Kobe, Japan, August 1992.

Brown, D.A., "Parallel-Wrapped Ellipsoidal Shell Acoustic Sensor," 8th Optical Fiber Sensors Conference-Interferometry II, OFS'92, January 1992.

Caudle, D.L., LT, and Colson, W.B., "Limit-Cycle Behavior in the CEBAF IR Free Electron Laser," Fourteenth International Free Electron Laser Conference, Kobe, Japan, August 1992.

Colson, W.B., "Analogies Between the Free Electron Laser and Whistler Mode Amplification in the Magnetosphere," presented at the Fourteenth International Free Electron Laser Conference, Kobe, Japan, August, 1992.

Colson, W.B., "Whistler Simulations at the Naval Postgraduate School," Presentation at the Office of Naval Research Space Plasma Workshop, Washington DC, April 1992.

Colson, W.B., "1992 Free Electron Laser Prize Winners," Presentation of the 1992 FEL Prize at the Fourteenth International Free Electron Laser Conference, Kobe, Japan, August 1992.

Cooper, A.W., Crittenden, E.C., Milne, E.A., Walker, P.L., and Gregoris, D.J., "Mid-and Far-IR Measurements and Analysis of Sea Surface Sun Glint," APIE Symposium on Optical Science and Engineering, paper 1749-19, San Diego, CA, 1992.

Cooper, A.W., Walker, P.L., Milne, E.A., and Cook, B.J., "Evaluation of Tactical Decision Aid Code Predictions of FLIR Range Performance," paper 1687-15, SPIE Symposium on EO/Aerospace Sensing, Orlando, Florida, 20 April 1992.

Davis, D.S. and Walters, D.L., "Polarization-Encoded Two Beam Interferometer for Optical Turbulence Measurements Along Low-Elevation Atmospheric Pats," Optical Society of America Technical Digest, Series 23, pp. 221, 1992. Annual Meeting of Optical Society of America, Albuquerque, NM, 25 September 1992.

Denardo, B., "Nonlinear Waves: Self-Localized Structures and Absorption of Sound by Anisotropic Noise," Physics Department and National Center for Physical Acoustic Colloquium, University of Mississippi, MS, 5 November 1992. (Attendance: 50).

Denardo, B., Galvin, B., Greenfield, A., Larraza, A., Putterman, S., and Wright, W., "Observation of Localized Structures in Nonlinear Vibratory Lattices: Domain Walls and Kinks," University of California Nonlinear Science Conference, Irvine, CA, February 1992. (Attendance: 50)

Denardo, B., Larraza, A., and McClelland, C., "Kink-Assisted Mode Hopping in a Resonator," Journal of the Acoustical Society of America, 91, Pt.2, 2PA2 (1992).

Denardo, B., "Physics Demonstrations: A Chaotic Double Pendulum, Feedback on a Cartasian Diver, and a Pressesing Tuning Fork." Education Session on Demonstrations, meeting of Acoustical Society of America, New Orleans, LA, 4 November 1992. (Attendance: 100).

Denardo, B., "Precessing Tuning Fork Demonstration: A Subtle Effect of Surface Impedance." Physics Department Gathering, Naval Postgraduate School, Monterey, CA, 28 January 1992. (Attendance: 20).

Denardo, B. and Larraza, A., "Far Off Equilibrium Phenomena in Acoustics: Localized States, Wave Turbulence, and Absorption of Sound by Ansiotropic Noise," Physical Acoustic Summer School, Asilomar, CA, June 1992.

Gaitan, D. and Atchley, A., "Finite Amplitude Standing Waves in Harmonic and Anharmonic Closed Tubes," 123rd Meeting of the Acoustical Society of America, Salt Lake City, UT, May 1992, Journal Acoustical Society of America 91 No. 4, Pt. 2,2330(A) (1992).

Gaitan, D., Holt, G., and Atchley, A., "Investigation of Periodicity of Sonoluminescing From a Single Bubble," 124th Meeting of the Acoustical Society of America, New Orleans, LA. October 1992, J. Acoustical Society of America 92 No. 4, Pt. 2,2452(A) (1992).

Gaitan, D., Lentz, J.W., and Atchley, A., "Further Investigation of a Single, Stable, Sonoluminescing Bubble Using Mie Scattering," 123rd Meeting of the Acoustical Society of America, Salt Lake City, UT, May 1992, J. Acoust. Soc. Am. 91 No. 4, Pt. 2,2331(A) (1992).

Gardner, D.L., Brown, D.A., and Garrett, S.L., "Fiber-Optic Push-Pull Hydrophone Systems," the Third International Workshop on Transducers for Sonics and Ultrasonics, Naval Research Laboratory, USRD May 1992.

Garrett, S.L., "ThermoAcoustic Refrigeration for Space Applications," American Institute of Aeronautics and Astronautics, Hunsville, Alabama, 25 March, 1992, paper No. 92-1712.

Garrett, S.L., Hofler, T.J., and Gardner, D.L., "TermoAcoustic Refrigeration Research at NPS," proceedings XIV International Congress on Acoustics, Beijing, China, 3-10 September 1992, Acoustica 76(4), 3 (1992); Vol I, paper A4-1.

Gregoris, D.J., Yu, S., Cooper, A.W., and Milne, E.A., "Dual-Band Infrared Measurements of Sun Glint From the Sea Surface," paper 1687-53, SPIE Symposium on EO/Aerospace Sensing, Orlando, Florida, 21 April 1992.

Hofler, T.J., "Theoretical Study of Heat Transport in ThermoAcoustic Stacks Having Arbitrary Plate Separation," Journal Acoustic Society of America, 91(4), Pt. 2, 2396, 1992.

Humm, D.C., Asfaw, A., Seyoum, H., Morgan, H., Fortna, J., and Cleary, D.D., "High-Resolution VUV Absolute Photo-Absorption Cross Sections of N2 and Rare Gases," Optical Society of America Annual Meeting, 1992.

Kamada, R. F., Mikkelsen, T., and Thykier-Nielsen, S., "LINCOM/RIMPUFF vs Mt. Iron, a Data/Modeling Comparison," 7th JANNAF Safety and Environmental Protection Subcommittee Meeting, Naval Postgraduate School, Monterey, CA, August 10-14, 1992.

Kamada, R.F. and Drake, S.A., "An e-ϵ Turbulence Closure Scheme for Mesoscale Windflow Models with Large Horizontal/vertical Grid Aspect Ratios," 10th Symposium on Turbulence and Diffusion, Portland, OR, Oct 29-Nov 2, 1992.

Kamada, R.F., "Generalizing w* to Mixed Forced/Free Convection in Dispersion and Boundary Layer Analysis," 10th Symposium on Turbulence and Diffusion, Portland, OR, Oct. 29- Nov. 2, 1992.

Kamada, R.F., "Multi-Fractal Analysis of Coherent Structures in Fluid Dynamic Time Series," 10th Symposium on Turbulence and Diffusion, Portland, OR, 29 October - 2 November 1992.

Kapolka, D., Brown, D.A., Gardner, D.L., and Garrett, S.L., "Composite Fiber Optic Flexural Disk Hydrophones" Journal of Acoustical Society of America, 91, Supplement 4, p. S2324, May 1991.

Keolian, R.M., Denk, W., Ogawa, S., and Jelinski, L.W., "Imaging Oscillatory Motion: An 'NMR Lock-in Amplifier'," The 33rd. ENC Experimental Nuclear Magnetic Resonance Conference, 29 Mar - 2 Apr 1992.

Keolian, R.M., Denk, W., Ogawa, S., Jelinski, W., "Cochlear Fluid Motion Visualized With Magnetic Resonance Imaging," 123rd. Meeting of the Acoustical Society of America, Journal of the Acoustical society of America, 91, Pt. 2, 2398, April 1992.

Keolian, R., Larraza, A., and Denardo, B., "Dynamics of a Gas of Random Nonlinear waves," 3rd Annual R&D Information Exchange Conference, Naval Surface Warfare Center, Silver Spring, MD, April 19[illegible]

Larraza, A., "Physical Applications [illegible]ave Turbulence: Wind Waves and Classical Collective Modes," in Nonlinear Waves and Weak Turbulence Conference, Cleveland, Ohio, May 1992.

Larraza, A. and Keolian, R., "Collective Modes in Nonlinear Random Gravity Waves," ONR Nonlinear Ocean Waves Workshop, Washington, D. C., October 1992.

Larraza, A. and Denardo, B., "Absorption of Sound by Noise in One Dimension," Acoustical Society Meeting, Salt Lake City, UT, May 1992.

Lawrence, R.T., Yarber, R.K., and Keolian, R.M., "Search for Second Sound in Deep Water Gravity Waves," Journal of the Acoustical Society of America, 92, Pt. 2, 2454 (1992).

Lentz, W.J., "High Background Photon Counting LIDAR," Sixteenth International Laser Radar Conference, Boston, MA, July 23 1992, Summary published in NASA Conference Publication 3158 Pt. II, pp 601-604.

Maruyama, X.K., Osborne, M.J., Evertson, S., Fiorito, R.B., Rule, D.W., Piestrup, M.A., Ho, A., and Li, Q., "First Observation of Enhanced Higher Order Parametric X-radiation," Bulletin American Physical Society, 37, 951, 1992, Washington, D. C., April 1992.

Maruyama, X.K., "Optical Transition Radiation Interferometry and Beam Emittance Measurements," Twelfth International Conference on the Applications of Accelerators in Research and Industry, Denton, TX, November 205, 1992.

Olsen, R.C., and Scott, L.J., "Equatorially Trapped Plasmas and Parallel Electric Fields," EOS, 72, pp. 401, 1991, Presented at fall meeting of the American Geophysical Union, San Francisco, CA, 9-13 December 1991.

Schwirzke, F., Hallal, M.P., Jr., Maruyama, X.K., "The Physics of 'Vacuum' Breakdown," 1992 High Voltage Workshop, Wright Laboratory, Wright Patterson AFB, Ohio, October 20-21, 1992. (Classified Conference).

Schwirzke, F., Hallal, M.P., Jr., Maruyama, X.K., "Onset Breakdown and Formation of Cathode Spots," XV International Symposium of Discharges and Electrical Insulation in Vacuum, Darmstadt, September 6-10, 1992.

Schwirzke, F., Hallal, M.P., Jr., and Maruyama, X.K., "Onset of Breakdown and Formation of Cathode Spots." Conference Record, IEEE Catalog No. 9THO460-6, 1992 IEEE International Conference on Plasma Science, June 1-3, 1992, Tampa, Florida, p.116.

Schwirzke, F., Hallal, M.P., Jr., and Maruyama, X.K., "The Physics of Vacuum Breakdown." 9th. International Conference on High Power Particle Beams, Washington, D. C., May 25-29, 1992.

Schwirzke, F., "Cathode Spots, Hot Spots for Impurities Release." 10th. International Conference on Plasma Surface Interactions in Controlled Fusion Devices, Monterey, CA. March 30-April 3, 1992.

Schwirzke, F., "Onset of Breakdown and Formation of Cathode Spots." Invited Paper, XV International Symposium on Discharges and Electrical Insulation in Vacuum." Darmstadt, Germany, September 6-10, 1992.

Schwirzke, F., "Breakdown and Formation of Cathode Spots." Seminar presentation at Kernforschungsinstitut, Karlsruhe, Germany, September 16, 1992.

Shwirzke, F., "The Physics of Vacuum Breakdown." DoD 1992 High Voltage Workshop, Wright Patterson Air Force Base, Ohio, October 20-21, 1992.

Schwirzke, F., "Onset of Breakdown and Plasma Formation on Electrodes." IX Symposium on High Current Electronics, Russia, 21-30 July 1992.

Schwirzke, F., "Breakdown and Formation of Cathode Spots." 1992 Annual Meeting of the Division of Plasma Physics of the American Physical Society, Seattle, WA., 16-20 November 1992, Abstract published in Bulletin Am. Phys. Society, 1563, 1992.

Sternberg, J., "Lethal Systems", Meeting of Army Science board, 8 April 1992.

Sternberg, J., "Analitic Pernetration Mechanics," Workshop on Penetration Mechanics in the Former Soviet Union, march 18, 1992. (Attendance: 60).

Sturgess, K., and Colson, W.B., "Short Pulse Evaluation in the Boeing APLE Oscillator," Fourteenth International Free Electron Laser Conference, Kobe, Japan, August 1992.

Walters, D.L., Gast, V.J., Mattingly, T.S., and Galarowicz, D., "Atmospheric Characterization for the Air Force-Maui 4m Telescope," Optical Society of America Topical Meeting on Adaptive Optics for Large Telescopes, Lahaina, Maui, 17 August 1992.

Walters, D.L.,"Higher Order Structure Functions and Their Effects on Remote Sensors," Optical Society of America Annual Meeting, Alburquerque, NM, September 25, 1992.

BOOK CONTRIBUTIONS

Bass, H.E., Fowlkes, J.B., and Atchley, A.A., "Ultrasonics," Encyclopedia of Science and Technology 6th Edition, McGraw Hill, New York, 1992.

Colson, W.B., Blau, J., Cord, G., Craun, D., Gillingham, D., Kiel, D., Park, J.H., and Souza, R., "Free Electron Lasers for Inertial Confinement Fusion," Chapter 16, pages 421-436, in Nuclear Fusion by Inertial Confinement, editors: G. Velarde, Y. Ronen, and J. M. Martinez-Val, CRC Press, Florida 1992.

Cooper, A.W., Walker, P.L., Milne, E.A., and Cook, B.J., "Evaluation of Tactical Decision Aid Predictions of FLIR Range Performance," Characterization, Propagation and Simulation of Sources and Backgrounds II, Dieter Clement and Wendell Watkins, Editors, Proc. SPIE 1687, pp. 147-157, 1992.

Gregoris, D.J., Yu, S., Cooper, A.W. and Milne, E.A., "Dual-Band Infrared Measurements of Sun Glint from the Sea Surface": Characterization, Propagation and Simulation of Sources and Backgrounds II, Dieter Clement and Wendell Watkins, Editors, Proc. SPIE 1687, 381-393, 1992.

PATENTS

Brininstool, R., Newmaster, J.T., and Garrett, S.L., "Fiber Optic Remote Angular Position Sensor Including a Polarization Track," U. S. Patent No. 5,073,711, December 17, 1991.

Brown, D.A., "Improved Flextensional Hydrophone," Navy Case 73806, Submitted July 1992, Patent Approved September 1992.

Brown, D.A., Garrett, S.L., and Hofler, T., "Fiber-Optic Flexural Disk Accelerometer," Navy Case No. 73,054.

Davis, D.S., "An Efficient and Versatile Method and Apparatus for Multiplexed Imaging using Optically Generated Kronocker Products", Navy Case 74667; PTO Serial No. 07/973099.

ANTISUBMARINE WARFARE ACADEMIC GROUP

Professor J.N. Eagle
Chairman

ANTISUBMARINE WARFARE ACADEMIC GROUP

The Antisubmarine Warfare Academic Group (ASWAG) consists of nine faculty members who hold appointments in five Departments at the Naval Postgraduate School. These faculty members teach in the Antisubmarine Warfare Curriculum and are responsible for its academic content. Members conduct Antisubmarine Warfare-related research and serve as thesis advisors for Antisubmarine Warfare students.

During 1992, the ASWAG consisted of the following members:

Professor Robert Bourke (OC)
Professor Ching-Sang Chiu (OC)
Professor Allan Coppens (PH)
Professor James Eagle (OR), Chairman
CDR Rick Erazo (3A), Curriculum Officer
Professor James Miller (EC)
Professor James Sanders (PH)
Professor Clyde Scandrett (MA)
Professor Steve Baker (PH)
Professor Alan Washburn (OR)

An overview of research supported by the Antisubmarine Warfare Academic Group is below.

CONDUCTIVITY, TEMPERATURE AND DEPTH STUDIES

Professor Robert Bourke examined conductivity, temperature, depth (CTD) data collect by a submarine operating in the Arctic Ocean. This was the first study of CTD data collected by a submarine and revealed information on submesoscale vortices which drifted through the area. A follow-on research submarine cruise is scheduled for August 93, which will collect additional CTD data. Professor Bourke's research has been influential in the planning for this submarine cruise.

SONAR TRANSDUCER ARRAYS

Professors David Canright (MA), **Clyde Scandrett** (MA), and **Steve Baker** (PH) continued their research program in low-frequency, active sonar transducer array performance modeling. The purpose of this research is to efficiently predict the performance of arbitrarily dense, volumetric active sonar arrays. They have developed a new, combined analytical/finite-element numerical analysis method for this purpose. The research goal is to couple a finite-element model of a low-frequency transducer of Navy interest to an acoustic field model which allows

arbitrarily dense arrays. In FY92 a new methodology was developed for determining the acoustic source levels of a transducer array which is computational more efficient than previous methods. Also, the array modelling procedure was extended to shallow water. In this work, the problem of mutual interactions of transducers has been coupled to a water "sound channel" which incorporates the effects of a free surface, and either an acoustically hard bottom of uniform depth, or an acoustically "fast" bottom.

ACOUSTIC AND ELECTROMAGNETIC DATA MODELING

Professors Charles Therrien (EC) and **Murali Tummala** (EC) continued work on multigrid techniques for application to transient acoustic and electromagnetic data modelling and compression. New algorithms were developed for modeling and processing one- and two-dimensional signals. Preliminary investigative work was conducted examining signal compression applications of wavelet transforms.

ACOUSTIC TOMOGRAPHY

Professors James Miller (EC) and **Ching-Sang Chiu** (OC) proposed a new ocean acoustic tomography method for real-time coastal ocean monitoring. The proposed method uses telemetered vertical line arrays to acquire a time series of both acoustic ray and mode arrivals in real time. Hybrid ray/mode inverse techniques are then used to map the ocean thermal structure at high spatial and temporal resolutions. Under the sponsorship of the Office of Naval Research, this new tomography method was successfully tested at sea in the Barents Sea Polar Front Experiment in August 1992. Additionally, Professors Miller and Chiu continued to develop a procedure for localizing transient acoustic signals. The accuracy and robustness of their algorithms were tested in several simulated complex shallow-water scenarios.

WAVELET TRANSFORM

Professors Ralph Hippenstiel (EC) and Monique Fargues began a two-year program to investigate use of the Wavelet Transform in undersea surveillance. The Wavelet Transform can serve as an alternative to conventional time-frequency transforms and is well suited for transient detection. Also investigated was the potential use of the Wavelet Transform to the modelling of radar transient returns in the presence of sea clutter, multipath returns and radic frequency interference. This work is scheduled to continue into FY93.

ELECTRONIC WARFARE ACADEMIC GROUP

Professor J.B. Knorr
Acting Chairman

ELECTRONIC WARFARE ACADEMIC GROUP

The Electronic Warfare Academic Group (EWAG) is an inter-disciplinary group of faculty who hold appointments in the eleven Departments at the Naval Postgraduate School. These faculty members are responsible for the electronic warfare curricula for U.S. and International students. Their participation in the EWAG is voluntary and is a result of their interest in applying their expertise to problems related to electronic combat.

Most EWAG faculty do some research related to electronic warfare. The primary purpose of this summary is to provide an overview of their work. In addition, there are a few faculty who do EW research and who are not presently EWAG members. They are included here, as well, in order to provide a complete picture.

The research summaries and publication lists of the faculty will not be included here. Since all EWAG faculty hold appointments in a Department, their summaries and publications appear elsewhere in this document.

During 1992, the membership of the Electronic Warfare Academic Group was as follows:

Prof. Michael Bailey (OR)
Prof. Alfred Cooper (PH)
Prof. Kenneth Davidson (MR)
CDR Rick Erazo (3A), Curriculum Officer
LCDR Danny Farley (32)
Prof. Wayne Hughes (OR)
Prof. David Jenn (EC), Academic Associate
Prof. Jeffrey Knorr (EW), Acting Chairman
Prof. Michael Morgan (EC)
Prof. Phillip Pace (EC)
Prof. Ron Pieper (EC)
Prof. Arthur Schoenstadt (MA)
Prof. Joseph Sternberg (PH)
Prof. Harold Titus (EC)

The following faculty, although not on the 1992 EWAG, had research programs which contributed to the success of the electronic warfare program:

Prof. Richard Adler (EC)
Prof. Fred Levien (EC)
Prof. Herschel Loomis (EC)

An overview of the Electronic Warfare Academic Group research program follows below.

AIR DEFENSE NETWORKS

Professor Mike Bailey (OR), published a paper "Measuring Performance of Integrated Air Defense Networks Using Stochastic Networks". The paper appeared in *Operations Research*, and reported on the results of an earlier project which investigated methodologies for designing optimal jamming against air defense radar systems and their command and control assets.

INFRARED TECHNOLOGY

Professor Alf Cooper continued with three research programs carried out in the Naval Academic Center for Infrared Technology (NACIT); Infrared Search and Target Designation, Strike Warfare Support, and FLIR Performance Prediction Code Validation. This work resulted in three conference presentations, three conference publications (Proceedings SPIE), and three theses.

EM/EO MODEL CALIBRATION/VALIDATION

Professor Ken Davidson carried out a project, EM/EO Model Calibration / Validation, in support of model development for assessment of evaporation duct estimation, vertical profiles of aerosol caused optical extinction, and thermal imaging of ships. Analysis/interpretation of marine atmospheric boundary layer data from several experiments was carried out and results provided to NCCOSC, RDT&E Division (NRaD).

LOW OBSERVABLE TECHNOLOGY

Professor Dave Jenn pursued several projects in the area of low observable technology including Radar Cross-Section Synthesis, Radar Cross-section Reduction of Reflector Antennas, and Radar Cross-Section Reduction of Indirect Fire Projectiles. The projects contribute to the understanding of techniques for reducing the radar cross-section and, therefore, the observability of a target. This work resulted in two conference presentations (North American Radio Science Meeting, 1992 ACES Progress in Electromagnetics), two theses, and one journal paper (IEEE Trans. on Antennas and Prop.).

IMPULSE RADAR TARGET DETECTION

Professor Mike Morgan continued work on his impulse radar target detection and identification project. This is an ongoing project which during 1992 resulted in two chapters in Ultra-Wideband Radar (Proceedings First Los Alamos Symposium), an article in *Naval Research Reviews*, and several conference presentations. In addition, **Professor Morgan** initiated a new project to

investigate the possibility for reducing wideband, bistatic RCS using distributed active cancellation.

RESOLUTION ENHANCEMENT

Professor Phillip Pace investigated a new preprocessing architecture for resolution enhancement in high-speed electro-optical/electronic A/D converters with application to EW receivers. This work looks at a performance of 10 to 12 bits for signal frequencies to 2 GHz. This research resulted in three conference presentations (IEEE Int. Symposium on Circuits and Systems, Third Annual DARPA Symposium on Photonic Systems for Antennas, IEEE Lasers and Electro-optics Proceedings) and one journal publication (Electronics Letters).

NEW METHODOLOGY FOR SUPPORTING C3I REQUIREMENTS

Professor Joe Sternberg initiated a new project, "A New Methodology for Supporting C3I Requirements". The objective of this project is to develop and exercise a new methodology for assessing the contribution of non-organic sensor information on the effectiveness of a battle force.

MISSILE SIMULATION

Professor Hal Titus continued his work with the Crossbow Committee and several of their intelligence teams. He has developed detailed simulations of several missle systems as a means of studying their guidance and control systems and developing possible counter-measures.

OPERATIONAL PERFORMANCE OF NAVY HFDF SITES

Professor Dick Adler continued ongoing projects to improve the operational performance of Navy HFDF sites around the world. The work involved identifying radio noise sources as well as predicting the signal environment.

LASER MISSILE COUNTERMEASURES

Professor Fred Levien conducted a research project to investigate countermeasures for laser designated missles and laser beam riding missles as well as countermeasures for missles with high definition video seekers.

ALGORITHMS AND ARCHITECTURES

Professor Hersch Loomis continued several research thrusts. One project involved algorithms and architectures for processing tactical information and the other involved advanced algorithms and architectures for the detection and characterization of broadband communications signals in noise and interference.

SPACE SYSTEMS ACADEMIC GROUP

Professor R. Panholzer
Acting Chairman

SPACE SYSTEMS ACADEMIC GROUP

The Space Systems Academic Group (SSAG) is an interdisciplinary association providing direction and guidance for the Space Systems Engineering and Space Systems Operations curricula. SSAG relies on faculty and facilities support from the departments of Administrative Sciences, Aeronautical and Astronautical Engineering, Computer Science, Electrical and Computer Engineering, Mathematics, Mechanical Engineering, Meteorology, Oceanography, Operations Research, and Physics.

In the 1992 academic year, officer students in the Space Systems Curricula and participating faculty from several departments were engaged in five major areas of space research and development: (1) Spacecraft Technology, (2) Acoustics in Space, (3) Satellite Communications, (4) Computer Memory Technology in Space, and (5) Orbitology. In Addition (6), SSAG assisted participating departments in the continuing support of several Spacecraft and Flight Hardware Laboratories and Support Facilities. An overview of research conducted under the auspices of the SSAG is below.

SPACECRAFT TECHNOLOGY

Small Satellite Design Studies

Professor Rudolfh Panholzer continued his research program on small Satellite Design Studies with the Petite Amateur Navy Satellite Project. PANSAT will function as a small radio communications satellite -- it is being designed to investigate spread spectrum communication with store-and-dump capability for relaying information digitally. In the 1992 academic year, a System Design Review (SDR) was presented by faculty, staff, and students, reviewing functional requirements and conceptual designs of the spacecraft and ground segment; and a frequency allocation and license was approved by the International Frequency Registration Board of the International Telecommunication Union.

ACOUSTICS IN SPACE

Space Thermoacoustic Refrigerator (STAR)

Professor Steve L. Garrett's team completed the testing of the Space Thermoacoustic Refrigerator (STAR and delivered it to fly on the Space Shuttle Discovery (STS-42) in Late January 1992. (See Department of Physics.)

Thermoacoustic Life Sciences Refrigerator (TALSR)

Professor Steve L. Garrett's team began design of a complete refrigeration system for use on board the Space Shuttle to provide cooling for biological samples. A Cooperative Research and Development Agreement (CRADA) was established involving NASA and General Electric Government Services. (See Department of Physics.)

SATELLITE COMMUNICATIONS

Low-Altitude Satellite Communications (LASAT) And Networks

Professor Tri Ha continued investigation of the performance characteristics of four types of frequency-hopped spread spectrum receivers suitable for satellite communications in low-earth orbits (LASAT). Four types of frequency-hopped spread spectrum receivers were investigated. (See Department of Electrical and Computer Engineering.)

COMPUTER MEMORY TECHNOLOGY IN SPACE

Ferrolectric Technology

Professor Panholzer's team continued research on Computer Memory Technology in Space to evaluate ferroelectric technology for its suitability in military and space applications. Under Professor Panholzer's direction, a Thin-Film Ferroelectric Experiment (NPS FERRO-001) was designed to test the effects of space environment on aging and fatiguing characteristics of ferroelectric capacitors. This research is expected to continue into 1993-94.

ORBITOLOGY

Orbit Prediction on Parallel Computers

Professors Donald Danielson and Beny Neta began research to investigate the feasibility of using parallel computers to efficiently predict orbits of objects in space. Their research will also document and improve orbit predictor, and document Semianalytic Satellite Theory to facilitate parallelization in the future. (See Mathematics Department.)

SPACECRAFT AND FLIGHT HARDWARE LABORATORIES/FACILITIES

The Space Systems Academic Group (Code SP) and participating departments have continued to dedicate both labor and material resources to the development

of several laboratories and support facilities:

(SP01) Spacecraft Integration & Test (Code SP)
(SP02) Open Site EMI/EMC (Code SP)
(SP03) Satellite Ground Station (Code SP)
(SP04) AIS Computing (Code SP)
(SP05) Precision Fabrication Facility (Code SP)
(AA17) FLTSATCOM Satellite Operations, Simulation & Test (SP/AA)
(AA18) Spacecraft Attitude Dynamics & Control (SP/AA)
(AA19) Spacecraft Environmental Simulation & Test (SP/AA)

SMALL SATELLITE DESIGN STUDIES

Rudolfh Panholzer, Professor and Chairman
Space Systems Academic Group
Sponsors: Naval Research Laboratory and Army Space Technology Research Office
Funding: Naval Research Laboratory, Army Space Technology Research Office, and Naval Postgraduate School

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 the Naval Postgraduate School, 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: In the 1992 academic year, A System Design Review was presented by faculty, staff, and students, reviewing functional requirements and conceptual designs of the spacecraft and ground segment; finite element analysis of the final satellite structural design was verified by test; antenna analysis and optimization studies were performed; a preliminary study simulating channel usage was done; fabrication of the engineering qualification model structure was completed; and a frequency allocation and license was approved by the International Frequency Registration Board of the International Telecommunication Union.

THESES DIRECTED: Sityar, I., LT, USN, "Sun Sensor Implementation Using Solar Power Arrays," Master's Thesis, September 1992.

Sakoda, D.J., DoD, "Structural Design, Analysis, and Modal Testing of the Petite Amateur Navy Satellite (PANSAT)," Master's Thesis, September 1992.

Payne, R.A., CPT, USA, "Applications of the Petite Amateur Navy Satellite (PANSAT," Master's Thesis, September 1992.

Gottfried, R., LT, USN, "PACSIM: Using Simulation in Designing a Communications Satellite," Master's Thesis, September 1992.

Fritz, T.M., LT, USN, "A Biphase Shift Keying (BPSK) Direct Sequence, Spread Spectrum Modem for Petite Amateur Navy Satellite (PANSAT)," Master's Thesis, December 1992.

THIN-FILM FERROELECTRIC EXPERIMENT (FERRO NPS-001)

Rudolfh Panholzer, Professor and Chairman
Spaces Systems Academic Group
Sponsor: Naval Research Laboratory
Funding: Naval Research Laboratory and Naval Postgraduate School

OBJECTIVE: The goal of the ongoing thin-film ferroelectric memory research project is to evaluate ferroelectric technology to determine its suitability in military and space memory applications.

SUMMARY: NPS-001 Ferro is a thin-film ferroelectric experiment manifested on the advanced Photovoltaic and Electronics Experiment satellite (APEX), manufactured by Orbital Sciences Corporation (OSC) of Fairfax, Virginia. Thirty-two ferroelectric capacitors provide the test material. Half of the capacitors reside external to the FERRO housing affording maximum exposure to the space environment. The remaining half are inside the housing and are shielded from radiation. Both groups of capacitors are further divided to undergo aging and fatigue testing separately. Fatiguing and aging test results when compared to results from the same tests conducted on the ground may show if the space environment has any effect on the ferroelectric material. Launch aboard OSC's Pegasus expendable launch vehicle is scheduled for February 1994.

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This report contains 344 summaries of research projects which were carried out under funding of the Naval Postgraduate School Research Program. A list of recent publications is also included which consists of conference presentations, contributions to books, published papers, magazine articles, and technical reports. The research was conducted under the areas Administrative Sciences, Aeronautics and Astronautics, Computer Science, Electrical and Computer Engineering, Mathematics, Mechanical Engineering, Meteorology, National Security Affairs, Oceanography, Operations Research, Physics, C3 Joint Academic Group, Electronic Warfare Academic Group, Antisubmarine Warfare Group, and Space Systems Academic Group.

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